DECLARATION OF JUNE ANN MUNFORD

1. My name is June Ann Munford. I am over the age of 18, have personal knowledge of the facts set forth herein, and am competent to testify to the same.

2. I earned a Master of Library and Information Science (MLIS) from the University of Wisconsin-Milwaukee in 2009. I have over ten years of experience in the library/information science field. Beginning in 2004, I have served in various positions in the public library sector including Assistant Librarian, Youth Services Librarian and Library Director. I have attached my Curriculum Vitae as Appendix CV.

3. During my career in the library profession, I have been responsible for materials acquisition for multiple libraries. In that position, I have cataloged, purchased and processed incoming library works. That includes purchasing materials directly from vendors, recording publishing data from the material in question, creating detailed material records for library catalogs and physically preparing that material for circulation. In addition to my experience in acquisitions, I was also responsible for analyzing large collections of library materials, tailoring library records for optimal catalog

search performance and creating lending agreements between libraries during my time as a Library Director.

4. I am fully familiar with the catalog record creation process in the library sector. In preparing a material for public availability, a library catalog record describing that material would be created. These records are typically written in Machine Readable Catalog (herein referred to as “MARC”) code and contain information such as a physical description of the material, metadata from the material’s publisher, and date of library acquisition. In particular, the 008 field of the MARC record is reserved for denoting the date of creation of the library record itself. As this typically occurs during the process of preparing materials for public access, it is my experience that an item’s MARC record indicates the date of an item’s public availability.

5. Typically, in creating a MARC record, a librarian would gather various bits of metadata such as book title, publisher and subject headings among others and assign each value to a relevant numerical field. For example, a book’s physical description is tracked in field 300 while title/attribution is tracked in field 245. The 008 field of the MARC record is reserved for denoting the creation of the library record itself. As this is the only date reflecting the inclusion of said materials within the library’s collection, it is my experience

that an item's 008 field accurately indicates the date of an item's public availability.

6. I am familiar with the Internet Archive, a digital library accessible to the general public. Among other services that the Internet Archive makes available to the general public is the Wayback Machine, an online archive of the web. The Internet Archive's Wayback Machine service archives webpages as of a certain capture date to track changes in the web over time. The Internet Archive has been in operation as a nonprofit library since 1996 and has hosted the Wayback Machine service since its inception in 2001. During my time as a librarian, I frequently used the Internet Archive's Wayback Machine for research and instruction purposes. This includes teaching instructional classes on using the Wayback Machine to library patrons and using the Wayback Machine to research reference inquiries that require hard-to-find online resources. I consider the Internet Archive's recordskeeping to be as rigorous and detailed as other formal library recordskeeping practices such as MARC records, OCLC records and Dublin Core.

7. I have reviewed Exhibit 1010 a document entitled ITU-T H.264 (11/2007) Series H: Audiovisual and Multimedia Systems (hereto referred to as ITU-T

H.264 2007). Page i of Exhibit 1010 indicates this standard was approved by the ITU-T Study Group as of November 22, 2007. I have also reviewed Exhibit 1011 a document entitled Editing State of Text Relating to ITU-T Rec. H.264 | ISO/IEC 14496-10 Amendments 1 and 2 (hereto referred to as ITU-T H.264 Draft).

8. Exhibits 1010 and 1011 are ITU-T standards, with 1011 representing a draft of the standard created in 2006 and 1010 representing a final edition of that standard created in 2007. The 2006 draft version of this standard discusses the integration of two amendments to the previous 2005 draft standard: “Support of Additional Colour Spaces and Removal of the High 4:4:4 Profile” (hereto referred to as Amendment 1) and "New Profiles for Professional Applications (hereto referred to as Amendment 2). According to the cover page of Exhibit 1011, Amendment 1 was approved on June 13, 2006 and Amendment 2 was approved on April 6, 2007.

9. Attached hereto as Appendix H26401 is a screen capture of a webpage entitled Recommendation H.264 (11/07) as hosted on the ITU website, as well as a copy of the PDF downloaded from that webpage. I secured this screen capture and downloaded PDF myself from https://www.itu.int/rec/T-REC-H.264-200711-S/en. This page presents a true and correct copy of

ITU-T H.264 2007 directly available for download from the publisher. In comparing Appendix H26401 to Exhibit 1010 it is my determination Exhibit 1010 is a true and correct copy of ITU-T H.264 (11/2007) Series H: Audiovisual and Multimedia Systems. Page 4 of Appendix H26401 (page i of the downloaded document) indicates this recommendation was approved as of November 22, 2007. Page 1 of Appendix H26401 (the screen capture) indicates this recommendation was posted to the ITU website as of May 29, 2008.

10. Attached hereto as Appendix H26402 is a screen capture of a webpage entitled Recommendation H.264 (2005) Amendment 1 (06/06) as hosted on the ITU website, as well as a copy of the PDF downloaded from that webpage. I secured this screen capture and downloaded PDF myself from https://www.itu.int/rec/T-REC-H.264-200606-S!Amd1/en. This appendix presents a true and correct copy of Amendment 1 directly available for download from the publisher. Page 1 of Appendix H26402 (the screen capture) indicates this amendment was posted to the ITU website as of October 18, 2006.

11. Attached hereto as Appendix H26403 is a screen capture of a webpage entitled Recommendation H.264 (2005) Amendment 2 (04/07) as hosted on

the ITU website, as well as a copy of the PDF downloaded from that webpage. I secured this screen capture and downloaded PDF myself from https://www.itu.int/rec/T-REC-H.264-200704-T!Amd2/en. This appendix presents a true and correct copy of ITU-T Amendment 2 directly available for download from the publisher. Page 1 of Appendix H26403 (the screen capture) indicates this amendment was posted to the ITU website as of November 2, 2007. Page 1 also contains the following passage: 'H.264 (2005) Amd.2 (2007) was available only as pre-published text since it was superseded by H.264 (11/2007) before its publication'.

12. Exhibit 1011 ITU-T H.264 Draft, is a pre-published edition of the H.264 standard containing green and blue text to denote language from Amendments 1 and 2 being integrated into the final draft. Exhibit 1010 ITU-T H.264 2007, represents a finalized edition of this draft which retains the addition of text from Amendments 1 and 2. Exhibit 1011 is available, through the Internet Archive, at https://web.archive.org/web/20120128140053/http:/ip.hhi.de/imagecom_G1/assets/pdfs/h264_iso-iec_14496-10.pdf. While not captured by the Internet Archive until 2012, the document appears to have been created after the release of Amendments 1 and 2, and before the release of ITU-T H.264 2007.

13. To illustrate the integration of this text, Amendment 1 proposes changes to Table E-3, entitled Colour Primaries. This table is present on page 9 of Appendix H26402 in proposed language. This table is also present in ITU-T H.264 Draft on page 352, with the language present on this page being identical to the language present within Amendment 1. This table is also present in ITU-T H.264 2007 on page 348, with the language present on this page being identical to the language present within ITU-T H.264 Draft and Amendment 1. I have also reviewed the additional revisions described in Amendment 1, and have determined that they have been incorporated into ITU-T H.264 Draft (as blue text) and ITU-T H.264 2007 (as accepted revisions).

14. A similar comparison can be made related to text found in Amendment 2. For instance, Amendment 2 proposes the addition of the following text to subclause 8.5.4: “Depending on ChromaArrayType, the following applies. If ChromaArrayType is equal to 3, the transform decoding process for chroma samples with ChromaArrayType equal to 3 as specified in subclause 8.5.4.1 is invoked. Otherwise (ChromaArrayType is not equal to 3), the following text specifies the transform decoding process for chroma samples.” This passage of text is present on page 29 of Appendix H26403 in proposed

language. This passage of text is also present in ITU-T H.264 Draft on page 172, with the language present on this page being identical to the language present within Amendment 2. This passage of text is also present in ITU-T H.264 2007 on page 171-172, with the language present on this page being identical to the language present within ITU-T H.264 Draft and Amendment 2 aside from a renumbered subclause. I have also reviewed the additional revisions described in Amendment 2, and have determined that they have been incorporated into ITU-T H.264 Draft (as green text) and ITU-T H.264 2007 (as accepted revisions).

15. In comparing ITU-T H.264 2007 and ITU-T H.264 Draft to Amendments 1 and 2, it is my determination changes proposed in ITU-T Amendments 1 and 2 are present in ITU-T H.264 2007, a document approved as an ITU-T standard as of November 22, 2007.

16. Attached hereto as Appendix H26404 is a download of a document entitled Content of ITU-T Recommendations on DVD September 2007 Edition as hosted on the ITU website. I secured this download myself from https://www.itu.int/dms_pub/itu-t/opb/rec/T-REC-DVD-2007-E09-TOC-PDF-E.pdf. Appendix H26404 is a table of contents for the September 2007 edition of ITU-T Standards as published on DVD-ROM. Page 57 of

Appendix H26404 contains an entry for ITU-T Amendments 1 and 2, indicating these amendments' availability to DVD-ROM subscribers as of September 2007 despite the amendments' pre-publication status.

17. Attached hereto as Appendix H26405 is a screen capture of the Internet Archive Wayback Machine entry for http://www.itu.int/publ/T-REC-DVD-2007/en. I secured these screen captures myself from https://web.archive.org/web/20080303023918/http://www.itu.int/publ/T-REC-DVD-2007/en. This record was captured as of March 3, 2008.

18. Appendix H26405 is an Internet Archive capture of a web page entitled ITU Recommendations – CD/DVD Rom 2007 as hosted on the ITU website. This page describes the DVD-ROM edition of the ITU-T Recommendations product offered by the ITU for purchase and specifically references the September 2007 edition for sale. As of March 3, 2008, users were capable of purchasing individual editions of the ITU-T Recommendations DVD-ROM from the ITU website or subscribe to the DVD-ROM edition to acquire each new edition of the DVD-ROM as it was published. As the September 2007 DVD-ROM Table of Contents indicates the contents of the DVD-ROM includes ITU-T Amendments 1 and 2, is it my determination users capable of purchasing the September 2007 DVD-ROM via the ITU website would be

able to secure access to ITU-T Amendments 1 and 2 in their pre-publication form.

19. Attached hereto as Appendix H26406 is a screen capture of the Internet Archive Wayback Machine entry for http://www.itu.int/publications/bookshop/how-to-buy.html#free. I secured these screen captures myself from https://web.archive.org/web/20071128093200/http://www.itu.int/publications/bookshop/how-to-buy.html#free. This record was captured as of November 28, 2007.

20. Appendix H26406 is an Internet Archive capture of a web page entitled How to Use the ITU Electronic Bookshop as hosted on the ITU website. This page describes the processes customers would follow to purchase materials from the ITU website as of November 28, 2007. Page 2 of Appendix H26406 indicates publications such as ITU-T H.264, Amendment 1 and Amendment 2 are individually available for purchase from the ITU Electronic Bookshop. Page 2 of Appendix H26406 also describes a program in which users of the ITU website are able to download individual ITU Standards from the bookstore for no cost: “All web-posted ITU-T…Recommendations, including those appearing in their pre-published

and/or draft formats, are accessible with this offer". As Amendments 1 and 2 were each uploaded to the ITU website prior to November 28, 2007, Appendix H26406 indicates these documents were able to be purchased from the ITU website via the electronic bookstore and via the ITU-T Free Recommendations program as of November 28, 2007. As ITU-T H.264 2007 was approved prior to November 28, 2007, it is my opinion that ITU-T H.264 was available in pre-publication form via the electronic bookstore and via the ITU-T Free Recommendations program prior to the posting date of May 29, 2008.

21. Appendices H26404, H26405 and H26406 indicate ITU-T documents in pre-publication (and Amendments 1 and 2 in particular) were available for purchase from the ITU via several different formats: DVD-ROM, the ITU Electronic Bookstore and the Free Recommendations program. The variety of methods for distribution indicates ITU-T documents approved in 2006 and 2007 would be available to the public soon after approval.

22. Attached hereto as Appendix 26407 is a screen capture of the Internet Archive Wayback Machine entry for http://www.itu.int/ITU-T/studygroups/com16/results.html. I secured these screen captures myself from https://web.archive.org/web/20060927080742/http://www.itu.int/ITU-

T/studygroups/com16/results.html. This record was captured as of September 27, 2006.

23. Appendix 26407 is an Internet Archive capture of a web page entitled Meeting Results Geneva, 3 - 13 April 2006 as hosted on the ITU-T SG16 Meeting Results website. Page 4 of Appendix 26407 contains a link to a draft of Amendment 1, accessible by ITU-T TIES subscribers. Page 5 contains the following passage: ‘Updated 2006-06-06’, indicating this draft of Amendment 1 was first made available via the ITU-T SG16 Meeting Results website as of June 6, 2006.

24. Attached hereto as Appendix 26408 is a screen capture of the Internet Archive Wayback Machine entry for http://www.itu.int/ITU-T/studygroups/com16/results.html. I secured these screen captures myself from https://web.archive.org/web/20070416211324/http://www.itu.int/ITU-T/studygroups/com16/results.html. This record was captured as of April 16, 2007.

25. Appendix 26408 is an Internet Archive capture of a web page entitled Meeting Results Geneva, 14 - 24 November 2006 as hosted on the ITU-T SG16 Meeting Results website. Page 4 of Appendix 26407 contains a link to

a draft of Amendment 2, accessible by ITU-T TIES subscribers. Page 5 contains the following passage: ‘Updated 2006-12-05’, indicating this draft of Amendment 2 was first made available via the ITU-T SG16 Meeting Results website as of December 5, 2006.

26. I have reviewed Exhibit 1015, a document entitled ITU-T H.264 Standard (03/2005) Series H: Audiovisual and Multimedia Systems hereto referred to as ITU-T H.264. Page i of Exhibit 1015 indicates this standard was approved by the ITU-T Study Group as of March 1, 2005.

27. Attached hereto as Appendix H26409 is a screen capture of a webpage entitled ITU-T H.264 Standard (03/2005) Series H: Audiovisual and Multimedia Systems as hosted on the ITU website. I secured these screen captures myself from https://www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-H.264-200503-S!!PDF-E&type=items. This page is a true and correct copy of ITU-T H.264 directly available for download from the publisher. In comparing Appendix H26409 to Exhibit 1015, it is my determination Exhibit 1015 is a true and correct copy of ITU-T H.264 Standard (03/2005) Series H: Audiovisual and Multimedia Systems.

28. Attached hereto as Appendix H26410 is a screen capture of a webpage entitled Content of ITU-T Recommendations on DVD June 2005 Edition as hosted on the ITU website. I secured these screen captures myself from https://www.itu.int/itudoc/gs/itutcd/87337.pdf. Appendix H26410 is a table of contents for the June 2005 edition of ITU-T standards as published on DVD-ROM. Page 48 of Appendix H26410 contains an entry for ITU-T H.264 (“03-2005”), indicating this standard’s publication and inclusion in the collection.

29. Attached hereto as Appendix H26411 is a screen capture of the Internet Archive Wayback Machine entry for http://www.itu.int/publications/main_publ/itut.html. I secured these screen captures myself from https://web.archive.org/web/20050307005300/http://www.itu.int/publications/main_publ/itut.html. This record was captured as of March 7, 2005.

30. Appendix H26411 is an Internet Archive capture of a web page entitled ITU Telecommunication Standards as hosted on the ITU website. This page describes various methods an interested member of the public could use to purchase a copy of ITU-T H.264 from the ITU. Page 2 includes the following passage describing the ITU-T DVD-Rom publication described in

Appendix H26410: “A single DVD will contain all the ITU-T Recommendations.” Page 3 includes the following passage describing the publication schedule of ITU-T Recommendations on DVD/CD-Rom: “Issues are published quarterly (March, June, September and December) in separate English, French and Spanish editions”.

31. Page 3 of Appendix H26411 also includes the following passage describing the publication of ITU-T Standards in paper: “Order hard-copy versions of ITU Publications directly, either via the Catalogue of Publications, which contains a general list of all publications, or via the List of ITU-T Recommendations.” Page 3 of Appendix H26411 also includes a passage describing the ITU-T standards subscription service: “This yearly subscription service contains all ITU-T Recommendations in force in English, French and Spanish…This service now also includes the pre-published…and superseded recommendations”. Page 3 describes the ITU Electronic Bookshop service as follows: “Any individual ITU-T Recommendation currently in force can be downloaded…This service now also includes the pre-published...Recommendations, as well as superseded Recommendations”.

32. Attached hereto as Appendix H26412 is a screen capture of the Internet Archive Wayback Machine entry for http://www.itu.int/publications/bookshop/how-to-buy.html#free. I secured these screen captures myself from https://web.archive.org/web/20050404191706/http://www.itu.int/publications/bookshop/how-to-buy.html#free. This record was captured as of April 4, 2005.

33. Appendix H26412 is an Internet Archive capture of a web page entitled How to Use the ITU Electronic Bookshop as hosted on the ITU website. This page describes the processes customers would follow to purchase materials from the ITU Electronic Bookshop as of April 2005. Page 2 of Appendix H26412 indicates publications such as ITU-T H.264 are individually available for purchase from the ITU Electronic Bookshop. Page 2 of Appendix H26412 also describes a program in which users of the ITU Electronic Bookstore are able to download individual ITU Standards from the bookstore for no cost: “All web-posted ITU-T…Recommendations, including those appearing in their pre-published and/or draft formats, are accessible with this offer”.

34. Appendices H26411 and H26412 indicate ITU-T standards were available for purchase from the ITU via several different formats: DVD-Rom, CD-Rom, paper publications, the ITU Standards subscription and the ITU Electronic Bookstore. The variety of methods for distribution indicates an ITU-T standard published in March 2005 such as ITU H.264 would be available to the public soon after approval.

35. Appendix H26409 indicates ITU H.264 was first approved and published as of March 1, 2005. Appendix H26410 indicates ITU H.264 was compiled in the June 2005 DVD-Rom edition of the compiled ITU-T Standards. Appendices H26411 and H26412 each describe various methods available for a member of the public to purchase ITU-T Standards as of March-April 2005. Considering this information, it is my determination ITU-T H.264 Standard (03/2005) Series H: Audiovisual and Multimedia Systems was first made available to the public soon after March 1, 2005 and certainly no later than June 2005.

36. Appendix H26401 indicates ITU-T H.264 2007 was first approved as of November 2007 and posted to the ITU website as of May 29, 2008. Appendix H26402 indicates ITU Amendment 1 was first approved as of June 2006 and posted to the ITU website as of October 18, 2006. Appendix

H26403 indicates ITU Amendment 2 was first approved as of June 2007 and posted to the ITU website as of November 2, 2007, despite the amendment's pre-publication status. Appendix 26404 indicates Amendments 1 and 2 were made available to the public via the September 2007 edition of ITU-T Recommendation on DVD-ROM. Appendix 26405 indicates the September 2007 edition of ITU-T Recommendations on DVD-ROM was available for purchase from the ITU website as of March 3, 2008. Appendix 26406 indicates interested members of the public could purchase individual ITU-T documents such ITU-T H.264 2007, Amendment 1 and Amendment 2 via the electronic bookstore of the ITU-T's subscription service. Appendices 26407 and 26508 indicate draft versions of ITU-T documents were available via the ITU-T SG16 Meeting Results, with drafts of Amendments 1 and 2 uploaded to the TIES subscription service in 2006. Although the final, approved edition of ITU-T H.264 2007 was posted to the ITU website and made available for purchase no later than May 29, 2008, large sections of this document were available to the public as Amendments 1 and 2 as early as September 2007 via the ITU-T Recommendation DVD-ROM and drafts available as early as 2006 via the TIES subscription service. Therefore, it is my opinion that Exhibit 1010 was publicly available no later than May 29,

2008, and the substance of that document was publicly available no later than September 2007.

37. I have been retained on behalf of the Petitioner to provide assistance in the above-illustrated matter in establishing the authenticity and public availability of the documents discussed in this declaration. I am being compensated for my services in this matter at the rate of $200.00 per hour plus reasonable expenses. My statements are objective, and my compensation does not depend on the outcome of this matter.

38. I declare under penalty of perjury that the foregoing is true and correct. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated: 1/5/2026



June Ann Munford

APPENDIX CV

June A. Munford
Curriculum Vitae

Education

University of Wisconsin-Milwaukee - MS, Library & Information Science, 2009
Milwaukee, WI

- Coursework included cataloging, metadata, data analysis, library systems, management strategies and collection development.
- Specialized in library advocacy, cataloging and public administration.

Grand Valley State University - BA, English Language & Literature, 2008
Allendale, MI

- Coursework included linguistics, documentation and literary analysis.
- Minor in political science with a focus in local-level economics and government.

Professional Experience

Researcher / Expert Witness, October 2017 – present
Freelance ● Pittsburgh, Pennsylvania & Grand Rapids, Michigan

- Material authentication and public accessibility determination. Declarations of authenticity and/or public accessibility provided upon research completion. Experienced with appeals and deposition process.

- Research provided on topics of public library operations, material publication history, digital database services and legacy web resources.

- Past clients include Alston & Bird, Arnold & Porter, Baker Botts, Fish & Richardson, Erise IP, Irell & Manella, O'Melveny & Myers, Perkins-Coie, Pillsbury Winthrop Shaw Pittman and Slayden Grubert Beard.

Library Director, February 2013 - March 2015
Dowagiac District Library ● Dowagiac, Michigan

- Executive administrator of the Dowagiac District Library. Located in Southwest Michigan, this library has a service area of 13,000, an annual operating budget of over $400,000 and total assets of approximately $1,300,000.

● Developed careful budgeting guidelines to produce a 15% surplus during the 2013-2014 & 2014-2015 fiscal years while being audited.

● Using this budget surplus, oversaw significant library investments including the purchase of property for a future building site, demolition of existing buildings and building renovation projects on the current facility.

● Led the organization and digitization of the library's archival records.

● Served as the public representative for the library, developing business relationships with local school, museum and tribal government entities.

● Developed an objective-based analysis system for measuring library services - including a full collection analysis of the library's 50,000+ circulating items and their records.

November 2010 - January 2013
Librarian & Branch Manager, Anchorage Public Library ● Anchorage, Alaska

● Headed the 2013 Anchorage Reads community reading campaign including event planning, staging public performances and creating marketing materials for mass distribution.

● Co-led the social media department of the library's marketing team, drafting social media guidelines, creating original content and instituting long-term planning via content calendars.

● Developed business relationships with The Boys & Girls Club, Anchorage School District and the US Army to establish summer reading programs for children.

June 2004 - September 2005, September 2006 - October 2013
Library Assistant, Hart Area Public Library
Hart, MI

● Responsible for verifying imported MARC records and original MARC cataloging for the local-level collection as well as the Michigan Electronic Library.

● Handled OCLC Worldcat interlibrary loan requests & fulfillment via ongoing communication with lending libraries.

Professional Involvement

Alaska Library Association - Anchorage Chapter

● Treasurer, 2012

Library Of Michigan
● Level VII Certification, 2008
● Level II Certification, 2013

Michigan Library Association Annual Conference 2014
● New Directors Conference Panel Member

Southwest Michigan Library Cooperative
● Represented the Dowagiac District Library, 2013-2015

Professional Development

Library Of Michigan Beginning Workshop, May 2008
Petoskey, MI
● Received training in cataloging, local history, collection management, children's literacy and reference service.

Public Library Association Intensive Library Management Training, October 2011
Nashville, TN
● Attended a five-day workshop focused on strategic planning, staff management, statistical analysis, collections and cataloging theory.

Alaska Library Association Annual Conference 2012 - Fairbanks, February 2012
Fairbanks, AK
● Attended seminars on EBSCO advanced search methods, budgeting, cataloging, database usage and marketing.

Depositions

2019 ● Fish & Richardson

Apple v. Qualcomm (Case No. IPR2018-001281, 39521-00421IP, IPR2018-01282 and 39521-00421IP2)

2019 ● Erise IP

Implicit, LLC v. Netscout Systems, Inc (Case No. 2:18-cv-53-JRG)

2019 ● Perkins-Coie

Adobe Inc. v. RAH Color Technologies LLC (Case No. IPR2019-00627, IPR2019-00628, IPR2019-00629 and IPR2019-00646)

2020 ● O'Melveny & Myers

Maxell, Ltd. v. Apple Inc. (Case No. 5:19-cv-00036-RWS)

2021 ● Pillsbury Winthrop Shaw Pittman LLP

Intel v. SRC (Case No. IPR2020-1449)

2022 ● Perkins-Coie

Realtek v. Future Link (Case No. IPR2021-01182)

2023 ● Fish & Richardson

Neuroderm Ltd. v. Abbvie, Inc (Case No. PGR2022-00040)

2023 ● Fish & Richardson

Nearmap US Inc. v. Pictometry International Corp. (Case No. IPR2022-00735)

2023 ● Fish & Richardson

Samsung Electronics v. MemoryWeb LLC (Case No. 39843-0136PS1)

2023 ● Pillsbury Winthrop Shaw Whitman LLP

Gravel Rating Systems v. Costco Wholesale Corp. (Case No. 4:21-cv-149-ALM)

2024 ● Willkie-Farr

Netflix, Inc. v. VideoLabs. Inc. (Case No. IPR2023-00628)

2024 ● Quinn Emanuel Urquhart & Sullivan

Purdue University v. Wolfspeed (Case No. 1:21-CV-840)

2024 ● Fish & Richardson

Dish Network v. Entropic Communications (Case No. IPR2024-00393)

2025 ● Perkins Coie

Amazon.com, Inc. v. Nokia Technologies Oy (Case No. IPR2024-00572)

2025 ● Fish & Richardson

Dish Network v. Entropic Communications (Case No. IPR2024-00373)

Limited Case and Clientele History

Alston & Bird

- Ericsson

  v. Collision Communications (Case No. IPR2022-01233)

- Nokia

  v. Neptune Subsea, Xtera (Case No. 1:17-cv-01876)

- Universal Electronics Inc

  v. Roku Inc (Case No. IPR2022-00818)

Alavi & Anaipakos PLLC

- Stingray Group Inc. and Stingray Music USA, Inc.

  v. Edwin A. Hernandez-Mondragon and Egla Corp. (Case No. 1:24-cv-21226-RAR)

Arnold & Porter

- Ivantis

  v. Glaukos (Case No. 8:18-cv-00620)

- Samsung

  v. Jawbone (Case No. 2:21-cv-00186)

Benesch Friedlander Coplan & Aronoff

- Voyis

  v. Cathx (Case No. 5:21-cv-00077-RWS)

Buchanan, Ingersoll & Rooney PC

- Google LLC, AT&T Service Inc., T Mobile USA Inc., Cellco Partnership, Ericsson Inc. & Nokia of America Corp.

  v. KT Corp & Pegasus Wireless Innovation LLC (Case No. IPR2025-00293)

Deschert LLP

- Smaxtec Animal Care

  v. ST Reproductive Technologies, LLC (Case No. IPR2024-00885)

Duane Morris

- Kangxi Communication Technologies

  v. Skyworks Solutions Inc. (Case No. IPR2025-00373)

- Microsoft

  v. Edge Networking Systems LLC (Case No. 1:24-cv-00215)

Erise I.P.

- Apple

  v. Ericsson Inc. (Case No. IPR2022-00715)

  v. Future Link Systems (Case No. IPRs 6317804, 6622108, 6807505, and 7917680)

  v. INVT (Case No. 20-1881)

  v. Navblazer LLC (Case No. IPR2020-01253)

  v. Qualcomm (Case No. IPR2018-001281, 39521-00421IP, IPR2018-01282, 39521-00421IP2)

v. Quest Nettech Corp (Case No. 2:19-cv-00118-JRG)

v. Telefonaktiebolaget LM Ericsson (Case No. IPR2022-00275)

v. Theta IP, LLC (Case No. IPR2024-00818)

v. THL Holding Company LLC (Case No. 1:23-cv-00548)

- Fanduel

v. CGT (Case No. 19-1393)

- Garmin

v. Phillips North America LLC (Case No. 2:19-cv-6301-AB-KS)

- Netscout

v. Longhorn HD LLC (Case No. 2:20-cv-00349)

v. Implicit, LLC (Case No. 2:18-cv-53-JRG)

- Sony Interactive Entertainment LLC

v. Bot M8 LLC (Case No. IPR2020-01288)

v. Infernal Technology LLC (Case No. 2:19-CV-00248-JRG)

- Tesla

v. Charge Fusion Technologies LLC (Case No. IPR2025-00032)

- Unified Patents

v. GE Video Compression (Case No. 2:19-cv-248)

Fish & Richardson

- Apple

v. AliveCor (Case No. 3:21-cv-03958)

v. LBS Innovations (Case No. 2:19-cv-00119-JRG-RSP)

v. Koss Corporation (Case No. IPR2021-00305)

v. Masimo (Case No. IPR 50095-0012IP1, 50095-0012IP2, 50095-0013IP1, 50095-0013IP2, 50095-0006IP1, 50095-0135IP1)

v. Neonode (Case No. 21-cv-08872-EMC)

v. Qualcomm (Case No. IPR2018-001281, 39521-00421IP, IPR2018-01282, 39521-00421IP2)

v. Resonant Sys. (Case No. 7:23-cv-00077-ADA)

- AsusTek Computer Inc.
  v. Videolabs, Inc. (Case No. 22-CV-00720-ADA)

- Dell
  v. Neo Wireless (Case No. IPR2022-00616)

- Dish Network

  v. Entropic Communications, LLC (Case No. 2:2023-CV-01043)

  v. Entropic Communications LLC (Case No. IPR2024-00393)

  v. Realtime Adaptive Streaming (Case No. 1:17-CV-02097-RBJ)

  v. TQ Delta LLC (Case No. 18-1798)

- Evapco Dry Cooling

  v. SPG Dry Cooling (Case No. IPR2021-00688)

- Genetec

  v. Sensormatic Electronics (Case No. 1:20-CV-00760)

- Huawei

  v. Bell Northern Research LLC (Case No. IPR2019-01174)

- Kianxis

  v. Blue Yonder (Case No. 3:20-cv-03636)

- LG Electronics

  v. Bell Northern Research LLC (Case No. 3:18-cv-2864-CAB-BLM)

- MediaTek

  v. MOSAID (Case No. IPR2024-00718)

- Metaswitch

  v. Sonus Networks (Case No. IPR2018-01719)

- Microsoft

  v. Throughputer Inc (Case No. IPR2022-00757)

- Mom Enterprises

  v. Ddrops Company (Case No. 1:22-cv-00332)

- MLC Intellectual Property

  v. MicronTech (Case No. 3:14-cv-03657-SI)

- Nearmap Inc

  v. EagleView Technologies (Case No. IPR2022-01009)

- Neuroderm Ltd.

  v. Abbvie, Inc (Case No. PGR2022-00040)

- Posco Co Ltd.

  v. Pascal Drillet et al. (Case No. IPR2025-00370)

- Realtek Semiconductor

  v. Future Link (Case No. IPR2021-01182)

- Quectel
  - v. Koninklijke Philips (Case No. 1:20-cv-01710)

- Samsung
  - v. Aire Technology (Case No. IPR2022-00877)
  - v. Bell Northern Research (Case No. 2:19-cv-00286-JRG)
  - v. Communication Technologies Inc (Case No. IPR2022-01221)
  - v. Jawbone Innovations (Case No. IPR2022-00865)
  - v. MemoryWeb LLC (Case No. IPR2022-00885)
  - v. Dodots Licensing Solutions (Case No. IPR2023-00701)
  - v. Telefonaktiebolaget LM Ericsson (Case No. IPR2021-00615)

- Texas Instruments
  - v. Vantage Micro LLC (Case No. IPR2020-01261)

- Xilinx
  - v. Sentient Sensors LCC (Case No. 1:22-cv-00173)

Goodwin Proctor

- Intel
  - v. Proxense, LLC (Case No. 6:24-cv-00283)

- Samsung Electronics
  - v. Mobile Data Technologies (Case No. 2:24-cv-00435)

- Taiwan Semiconductor Manufacturing Company Ltd.
  - v. Advanced Integrated Circuit Process LLC (Case No. 2:24-cv-00623)

Groombridge Wu

- Nearmap

  v. Eagle View Technologies Inc. and Pictometry International Corp. (Case No. 2:21-cv-00283-TS-DAO)

Irell & Manella

- Curium

Latham & Watkins LLP

- Apple

  v. Advanced Coding Research LLC

Leydig, Voit & Mayer, Ltd.

- Public Availability Consultancy

O'Melveny & Myers

- Apple

  v. Maxell (Case No. 5:19-cv-00036-RWS)

- Disney Media & Entertainment Distribution LLC

  v. Digital Media Technology Holdings, LLC (Case No. 2:22-cv-01642)

- Micron Technology Inc.

  v. Besang Inc (Case No. IPR2023-00900)

- Samsung

  v. Daedalus Prime LLC (1335 Investigation)

Perkins-Coie

- Amazon
  - v. Nokia (Case No. IPR2024-00847 and IPR2024-00848)
  - v. Nokia Technologies Oy (Case No. IPR2024-00572)
- Heru Industries
  - v. The UAB Research Foundation (Case No. IPR2022-01148)
- Intel Corporation
  - v. BeSang Inc. (Case No. IPR2023-00991)
  - v. BitMICRO (Case No. 5:23-cv-00625)
  - v. Telefonaktiebolaget L M Ericsson (Case No. IPR2024-00610)
- Realtek Semiconductor
  - v. Future Link (Case No. IPR2021-01182)
- r-pac
  - v. Adasa, Inc. (Case No. 1:2024cv06102)
- Twitter Inc
  - v. VOIP-Pal.com (Case No. 3:20-cv-02397-JD)
- TCL Industries
  - v. Koninklijke Philips NV (Case No. IPR2021-00495, IPR2021-00496 and IPR2021-00497)
- VusionGroup
  - v. Hanshow (Case No. IPR2024-00857)

Pillsbury Winthrop Shaw Pittman

- Intel

  v. FG SRC LLC (Case No. 6:20-cv-00315)

- Gravel Rating Systems

  v. Costco (Case No. 4:21-cv-149)
  v. Lowe's Home Centers (Case No. 4:21-cv-150)
  v. T-Mobile USA (Case No. 4:21-cv-152)
  v. Kohl's Inc. (Case No. 4:21-cv-258)
  v. Under Armor (Case No. 4:21-cv-356)

Quinn Emanuel

- Exact Sciences Corporation

  v. Geneoscopy, Inc. (Case No. IPR2024-00459 and IPR2024-1330)

- ServiceNow, Inc.

  v. InQuisient, Inc. (Case No. 22-900-CJB)

- Wolfspeed

  v. The Trustees of Purdue University (Case No. 1:2021-cv-00840)

Sheppard, Mullin, Richter & Hampton LLP

- Advanced Micro Devices, Inc and Pensando Systems, Inc.

  v. Concurrent Ventures LLC and Xtreamedge, Inc. (Case No. IPR2025-00478)

- Cadence Design Systems Inc.

  v. Semiconductor Design Technologies (Case No. 3:23-cv-01001)

Shook, Hardy & Bacon LLP

- HP Inc.

  v. Universal Connectivity Technologies (Case No. 1:23-cv-01177)

Stern, Kessler, Goldstein & Fox

- Preliminary Research

Wilmer, Cutler, Pickering, Hale and Dorr

- Apple

  v. Shunock (Case No. 1:23-cv-08598)

- Quest Diagnostics Inc., Haystack Oncology Inc. and Haystack Oncology GmbH

  v. Natera, Inc. (Case No. 1:23-cv-08598)

- Roche Diabetes, Inc.

  v. Trividia Health, Inc. (Case No. 1:24-cv-00668)

Willkie, Farr & Gallagher LLP

- Lenovo, Dell, HP

  v. Universal Connectivity Technologies Inc. (Case No. 2:2023cv00449)

- Neurent

  v. The Foundry, LLC (Case No. IPR2024-00669)

- Netflix, Inc.

  v. VideoLabs, Inc. (Case No. IPR2023-00628)

APPENDIX H26401



H.264 : Advanced video coding for generic audiovisual services

Recommendation H.264 (11/07)

Table of Contents

Summary

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International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

H.264

(11/2007)

SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Infrastructure of audiovisual services – Coding of moving video

Advanced video coding for generic audiovisual services

ITU-T Recommendation H.264

ITU-T H-SERIES RECOMMENDATIONS

AUDIOVISUAL AND MULTIMEDIA SYSTEMS

CHARACTERISTICS OF VISUAL TELEPHONE SYSTEMS	H.100–H.199
INFRASTRUCTURE OF AUDIOVISUAL SERVICES	
General	H.200–H.219
Transmission multiplexing and synchronization	H.220–H.229
Systems aspects	H.230–H.239
Communication procedures	H.240–H.259
Coding of moving video	**H.260–H.279**
Related systems aspects	H.280–H.299
Systems and terminal equipment for audiovisual services	H.300–H.349
Directory services architecture for audiovisual and multimedia services	H.350–H.359
Quality of service architecture for audiovisual and multimedia services	H.360–H.369
Supplementary services for multimedia	H.450–H.499
MOBILITY AND COLLABORATION PROCEDURES	
Overview of Mobility and Collaboration, definitions, protocols and procedures	H.500–H.509
Mobility for H-Series multimedia systems and services	H.510–H.519
Mobile multimedia collaboration applications and services	H.520–H.529
Security for mobile multimedia systems and services	H.530–H.539
Security for mobile multimedia collaboration applications and services	H.540–H.549
Mobility interworking procedures	H.550–H.559
Mobile multimedia collaboration inter-working procedures	H.560–H.569
BROADBAND AND TRIPLE-PLAY MULTIMEDIA SERVICES	
Broadband multimedia services over VDSL	H.610–H.619

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation H.264

Advanced video coding for generic audiovisual services

Summary

This Recommendation | International Standard represents an evolution of the existing video coding standards (H.261, H.262, and H.263) and it was developed in response to the growing need for higher compression of moving pictures for various applications such as videoconferencing, digital storage media, television broadcasting, Internet streaming, and communication. It is also designed to enable the use of the coded video representation in a flexible manner for a wide variety of network environments. The use of this Recommendation | International Standard allows motion video to be manipulated as a form of computer data and to be stored on various storage media, transmitted and received over existing and future networks and distributed on existing and future broadcasting channels.

The revision approved 2005-03 contained modifications of the video coding standard to add four new profiles, referred to as the High, High 10, High 4:2:2, and High 4:4:4 profiles, to improve video quality capability and to extend the range of applications addressed by the standard (for example, by including support for a greater range of picture sample precision and higher-resolution chroma formats). Additionally, a definition of new types of supplemental data was specified to further broaden the applicability of the video coding standard. Finally, a number of corrections to errors in the published text were included.

Corrigendum 1 to ITU-T Rec. H.264 corrected and updated various minor aspects to bring the ITU-T version of the text up to date relative to the April 2005 output status approved as a new edition of the corresponding jointly-developed and technically-aligned text ISO/IEC 14496-10. It additionally fixed a number of minor errors and needs for clarification and defined three previously-reserved sample aspect ratio indicators.

Amendment 1 "Support of additional colour spaces and removal of the High 4:4:4 Profile" contained alterations to ITU-T Rec. H.264 | ISO/IEC 14496-10 Advanced Video Coding to specify the support of additional colour spaces and to remove the definition of the High 4:4:4 Profile.

NOTE – ITU-T Rec. H.264 is a twin text with ISO/IEC 14496-10 and this amendment is published in two different documents in the ISO/IEC series:

- The removal of the High 4:4:4 profile is found in ISO/IEC 14496-10:2005/Cor.2.
- The specification for support of additional colour space will be found in ISO/IEC 14496-10:2005/Amd.1.

Amendment 2 "New profiles for professional applications" contained extensions to ITU-T Rec. H.264 | ISO/IEC 14496-10 Advanced Video Coding to specify the support of five additional profiles intended primarily for professional applications (the High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, CAVLC 4:4:4 Intra, and High 4:4:4 Predictive profiles) and two new types of supplemental enhancement information (SEI) messages (the post-filter hint SEI message and the tone mapping information SEI message).

Amendment 3 "Scalable video coding" contained extensions to ITU-T Rec. H.264 | ISO/IEC 14496-10 Advanced Video Coding to specify a scalable video coding extension in three profiles (the Scalable Baseline, Scalable High, and Scalable High Intra profiles).

The H.264 edition published in 2005-11 included the text approved 2005-03 and its Corrigendum 1 approved 2005-09. H.264 (2005) Amd.2 (2007) was available only as pre-published text since it was superseded by H.264 Amd.3 (11/2007) before its publication; further, H.264 Amd.3 was not published separately. This third edition integrates into the H.264 edition published in 2005-11 all changes approved in Amendments 1 (2006-06), 2 (2007-04) and 3 (2007-11).

Source

ITU-T Recommendation H.264 was approved on 22 November 2007 by ITU-T Study Group 16 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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CONTENTS

Page

Foreword ..... **xix**

0 Introduction **1**
0.1 Prologue *1*
0.2 Purpose *1*
0.3 Applications *1*
0.4 Publication and versions of this specification *1*
0.5 Profiles and levels *2*
0.6 Overview of the design characteristics *3*
0.6.1 Predictive coding 3
0.6.2 Coding of progressive and interlaced video 3
0.6.3 Picture partitioning into macroblocks and smaller partitions 3
0.6.4 Spatial redundancy reduction 4
0.7 How to read this specification *4*

1 Scope **4**

2 Normative references **4**

3 Definitions **5**

4 Abbreviations **13**

5 Conventions **13**
5.1 Arithmetic operators *13*
5.2 Logical operators *14*
5.3 Relational operators *14*
5.4 Bit-wise operators *14*
5.5 Assignment operators *15*
5.6 Range notation *15*
5.7 Mathematical functions *15*
5.8 Variables, syntax elements, and tables *16*
5.9 Text description of logical operations *17*
5.10 Processes *18*

6 Source, coded, decoded and output data formats, scanning processes, and neighbouring relationships **18**
6.1 Bitstream formats *18*
6.2 Source, decoded, and output picture formats *18*
6.3 Spatial subdivision of pictures and slices *23*
6.4 Inverse scanning processes and derivation processes for neighbours *24*
6.4.1 Inverse macroblock scanning process 24
6.4.2 Inverse macroblock partition and sub-macroblock partition scanning process 25
6.4.2.1 Inverse macroblock partition scanning process 26
6.4.2.2 Inverse sub-macroblock partition scanning process 26
6.4.3 Inverse 4x4 luma block scanning process 27
6.4.4 Inverse 4x4 Cb or Cr block scanning process for ChromaArrayType equal to 3 27
6.4.5 Inverse 8x8 luma block scanning process 27
6.4.6 Inverse 8x8 Cb or Cr block scanning process for ChromaArrayType equal to 3 28
6.4.7 Derivation process of the availability for macroblock addresses 28
6.4.8 Derivation process for neighbouring macroblock addresses and their availability 28
6.4.9 Derivation process for neighbouring macroblock addresses and their availability in MBAFF frames 29
6.4.10 Derivation processes for neighbouring macroblocks, blocks, and partitions 29
6.4.10.1 Derivation process for neighbouring macroblocks 30
6.4.10.2 Derivation process for neighbouring 8x8 luma block 30
6.4.10.3 Derivation process for neighbouring 8x8 chroma blocks for ChromaArrayType equal to 3 31
6.4.10.4 Derivation process for neighbouring 4x4 luma blocks 31
6.4.10.5 Derivation process for neighbouring 4x4 chroma blocks 32
6.4.10.6 Derivation process for neighbouring 4x4 chroma blocks for ChromaArrayType equal to 3 32
6.4.10.7 Derivation process for neighbouring partitions 32
6.4.11 Derivation process for neighbouring locations 34
6.4.11.1 Specification for neighbouring locations in fields and non-MBAFF frames 34
6.4.11.2 Specification for neighbouring locations in MBAFF frames 35

7 Syntax and semantics **37**
7.1 Method of specifying syntax in tabular form *37*
7.2 Specification of syntax functions, categories, and descriptors *38*

7.3 Syntax in tabular form *39*
7.3.1 NAL unit syntax 39
7.3.2 Raw byte sequence payloads and RBSP trailing bits syntax 39
7.3.2.1 Sequence parameter set RBSP syntax 39
7.3.2.1.1 Sequence parameter set data syntax 40
7.3.2.1.1.1 Scaling list syntax 41
7.3.2.1.2 Sequence parameter set extension RBSP syntax 41
7.3.2.2 Picture parameter set RBSP syntax 42
7.3.2.3 Supplemental enhancement information RBSP syntax 43
7.3.2.3.1 Supplemental enhancement information message syntax 43
7.3.2.4 Access unit delimiter RBSP syntax 43
7.3.2.5 End of sequence RBSP syntax 44
7.3.2.6 End of stream RBSP syntax 44
7.3.2.7 Filler data RBSP syntax 44
7.3.2.8 Slice layer without partitioning RBSP syntax 44
7.3.2.9 Slice data partition RBSP syntax 44
7.3.2.9.1 Slice data partition A RBSP syntax 44
7.3.2.9.2 Slice data partition B RBSP syntax 45
7.3.2.9.3 Slice data partition C RBSP syntax 45
7.3.2.10 RBSP slice trailing bits syntax 45
7.3.2.11 RBSP trailing bits syntax 45
7.3.3 Slice header syntax 46
7.3.3.1 Reference picture list reordering syntax 47
7.3.3.2 Prediction weight table syntax 48
7.3.3.3 Decoded reference picture marking syntax 49
7.3.4 Slice data syntax 50
7.3.5 Macroblock layer syntax 51
7.3.5.1 Macroblock prediction syntax 52
7.3.5.2 Sub-macroblock prediction syntax 53
7.3.5.3 Residual data syntax 54
7.3.5.3.1 Residual luma syntax 55
7.3.5.3.2 Residual block CAVLC syntax 56
7.3.5.3.3 Residual block CABAC syntax 57
7.4 Semantics *58*
7.4.1 NAL unit semantics 58
7.4.1.1 Encapsulation of an SODB within an RBSP (informative) 61
7.4.1.2 Order of NAL units and association to coded pictures, access units, and video sequences 61
7.4.1.2.1 Order of sequence and picture parameter set RBSPs and their activation 61
7.4.1.2.2 Order of access units and association to coded video sequences 62
7.4.1.2.3 Order of NAL units and coded pictures and association to access units 63
7.4.1.2.4 Detection of the first VCL NAL unit of a primary coded picture 65
7.4.1.2.5 Order of VCL NAL units and association to coded pictures 65
7.4.2 Raw byte sequence payloads and RBSP trailing bits semantics 66
7.4.2.1 Sequence parameter set RBSP semantics 66
7.4.2.1.1 Sequence parameter set data semantics 66
7.4.2.1.1.1 Scaling list semantics 72
7.4.2.1.2 Sequence parameter set extension RBSP semantics 72
7.4.2.2 Picture parameter set RBSP semantics 74
7.4.2.3 Supplemental enhancement information RBSP semantics 77
7.4.2.3.1 Supplemental enhancement information message semantics 77
7.4.2.4 Access unit delimiter RBSP semantics 77
7.4.2.5 End of sequence RBSP semantics 77
7.4.2.6 End of stream RBSP semantics 77
7.4.2.7 Filler data RBSP semantics 77
7.4.2.8 Slice layer without partitioning RBSP semantics 77
7.4.2.9 Slice data partition RBSP semantics 78
7.4.2.9.1 Slice data partition A RBSP semantics 78
7.4.2.9.2 Slice data partition B RBSP semantics 78
7.4.2.9.3 Slice data partition C RBSP semantics 78
7.4.2.10 RBSP slice trailing bits semantics 79
7.4.2.11 RBSP trailing bits semantics 79
7.4.3 Slice header semantics 79
7.4.3.1 Reference picture list reordering semantics 85

7.4.3.2 Prediction weight table semantics 86
7.4.3.3 Decoded reference picture marking semantics 86
7.4.4 Slice data semantics 89
7.4.5 Macroblock layer semantics 90
7.4.5.1 Macroblock prediction semantics 97
7.4.5.2 Sub-macroblock prediction semantics 97
7.4.5.3 Residual data semantics 100
7.4.5.3.1 Residual luma data semantics 100
7.4.5.3.2 Residual block CAVLC semantics 101
7.4.5.3.3 Residual block CABAC semantics 101
8 Decoding process 102
8.1 NAL unit decoding process 103
8.2 Slice decoding process 104
8.2.1 Decoding process for picture order count 104
8.2.1.1 Decoding process for picture order count type 0 105
8.2.1.2 Decoding process for picture order count type 1 106
8.2.1.3 Decoding process for picture order count type 2 107
8.2.2 Decoding process for macroblock to slice group map 108
8.2.2.1 Specification for interleaved slice group map type 109
8.2.2.2 Specification for dispersed slice group map type 109
8.2.2.3 Specification for foreground with left-over slice group map type 109
8.2.2.4 Specification for box-out slice group map types 110
8.2.2.5 Specification for raster scan slice group map types 110
8.2.2.6 Specification for wipe slice group map types 111
8.2.2.7 Specification for explicit slice group map type 111
8.2.2.8 Specification for conversion of map unit to slice group map to macroblock to slice group map 111
8.2.3 Decoding process for slice data partitioning 111
8.2.4 Decoding process for reference picture lists construction 112
8.2.4.1 Decoding process for picture numbers 112
8.2.4.2 Initialisation process for reference picture lists 113
8.2.4.2.1 Initialisation process for the reference picture list for P and SP slices in frames 114
8.2.4.2.2 Initialisation process for the reference picture list for P and SP slices in fields 114
8.2.4.2.3 Initialisation process for reference picture lists for B slices in frames 115
8.2.4.2.4 Initialisation process for reference picture lists for B slices in fields 115
8.2.4.2.5 Initialisation process for reference picture lists in fields 116
8.2.4.3 Reordering process for reference picture lists 116
8.2.4.3.1 Reordering process of reference picture lists for short-term reference pictures 117
8.2.4.3.2 Reordering process of reference picture lists for long-term reference pictures 118
8.2.5 Decoded reference picture marking process 118
8.2.5.1 Sequence of operations for decoded reference picture marking process 119
8.2.5.2 Decoding process for gaps in frame_num 119
8.2.5.3 Sliding window decoded reference picture marking process 120
8.2.5.4 Adaptive memory control decoded reference picture marking process 120
8.2.5.4.1 Marking process of a short-term reference picture as “unused for reference” 120
8.2.5.4.2 Marking process of a long-term reference picture as “unused for reference” 121
8.2.5.4.3 Assignment process of a LongTermFrameIdx to a short-term reference picture 121
8.2.5.4.4 Decoding process for MaxLongTermFrameIdx 121
8.2.5.4.4.1 Marking process of all reference pictures as “unused for reference” and setting MaxLongTermFrameIdx to “no long-term frame indices” 121
8.2.5.4.5 Process for assigning a long-term frame index to the current picture 122
8.3 Intra prediction process 122
8.3.1 Intra_4x4 prediction process for luma samples 123
8.3.1.1 Derivation process for the Intra4x4PredMode 123
8.3.1.2 Intra_4x4 sample prediction 125
8.3.1.2.1 Specification of Intra_4x4_Vertical prediction mode 126
8.3.1.2.2 Specification of Intra_4x4_Horizontal prediction mode 126
8.3.1.2.3 Specification of Intra_4x4_DC prediction mode 126
8.3.1.2.4 Specification of Intra_4x4_Diagonal_Down_Left prediction mode 127
8.3.1.2.5 Specification of Intra_4x4_Diagonal_Down_Right prediction mode 127
8.3.1.2.6 Specification of Intra_4x4_Vertical_Right prediction mode 127
8.3.1.2.7 Specification of Intra_4x4_Horizontal_Down prediction mode 128
8.3.1.2.8 Specification of Intra_4x4_Vertical_Left prediction mode 128
8.3.1.2.9 Specification of Intra_4x4_Horizontal_Up prediction mode 128

8.3.2 Intra_8x8 prediction process for luma samples 129
8.3.2.1 Derivation process for Intra8x8PredMode 129
8.3.2.2 Intra_8x8 sample prediction 131
8.3.2.2.1 Reference sample filtering process for Intra_8x8 sample prediction 132
8.3.2.2.2 Specification of Intra_8x8_Vertical prediction mode 133
8.3.2.2.3 Specification of Intra_8x8_Horizontal prediction mode 133
8.3.2.2.4 Specification of Intra_8x8_DC prediction mode 133
8.3.2.2.5 Specification of Intra_8x8_Diagonal_Down_Left prediction mode 134
8.3.2.2.6 Specification of Intra_8x8_Diagonal_Down_Right prediction mode 134
8.3.2.2.7 Specification of Intra_8x8_Vertical_Right prediction mode 135
8.3.2.2.8 Specification of Intra_8x8_Horizontal_Down prediction mode 135
8.3.2.2.9 Specification of Intra_8x8_Vertical_Left prediction mode 135
8.3.2.2.10 Specification of Intra_8x8_Horizontal_Up prediction mode 136
8.3.3 Intra_16x16 prediction process for luma samples 136
8.3.3.1 Specification of Intra_16x16_Vertical prediction mode 137
8.3.3.2 Specification of Intra_16x16_Horizontal prediction mode 137
8.3.3.3 Specification of Intra_16x16_DC prediction mode 137
8.3.3.4 Specification of Intra_16x16_Plane prediction mode 138
8.3.4 Intra prediction process for chroma samples 138
8.3.4.1 Specification of Intra_Chroma_DC prediction mode 140
8.3.4.2 Specification of Intra_Chroma_Horizontal prediction mode 141
8.3.4.3 Specification of Intra_Chroma_Vertical prediction mode 141
8.3.4.4 Specification of Intra_Chroma_Plane prediction mode 142
8.3.4.5 Intra prediction for chroma samples with ChromaArrayType equal to 3 142
8.3.5 Sample construction process for I_PCM macroblocks 143
8.4 Inter prediction process 143
8.4.1 Derivation process for motion vector components and reference indices 146
8.4.1.1 Derivation process for luma motion vectors for skipped macroblocks in P and SP slices 147
8.4.1.2 Derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8 147
8.4.1.2.1 Derivation process for the co-located 4x4 sub-macroblock partitions 148
8.4.1.2.2 Derivation process for spatial direct luma motion vector and reference index prediction mode . 151
8.4.1.2.3 Derivation process for temporal direct luma motion vector and reference index prediction mode 152
8.4.1.3 Derivation process for luma motion vector prediction 155
8.4.1.3.1 Derivation process for median luma motion vector prediction 156
8.4.1.3.2 Derivation process for motion data of neighbouring partitions 157
8.4.1.4 Derivation process for chroma motion vectors 158
8.4.2 Decoding process for Inter prediction samples 158
8.4.2.1 Reference picture selection process 159
8.4.2.2 Fractional sample interpolation process 160
8.4.2.2.1 Luma sample interpolation process 162
8.4.2.2.2 Chroma sample interpolation process 164
8.4.2.3 Weighted sample prediction process 165
8.4.2.3.1 Default weighted sample prediction process 166
8.4.2.3.2 Weighted sample prediction process 166
8.4.3 Derivation process for prediction weights 167
8.5 Transform coefficient decoding process and picture construction process prior to deblocking filter process. 169
8.5.1 Specification of transform decoding process for 4x4 luma residual blocks 169
8.5.2 Specification of transform decoding process for luma samples of Intra_16x16 macroblock prediction mode 170
8.5.3 Specification of transform decoding process for 8x8 luma residual blocks 171
8.5.4 Specification of transform decoding process for chroma samples 171
8.5.5 Specification of transform decoding process for chroma samples with ChromaArrayType equal to 3 .. 173
8.5.6 Inverse scanning process for transform coefficients 174
8.5.7 Inverse scanning process for 8x8 transform coefficients 174
8.5.8 Derivation process for the chroma quantisation parameters and scaling function 176
8.5.9 Scaling and transformation process for DC transform coefficients for Intra_16x16 macroblock type ... 178
8.5.10 Scaling and transformation process for chroma DC transform coefficients 179
8.5.10.1 Transformation process for chroma DC transform coefficients 179
8.5.10.2 Scaling process for chroma DC transform coefficients 179
8.5.11 Scaling and transformation process for residual 4x4 blocks 180
8.5.11.1 Scaling process for residual 4x4 blocks 181
8.5.11.2 Transformation process for residual 4x4 blocks 182

8.5.12 Scaling and transformation process for residual 8x8 blocks 183
8.5.12.1 Scaling process for residual 8x8 blocks 183
8.5.12.2 Transformation process for residual 8x8 blocks 184
8.5.13 Picture construction process prior to deblocking filter process 187
8.5.14 Intra residual transform-bypass decoding process 188
8.6 Decoding process for P macroblocks in SP slices or SI macroblocks 189
8.6.1 SP decoding process for non-switching pictures 189
8.6.1.1 Luma transform coefficient decoding process 189
8.6.1.2 Chroma transform coefficient decoding process 190
8.6.2 SP and SI slice decoding process for switching pictures 192
8.6.2.1 Luma transform coefficient decoding process 192
8.6.2.2 Chroma transform coefficient decoding process 192
8.7 Deblocking filter process 193
8.7.1 Filtering process for block edges 197
8.7.2 Filtering process for a set of samples across a horizontal or vertical block edge 199
8.7.2.1 Derivation process for the luma content dependent boundary filtering strength 200
8.7.2.2 Derivation process for the thresholds for each block edge 201
8.7.2.3 Filtering process for edges with bS less than 4 202
8.7.2.4 Filtering process for edges for bS equal to 4 204
9 Parsing process 205
9.1 Parsing process for Exp-Golomb codes 205
9.1.1 Mapping process for signed Exp-Golomb codes 207
9.1.2 Mapping process for coded block pattern 207
9.2 CAVLC parsing process for transform coefficient levels 210
9.2.1 Parsing process for total number of transform coefficient levels and trailing ones 210
9.2.2 Parsing process for level information 213
9.2.2.1 Parsing process for level_prefix 214
9.2.3 Parsing process for run information 215
9.2.4 Combining level and run information 218
9.3 CABAC parsing process for slice data 218
9.3.1 Initialisation process 219
9.3.1.1 Initialisation process for context variables 220
9.3.1.2 Initialisation process for the arithmetic decoding engine 242
9.3.2 Binarization process 242
9.3.2.1 Unary (U) binarization process 245
9.3.2.2 Truncated unary (TU) binarization process 246
9.3.2.3 Concatenated unary/ k-th order Exp-Golomb (UEGk) binarization process 246
9.3.2.4 Fixed-length (FL) binarization process 247
9.3.2.5 Binarization process for macroblock type and sub-macroblock type 247
9.3.2.6 Binarization process for coded block pattern 250
9.3.2.7 Binarization process for mb_qp_delta 250
9.3.3 Decoding process flow 250
9.3.3.1 Derivation process for ctxIdx 251
9.3.3.1.1 Assignment process of ctxIdxInc using neighbouring syntax elements 253
9.3.3.1.1.1 Derivation process of ctxIdxInc for the syntax element mb_skip_flag 253
9.3.3.1.1.2 Derivation process of ctxIdxInc for the syntax element mb_field_decoding_flag 253
9.3.3.1.1.3 Derivation process of ctxIdxInc for the syntax element mb_type 254
9.3.3.1.1.4 Derivation process of ctxIdxInc for the syntax element coded_block_pattern 254
9.3.3.1.1.5 Derivation process of ctxIdxInc for the syntax element mb_qp_delta 255
9.3.3.1.1.6 Derivation process of ctxIdxInc for the syntax elements ref_idx_l0 and ref_idx_l1 255
9.3.3.1.1.7 Derivation process of ctxIdxInc for the syntax elements mvd_l0 and mvd_l1 256
9.3.3.1.1.8 Derivation process of ctxIdxInc for the syntax element intra_chroma_pred_mode 257
9.3.3.1.1.9 Derivation process of ctxIdxInc for the syntax element coded_block_flag 258
9.3.3.1.1.10 Derivation process of ctxIdxInc for the syntax element transform_size_8x8_flag 261
9.3.3.1.2 Assignment process of ctxIdxInc using prior decoded bin values 261
9.3.3.1.3 Assignment process of ctxIdxInc for syntax elements significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1 261
9.3.3.2 Arithmetic decoding process 264
9.3.3.2.1 Arithmetic decoding process for a binary decision 265
9.3.3.2.1.1 State transition process 266
9.3.3.2.2 Renormalization process in the arithmetic decoding engine 268
9.3.3.2.3 Bypass decoding process for binary decisions 269
9.3.3.2.4 Decoding process for binary decisions before termination 269

9.3.4 Arithmetic encoding process (informative) 270
9.3.4.1 Initialisation process for the arithmetic encoding engine (informative) 270
9.3.4.2 Encoding process for a binary decision (informative) 270
9.3.4.3 Renormalization process in the arithmetic encoding engine (informative) 271
9.3.4.4 Bypass encoding process for binary decisions (informative) 273
9.3.4.5 Encoding process for a binary decision before termination (informative) 273
9.3.4.6 Byte stuffing process (informative) 274
Annex A Profiles and levels 276
A.1 Requirements on video decoder capability 276
A.2 Profiles 276
A.2.1 Baseline profile 276
A.2.2 Main profile 277
A.2.3 Extended profile 277
A.2.4 High profile 277
A.2.5 High 10 profile 278
A.2.6 High 4:2:2 profile 278
A.2.7 High 4:4:4 Predictive profile 279
A.2.8 High 10 Intra profile 279
A.2.9 High 4:2:2 Intra profile 280
A.2.10 High 4:4:4 Intra profile 280
A.2.11 CAVLC 4:4:4 Intra profile 281
A.3 Levels 281
A.3.1 Level limits common to the Baseline, Main, and Extended profiles 281
A.3.2 Level limits common to the High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles 283
A.3.3 Profile-specific level limits 284
A.3.3.1 Baseline profile level limits 286
A.3.3.2 Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profile level limits 286
A.3.3.3 Extended Profile level limits 287
A.3.4 Effect of level limits on frame rate (informative) 288
Annex B Byte stream format 291
B.1 Byte stream NAL unit syntax and semantics 291
B.1.1 Byte stream NAL unit syntax 291
B.1.2 Byte stream NAL unit semantics 291
B.2 Byte stream NAL unit decoding process 291
B.3 Decoder byte-alignment recovery (informative) 292
Annex C Hypothetical reference decoder 293
C.1 Operation of coded picture buffer (CPB) 295
C.1.1 Timing of bitstream arrival 295
C.1.2 Timing of coded picture removal 296
C.2 Operation of the decoded picture buffer (DPB) 297
C.2.1 Decoding of gaps in frame_num and storage of "non-existing" frames 297
C.2.2 Picture decoding and output 297
C.2.3 Removal of pictures from the DPB before possible insertion of the current picture 298
C.2.4 Current decoded picture marking and storage 298
C.2.4.1 Marking and storage of a reference decoded picture into the DPB 298
C.2.4.2 Storage of a non-reference picture into the DPB 299
C.3 Bitstream conformance 299
C.4 Decoder conformance 300
C.4.1 Operation of the output order DPB 301
C.4.2 Decoding of gaps in frame_num and storage of "non-existing" pictures 301
C.4.3 Picture decoding 301
C.4.4 Removal of pictures from the DPB before possible insertion of the current picture 302
C.4.5 Current decoded picture marking and storage 302
C.4.5.1 Storage and marking of a reference decoded picture into the DPB 302
C.4.5.2 Storage and marking of a non-reference decoded picture into the DPB 303
C.4.5.3 "Bumping" process 303
Annex D Supplemental enhancement information 305
D.1 SEI payload syntax 305
D.1.1 Buffering period SEI message syntax 307
D.1.2 Picture timing SEI message syntax 307

D.1.3 Pan-scan rectangle SEI message syntax 308
D.1.4 Filler payload SEI message syntax 308
D.1.5 User data registered by ITU-T Rec. T.35 SEI message syntax 309
D.1.6 User data unregistered SEI message syntax 309
D.1.7 Recovery point SEI message syntax 309
D.1.8 Decoded reference picture marking repetition SEI message syntax 309
D.1.9 Spare picture SEI message syntax 310
D.1.10 Scene information SEI message syntax 310
D.1.11 Sub-sequence information SEI message syntax 311
D.1.12 Sub-sequence layer characteristics SEI message syntax 311
D.1.13 Sub-sequence characteristics SEI message syntax 311
D.1.14 Full-frame freeze SEI message syntax 312
D.1.15 Full-frame freeze release SEI message syntax 312
D.1.16 Full-frame snapshot SEI message syntax 312
D.1.17 Progressive refinement segment start SEI message syntax 312
D.1.18 Progressive refinement segment end SEI message syntax 312
D.1.19 Motion-constrained slice group set SEI message syntax 312
D.1.20 Film grain characteristics SEI message syntax 313
D.1.21 Deblocking filter display preference SEI message syntax 313
D.1.22 Stereo video information SEI message syntax 314
D.1.23 Post-filter hint SEI message syntax 314
D.1.24 Tone mapping information SEI message syntax 315
D.1.25 Reserved SEI message syntax 315
D.2 SEI payload semantics 315
D.2.1 Buffering period SEI message semantics 315
D.2.2 Picture timing SEI message semantics 316
D.2.3 Pan-scan rectangle SEI message semantics 319
D.2.4 Filler payload SEI message semantics 321
D.2.5 User data registered by ITU-T Rec. T.35 SEI message semantics 321
D.2.6 User data unregistered SEI message semantics 321
D.2.7 Recovery point SEI message semantics 321
D.2.8 Decoded reference picture marking repetition SEI message semantics 323
D.2.9 Spare picture SEI message semantics 323
D.2.10 Scene information SEI message semantics 324
D.2.11 Sub-sequence information SEI message semantics 326
D.2.12 Sub-sequence layer characteristics SEI message semantics 328
D.2.13 Sub-sequence characteristics SEI message semantics 328
D.2.14 Full-frame freeze SEI message semantics 330
D.2.15 Full-frame freeze release SEI message semantics 330
D.2.16 Full-frame snapshot SEI message semantics 330
D.2.17 Progressive refinement segment start SEI message semantics 331
D.2.18 Progressive refinement segment end SEI message semantics 331
D.2.19 Motion-constrained slice group set SEI message semantics 331
D.2.20 Film grain characteristics SEI message semantics 332
D.2.21 Deblocking filter display preference SEI message semantics 338
D.2.22 Stereo video information SEI message semantics 339
D.2.23 Post-filter hint SEI message semantics 340
D.2.24 Tone mapping information SEI message semantics 341
D.2.25 Reserved SEI message semantics 343
Annex E Video usability information 344
E.1 VUI syntax 344
E.1.1 VUI parameters syntax 344
E.1.2 HRD parameters syntax 345
E.2 VUI semantics 346
E.2.1 VUI parameters semantics 346
E.2.2 HRD parameters semantics 357
Annex G Scalable video coding 359
G.1 Scope 359
G.2 Normative References 359
G.3 Definitions 359
G.4 Abbreviations 363
G.5 Conventions 363

G.6 Source, coded, decoded and output data formats, scanning processes, neighbouring and reference layer relationships *363*
G.6.1 Derivation process for reference layer macroblocks 363
G.6.1.1 Field-to-frame reference layer macroblock conversion process 365
G.6.1.2 Frame-to-field reference layer macroblock conversion process 366
G.6.2 Derivation process for reference layer partitions 366
G.6.3 Derivation process for reference layer sample locations in resampling 367
G.7 Syntax and semantics *369*
G.7.1 Method of specifying syntax in tabular form 369
G.7.2 Specification of syntax functions, categories, and descriptors 369
G.7.3 Syntax in tabular form 370
G.7.3.1 NAL unit syntax 370
G.7.3.1.1 NAL unit header SVC extension syntax 370
G.7.3.2 Raw byte sequence payloads and RBSP trailing bits syntax 370
G.7.3.2.1 Sequence parameter set RBSP syntax 370
G.7.3.2.1.1 Sequence parameter set data syntax 370
G.7.3.2.1.2 Sequence parameter set extension RBSP syntax 370
G.7.3.2.1.3 Subset sequence parameter set RBSP syntax 371
G.7.3.2.1.4 Sequence parameter set SVC extension syntax 371
G.7.3.2.2 Picture parameter set RBSP syntax 371
G.7.3.2.3 Supplemental enhancement information RBSP syntax 372
G.7.3.2.3.1 Supplemental enhancement information message syntax 372
G.7.3.2.4 Access unit delimiter RBSP syntax 372
G.7.3.2.5 End of sequence RBSP syntax 372
G.7.3.2.6 End of stream RBSP syntax 372
G.7.3.2.7 Filler data RBSP syntax 372
G.7.3.2.8 Slice layer without partitioning RBSP syntax 372
G.7.3.2.9 Slice data partition RBSP syntax 372
G.7.3.2.10 RBSP slice trailing bits syntax 372
G.7.3.2.11 RBSP trailing bits syntax 372
G.7.3.2.12 Prefix NAL unit RBSP syntax 372
G.7.3.2.13 Slice layer in scalable extension RBSP syntax 373
G.7.3.3 Slice header syntax 373
G.7.3.3.1 Reference picture list reordering syntax 373
G.7.3.3.2 Prediction weight table syntax 373
G.7.3.3.3 Decoded reference picture marking syntax 373
G.7.3.3.4 Slice header in scalable extension syntax 373
G.7.3.3.5 Decoded reference base picture marking syntax 376
G.7.3.4 Slice data syntax 376
G.7.3.4.1 Slice data in scalable extension syntax 376
G.7.3.5 Macroblock layer syntax 377
G.7.3.5.1 Macroblock prediction syntax 377
G.7.3.5.2 Sub-macroblock prediction syntax 377
G.7.3.5.3 Residual data syntax 377
G.7.3.5.3.1 Residual luma syntax 377
G.7.3.5.3.2 Residual block CAVLC syntax 377
G.7.3.5.3.3 Residual block CABAC syntax 377
G.7.3.6 Macroblock layer in scalable extension syntax 377
G.7.3.6.1 Macroblock prediction in scalable extension syntax 379
G.7.3.6.2 Sub-macroblock prediction in scalable extension syntax 380
G.7.4 Semantics 380
G.7.4.1 NAL unit semantics 381
G.7.4.1.1 NAL unit header SVC extension semantics 381
G.7.4.1.2 Order of NAL units and association to coded pictures, access units, and video sequences 382
G.7.4.1.2.1 Order of SVC sequence parameter set RBSPs and picture parameter set RBSPs and their activation 382
G.7.4.1.2.2 Order of access units and association to coded video sequences 386
G.7.4.1.2.3 Order of NAL units and coded pictures and association to access units 387
G.7.4.1.2.4 Detection of the first VCL NAL unit of a primary coded picture 387
G.7.4.1.2.5 Order of VCL NAL units and association to coded pictures 388
G.7.4.2 Raw byte sequence payloads and RBSP trailing bits semantics 388
G.7.4.2.1 Sequence parameter set RBSP semantics 388
G.7.4.2.1.1 Sequence parameter set data semantics 388

G.7.4.2.1.2 Sequence parameter set extension RBSP semantics 389
G.7.4.2.1.3 Subset sequence parameter set RBSP semantics 389
G.7.4.2.1.4 Sequence parameter set SVC extension semantics 389
G.7.4.2.2 Picture parameter set RBSP semantics 391
G.7.4.2.3 Supplemental enhancement information RBSP semantics 391
G.7.4.2.3.1 Supplemental enhancement information message semantics 391
G.7.4.2.4 Access unit delimiter RBSP semantics 391
G.7.4.2.5 End of sequence RBSP semantics 391
G.7.4.2.6 End of stream RBSP semantics 391
G.7.4.2.7 Filler data RBSP semantics 391
G.7.4.2.8 Slice layer without partitioning RBSP semantics 391
G.7.4.2.9 Slice data partition RBSP semantics 391
G.7.4.2.10 RBSP slice trailing bits semantics 391
G.7.4.2.11 RBSP trailing bits semantics 391
G.7.4.2.12 Prefix NAL unit RBSP semantics 391
G.7.4.2.13 Slice layer in scalable extension RBSP semantics 392
G.7.4.3 Slice header semantics 392
G.7.4.3.1 Reference picture list reordering semantics 392
G.7.4.3.2 Prediction weight table semantics 392
G.7.4.3.3 Decoded reference picture marking semantics 392
G.7.4.3.4 Slice header in scalable extension semantics 392
G.7.4.3.5 Decoded reference base picture marking semantics 401
G.7.4.4 Slice data semantics 402
G.7.4.4.1 Slice data in scalable extension semantics 402
G.7.4.5 Macroblock layer semantics 402
G.7.4.5.1 Macroblock prediction semantics 402
G.7.4.5.2 Sub-macroblock prediction semantics 402
G.7.4.5.3 Residual data semantics 402
G.7.4.5.3.1 Residual luma semantics 402
G.7.4.5.3.2 Residual block CAVLC semantics 402
G.7.4.5.3.3 Residual block CABAC semantics 402
G.7.4.6 Macroblock layer in scalable extension semantics 403
G.7.4.6.1 Macroblock prediction in scalable extension semantics 404
G.7.4.6.2 Sub-macroblock prediction in scalable extension semantics 404
G.8 SVC decoding process *405*
G.8.1 SVC initialisation and decoding processes 406
G.8.1.1 Derivation process for the set of layer representations required for decoding 406
G.8.1.2 Array assignment, initialisation, and restructuring processes 406
G.8.1.2.1 Array assignment and initialisation process 406
G.8.1.2.2 Array restructuring process 408
G.8.1.3 Layer representation decoding processes 409
G.8.1.3.1 Base decoding process for layer representations without resolution change 409
G.8.1.3.2 Base decoding process for layer representations with resolution change 410
G.8.1.3.3 Target layer representation decoding process 411
G.8.1.4 Slice decoding processes 412
G.8.1.4.1 Base decoding process for slices without resolution change 412
G.8.1.4.2 Base decoding process for slices with resolution change 412
G.8.1.5 Macroblock initialisation and decoding processes 413
G.8.1.5.1 Macroblock initialisation process 413
G.8.1.5.1.1 Derivation process for macroblock type, sub-macroblock type, and inter-layer predictors for reference indices and motion vectors 414
G.8.1.5.1.2 Derivation process for quantisation parameters and transform type 415
G.8.1.5.2 Base decoding process for macroblocks in slices without resolution change 417
G.8.1.5.3 Base decoding process for macroblocks in slices with resolution change 418
G.8.1.5.4 Macroblock decoding process prior to decoding a layer representation without resolution change and tcoeff_level_prediction_flag equal to 0 420
G.8.1.5.5 Macroblock decoding process prior to resolution change 420
G.8.1.5.6 Target macroblock decoding process 421
G.8.2 SVC reference picture lists construction and decoded reference picture marking process 423
G.8.2.1 SVC decoding process for picture order count 424
G.8.2.2 SVC decoding process for picture numbers 425
G.8.2.3 SVC decoding process for reference picture lists construction 427
G.8.2.4 SVC decoded reference picture marking process 428

G.8.2.4.1 SVC reference picture marking process for a dependency representation 428
G.8.2.5 SVC decoding process for gaps in frame_num 430
G.8.3 SVC intra decoding processes 431
G.8.3.1 SVC derivation process for intra prediction modes 431
G.8.3.1.1 SVC derivation process for Intra_4x4 prediction modes 432
G.8.3.1.2 SVC derivation process for Intra_8x8 prediction modes 432
G.8.3.2 SVC intra sample prediction and construction process 434
G.8.3.2.1 SVC intra prediction and construction process for luma samples or chroma samples with ChromaArrayType equal to 3 435
G.8.3.2.1.1 SVC construction process for luma samples and chroma samples with ChromaArrayType equal to 3 of I_PCM macroblocks 435
G.8.3.2.1.2 SVC Intra_4x4 sample prediction and construction process 436
G.8.3.2.1.3 SVC Intra_8x8 sample prediction and construction process 436
G.8.3.2.1.4 SVC Intra_16x16 sample prediction and construction process 437
G.8.3.2.2 SVC intra prediction and construction process for chroma samples 438
G.8.3.2.2.1 SVC construction process for chroma samples of I_PCM macroblocks 438
G.8.3.2.2.2 SVC intra prediction and construction process for chroma samples with ChromaArrayType equal to 1 or 2 438
G.8.4 SVC Inter prediction process 439
G.8.4.1 SVC derivation process for motion vector components and reference indices 439
G.8.4.1.1 SVC derivation process for luma motion vector components and reference indices of a macroblock or sub-macroblock partition 441
G.8.4.1.2 SVC derivation process for luma motion vectors and reference indices for B_Skip, B_Direct_16x16, and B_Direct_8x8 in NAL units with nal_unit_type equal to 20 444
G.8.4.2 SVC decoding process for Inter prediction samples 445
G.8.4.2.1 SVC derivation process for prediction weights 448
G.8.4.2.2 Intra-inter prediction combination process 449
G.8.5 SVC transform coefficient decoding and sample array construction processes 450
G.8.5.1 Transform coefficient scaling and refinement process 450
G.8.5.1.1 Refinement process for luma transform coefficients or chroma transform coefficients with ChromaArrayType equal to 3 451
G.8.5.1.1.1 Assignment process for luma transform coefficient values or chroma transform coefficient values with ChromaArrayType equal to 3 for I_PCM macroblocks 451
G.8.5.1.1.2 Refinement process for transform coefficients of residual 4x4 blocks 452
G.8.5.1.1.3 Refinement process for transform coefficients of residual 8x8 blocks 453
G.8.5.1.1.4 Refinement process for transform coefficients of Intra_16x16 macroblocks 453
G.8.5.1.2 Refinement process for chroma transform coefficients 455
G.8.5.1.2.1 Assignment process for chroma transform coefficient values for I_PCM macroblocks 455
G.8.5.1.2.2 Refinement process for chroma transform coefficients with ChromaArrayType equal to 1 or 2 456
G.8.5.2 Transform coefficient level scaling process prior to transform coefficient refinement 457
G.8.5.3 Residual construction and accumulation process 459
G.8.5.3.1 Construction process for luma residuals or chroma residuals with ChromaArrayType equal to 3 460
G.8.5.3.1.1 Construction process for luma residuals or chroma residuals with ChromaArrayType equal to 3 of I_PCM macroblocks 460
G.8.5.3.1.2 Construction process for residual 4x4 blocks 460
G.8.5.3.1.3 Construction process for residual 8x8 blocks 461
G.8.5.3.1.4 Construction process for residuals of Intra_16x16 macroblocks 461
G.8.5.3.2 Construction process for chroma residuals 462
G.8.5.3.2.1 Construction process for chroma residuals of I_PCM macroblocks 462
G.8.5.3.2.2 Construction process for chroma residuals with ChromaArrayType equal to 1 or 2 462
G.8.5.4 Sample array accumulation process 463
G.8.5.4.1 Picture sample array construction process 464
G.8.5.4.2 Macroblock sample array extraction process 464
G.8.5.4.3 Picture sample array construction process for a colour component 465
G.8.5.4.4 Macroblock sample array extraction process for a colour component 465
G.8.5.5 Sample array re-initialisation process 466
G.8.6 Resampling processes for prediction data, intra samples, and residual samples 466
G.8.6.1 Derivation process for inter-layer predictors for macroblock type, sub-macroblock type, reference indices, and motion vectors 466
G.8.6.1.1 Derivation process for reference layer partition identifications 467
G.8.6.1.2 Derivation process for inter-layer predictors for reference indices and motion vectors 469

G.8.6.1.3 Derivation process for inter-layer predictors for P and B macroblock and sub-macroblock types 473
G.8.6.2 Resampling process for intra samples 476
G.8.6.2.1 Resampling process for intra samples of a macroblock colour component 476
G.8.6.2.2 Reference layer sample array construction process prior to intra resampling 478
G.8.6.2.2.1 Derivation process for reference layer slice and intra macroblock identifications 480
G.8.6.2.2.2 Construction process for not available sample values prior to intra resampling 481
G.8.6.2.3 Interpolation process for Intra_Base prediction 482
G.8.6.2.4 Vertical interpolation process for Intra_Base prediction 484
G.8.6.3 Resampling process for residual samples 485
G.8.6.3.1 Resampling process for residual samples of a macroblock colour component 486
G.8.6.3.2 Reference layer sample array construction process prior to residual resampling 487
G.8.6.3.2.1 Derivation process for reference layer transform block identifications 489
G.8.6.3.3 Interpolation process for residual prediction 490
G.8.6.3.4 Vertical interpolation process for residual prediction 491
G.8.7 SVC deblocking filter processes 491
G.8.7.1 Deblocking filter process for Intra_Base prediction 491
G.8.7.2 Deblocking filter process for target representations 492
G.8.7.3 Derivation process for quantisation parameters used in the deblocking filter process 492
G.8.7.4 Macroblock deblocking filter process 493
G.8.7.4.1 SVC filtering process for block edges 497
G.8.7.4.2 SVC filtering process for a set of samples across a horizontal or vertical block edge 498
G.8.7.4.3 SVC derivation process for the luma content dependent boundary filtering strength 499
G.8.8 Specification of bitstream subsets 502
G.8.8.1 Sub-bitstream extraction process 502
G.8.8.2 Specification of the base layer bitstream 502
G.9 Parsing process 502
G.9.1 Alternative parsing process for coded block pattern 503
G.9.2 Alternative CAVLC parsing process for transform coefficient levels 504
G.9.2.1 Additional parsing process for total number of transform coefficient levels and trailing ones 504
G.9.2.2 Alternative parsing process for run information 506
G.9.3 Alternative CABAC parsing process for slice data in scalable extension 507
G.9.3.1 Initialisation process 507
G.9.3.2 Binarization process 509
G.9.3.3 Decoding process flow 509
G.9.3.3.1 Derivation process for ctxIdx 509
G.9.3.3.2 Assignment process of ctxIdxInc using neighbouring syntax elements 510
G.9.3.3.2.1 Derivation process of ctxIdxInc for the syntax element base_mode_flag 510
G.9.3.3.2.2 Derivation process of ctxIdxInc for the syntax element residual_prediction_flag 510
G.10 Profiles and levels 510
G.10.1 Profiles 510
G.10.1.1 Scalable Baseline profile 510
G.10.1.2 Scalable High profile 511
G.10.1.3 Scalable High Intra profile 512
G.10.2 Levels 513
G.10.2.1 Level limits common to Scalable Baseline, Scalable High, and Scalable High Intra profiles 513
G.10.2.2 Profile specific level limits 515
G.11 Byte stream format 517
G.12 Hypothetical reference decoder 517
G.13 Supplemental enhancement information 517
G.13.1 SEI payload syntax 517
G.13.1.1 Scalability information SEI message syntax 517
G.13.1.2 Layers not present SEI message syntax 520
G.13.1.3 Layer dependency change SEI message syntax 520
G.13.1.4 Sub-picture scalable layer SEI message syntax 520
G.13.1.5 Non-required layer representation SEI message syntax 521
G.13.1.6 Priority layer information SEI message syntax 521
G.13.1.7 Scalable nesting SEI message syntax 521
G.13.1.8 Base layer temporal HRD SEI message syntax 522
G.13.1.9 Quality layer integrity check SEI message syntax 522
G.13.1.10 Redundant picture property SEI message syntax 523
G.13.1.11 Temporal level zero dependency representation index SEI message syntax 523
G.13.1.12 Temporal level switching point SEI message syntax 523

G.13.2 SEI payload semantics 523
G.13.2.1 Scalability information SEI message semantics 524
G.13.2.2 Layers not present SEI message semantics 532
G.13.2.3 Layer dependency change SEI message semantics 533
G.13.2.4 Sub-picture scalable layer SEI message semantics 533
G.13.2.5 Non-required layer representation SEI message semantics 533
G.13.2.6 Priority layer information SEI message semantics 534
G.13.2.7 Scalable nesting SEI message semantics 534
G.13.2.8 Base layer temporal HRD SEI message semantics 535
G.13.2.9 Quality layer integrity check SEI message semantics 536
G.13.2.10 Redundant picture property SEI message semantics 536
G.13.2.11 Temporal level zero dependency representation index SEI message semantics 537
G.13.2.12 Temporal level switching point SEI message semantics 538
G.14 SVC video usability information extension 539
G.14.1 SVC VUI parameters extension syntax 539
G.14.2 SVC VUI parameters extension semantics 539

LIST OF FIGURES

Figure 6-1 – Nominal vertical and horizontal locations of 4:2:0 luma and chroma samples in a frame 20

Figure 6-2 – Nominal vertical and horizontal sampling locations of 4:2:0 samples in top and bottom fields 21

Figure 6-3 – Nominal vertical and horizontal locations of 4:2:2 luma and chroma samples in a frame 21

Figure 6-4 – Nominal vertical and horizontal sampling locations of 4:2:2 samples top and bottom fields 22

Figure 6-5 – Nominal vertical and horizontal locations of 4:4:4 luma and chroma samples in a frame 22

Figure 6-6 – Nominal vertical and horizontal sampling locations of 4:4:4 samples top and bottom fields 23

Figure 6-7 – A picture with 11 by 9 macroblocks that is partitioned into two slices 24

Figure 6-8 – Partitioning of the decoded frame into macroblock pairs 24

Figure 6-9 – Macroblock partitions, sub-macroblock partitions, macroblock partition scans, and sub-macroblock partition scans 26

Figure 6-10 – Scan for 4x4 luma blocks 27

Figure 6-11 – Scan for 8x8 luma blocks 27

Figure 6-12 – Neighbouring macroblocks for a given macroblock 28

Figure 6-13 – Neighbouring macroblocks for a given macroblock in MBAFF frames 29

Figure 6-14 – Determination of the neighbouring macroblock, blocks, and partitions (informative) 30

Figure 7-1 – Structure of an access unit not containing any NAL units with nal_unit_type equal to 0, 7, 8, or in the range of 12 to 18, inclusive, or in the range of 20 to 31, inclusive 64

Figure 8-1 – Intra_4x4 prediction mode directions (informative) 124

Figure 8-2 – Example for temporal direct-mode motion vector inference (informative) 155

Figure 8-3 – Directional segmentation prediction (informative) 156

Figure 8-4 – Integer samples (shaded blocks with upper-case letters) and fractional sample positions (un-shaded blocks with lower-case letters) for quarter sample luma interpolation 162

Figure 8-5 – Fractional sample position dependent variables in chroma interpolation and surrounding integer position samples A, B, C, and D 164

Figure 8-6 – Assignment of the indices of dcY to luma4x4BlkIdx 170

Figure 8-7 – Assignment of the indices of dcC to chroma4x4BlkIdx: (a) ChromaArrayType equal to 1, (b) ChromaArrayType equal to 2 172

Figure 8-8 – 4x4 block scans. (a) Zig-zag scan. (b) Field scan (informative) 174

Figure 8-9 – 8x8 block scans. (a) 8x8 zig-zag scan. (b) 8x8 field scan (informative) 175

Figure 8-10 – Boundaries in a macroblock to be filtered 194
Figure 8-11 – Convention for describing samples across a 4x4 block horizontal or vertical boundary 198
Figure 9-1 – Illustration of CABAC parsing process for a syntax element SE (informative) 219
Figure 9-2 – Overview of the arithmetic decoding process for a single bin (informative) 265
Figure 9-3 – Flowchart for decoding a decision 266
Figure 9-4 – Flowchart of renormalization 268
Figure 9-5 – Flowchart of bypass decoding process 269
Figure 9-6 – Flowchart of decoding a decision before termination 270
Figure 9-7 – Flowchart for encoding a decision 271
Figure 9-8 – Flowchart of renormalization in the encoder 272
Figure 9-9 – Flowchart of PutBit(B) 272
Figure 9-10 – Flowchart of encoding bypass 273
Figure 9-11 – Flowchart of encoding a decision before termination 274
Figure 9-12 – Flowchart of flushing at termination 274
Figure C-1 – Structure of byte streams and NAL unit streams for HRD conformance checks 293
Figure C-2 – HRD buffer model 294
Figure E-1 – Location of chroma samples for top and bottom fields as a function of chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field 353

LIST OF TABLES

Table 6-1 – SubWidthC, and SubHeightC values derived from chroma_format_idc and separate_colour_plane_flag 19
Table 6-2 – Specification of input and output assignments for subclauses 6.4.10.1 to 6.4.10.7 30
Table 6-3 – Specification of mbAddrN 34
Table 6-4 – Specification of mbAddrN and yM 36
Table 7-1 – NAL unit type codes, syntax element categories, and NAL unit type classes 59
Table 7-2 – Assignment of mnemonic names to scaling list indices and specification of fall-back rule 69
Table 7-3 – Specification of default scaling lists Default_4x4_Intra and Default_4x4_Inter 69
Table 7-4 – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter 70
Table 7-5 – Meaning of primary_pic_type 77
Table 7-6 – Name association to slice_type 80
Table 7-7 – reordering_of_pic_nums_idc operations for reordering of reference picture lists 85
Table 7-8 – Interpretation of adaptive_ref_pic_marking_mode_flag 87
Table 7-9 – Memory management control operation (memory_management_control_operation) values 88
Table 7-10 – Allowed collective macroblock types for slice_type 90
Table 7-11 – Macroblock types for I slices 91
Table 7-12 – Macroblock type with value 0 for SI slices 92
Table 7-13 – Macroblock type values 0 to 4 for P and SP slices 93
Table 7-14 – Macroblock type values 0 to 22 for B slices 94
Table 7-15 – Specification of CodedBlockPatternChroma values 96
Table 7-16 – Relationship between intra_chroma_pred_mode and spatial prediction modes 97

Table 7-17 – Sub-macroblock types in P macroblocks 98
Table 7-18 – Sub-macroblock types in B macroblocks 99
Table 8-1 – Refined slice group map type 108
Table 8-2 – Specification of Intra4x4PredMode[luma4x4BlkIdx] and associated names 123
Table 8-3 – Specification of Intra8x8PredMode[luma8x8BlkIdx] and associated names 130
Table 8-4 – Specification of Intra16x16PredMode and associated names 137
Table 8-5 – Specification of Intra chroma prediction modes and associated names 140
Table 8-6 – Specification of the variable colPic 148
Table 8-7 – Specification of PicCodingStruct(X) 148
Table 8-8 – Specification of mbAddrCol, yM, and vertMvScale 150
Table 8-9 – Assignment of prediction utilization flags 152
Table 8-10 – Derivation of the vertical component of the chroma vector in field coding mode 158
Table 8-11 – Differential full-sample luma locations 163
Table 8-12 – Assignment of the luma prediction sample predPartLX$_L$[x_L, y_L] 164
Table 8-13 – Specification of mapping of idx to c_{ij} for zig-zag and field scan 174
Table 8-14 – Specification of mapping of idx to c_{ij} for 8x8 zig-zag and 8x8 field scan 175
Table 8-15 – Specification of QP_C as a function of qP_I 176
Table 8-16 – Derivation of offset dependent threshold variables α' and β' from indexA and indexB 202
Table 8-17 – Value of variable t'_{C0} as a function of indexA and bS 204
Table 9-1 – Bit strings with “prefix” and “suffix” bits and assignment to codeNum ranges (informative) 206
Table 9-2 – Exp-Golomb bit strings and codeNum in explicit form and used as ue(v) (informative) 206
Table 9-3 – Assignment of syntax element to codeNum for signed Exp-Golomb coded syntax elements se(v) 207
Table 9-4 – Assignment of codeNum to values of coded_block_pattern for macroblock prediction modes 207
Table 9-5 – coeff_token mapping to TotalCoeff(coeff_token) and TrailingOnes(coeff_token) 212
Table 9-6 – Codeword table for level_prefix (informative) 215
Table 9-7 – total_zeros tables for 4x4 blocks with tzVlcIndex 1 to 7 216
Table 9-8 – total_zeros tables for 4x4 blocks with tzVlcIndex 8 to 15 217
Table 9-9 – total_zeros tables for chroma DC 2x2 and 2x4 blocks 217
Table 9-10 – Tables for run_before 218
Table 9-11 – Association of ctxIdx and syntax elements for each slice type in the initialisation process 220
Table 9-12 – Values of variables m and n for ctxIdx from 0 to 10 221
Table 9-13 – Values of variables m and n for ctxIdx from 11 to 23 222
Table 9-14 – Values of variables m and n for ctxIdx from 24 to 39 222
Table 9-15 – Values of variables m and n for ctxIdx from 40 to 53 222
Table 9-16 – Values of variables m and n for ctxIdx from 54 to 59, and 399 to 401 223
Table 9-17 – Values of variables m and n for ctxIdx from 60 to 69 223
Table 9-18 – Values of variables m and n for ctxIdx from 70 to 104 224
Table 9-19 – Values of variables m and n for ctxIdx from 105 to 165 225
Table 9-20 – Values of variables m and n for ctxIdx from 166 to 226 226
Table 9-21 – Values of variables m and n for ctxIdx from 227 to 275 227

Table 9-22 – Values of variables m and n for ctxIdx from 277 to 337 228
Table 9-23 – Values of variables m and n for ctxIdx from 338 to 398 229
Table 9-24 – Values of variables m and n for ctxIdx from 402 to 459 230
Table 9-25 – Values of variables m and n for ctxIdx from 460 to 483 231
Table 9-26 – Values of variables m and n for ctxIdx from 484 to 571 231
Table 9-27 – Values of variables m and n for ctxIdx from 572 to 659 233
Table 9-28– Values of variables m and n for ctxIdx from 660 to 717 235
Table 9-29– Values of variables m and n for ctxIdx from 718 to 775 236
Table 9-30 – Values of variables m and n for ctxIdx from 776 to 863 237
Table 9-31 – Values of variables m and n for ctxIdx from 864 to 951 239
Table 9-32 – Values of variables m and n for ctxIdx from 952 to 1011 241
Table 9-33 – Values of variables m and n for ctxIdx from 1012 to 1023 242
Table 9-34 – Syntax elements and associated types of binarization, maxBinIdxCtx, and ctxIdxOffset 243
Table 9-35 – Bin string of the unary binarization (informative) 246
Table 9-36 – Binarization for macroblock types in I slices 248
Table 9-37 – Binarization for macroblock types in P, SP, and B slices 249
Table 9-38 – Binarization for sub-macroblock types in P, SP, and B slices 250
Table 9-39 – Assignment of ctxIdxInc to binIdx for all ctxIdxOffset values except those related to the syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1 252
Table 9-40 – Assignment of ctxIdxBlockCatOffset to ctxBlockCat for syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1 253
Table 9-41 – Specification of ctxIdxInc for specific values of ctxIdxOffset and binIdx 261
Table 9-42 – Specification of ctxBlockCat for the different blocks 262
Table 9-43 – Mapping of scanning position to ctxIdxInc for ctxBlockCat == 5, 9, or 13 263
Table 9-44 – Specification of rangeTabLPS depending on pStateIdx and qCodIRangeIdx 267
Table 9-45 – State transition table 268
Table A-1 – Level limits 283
Table A-2 – Specification of cpbBrVclFactor and cpbBrNalFactor 286
Table A-3 – Baseline profile level limits 286
Table A-4 – Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profile level limits 287
Table A-5 – Extended profile level limits 288
Table A-6 – Maximum frame rates (frames per second) for some example frame sizes 288
Table D-1 – Interpretation of pic_struct 317
Table D-2 – Mapping of ct_type to source picture scan 318
Table D-3 – Definition of counting_type values 318
Table D-4 – scene_transition_type values 325
Table D-5 – model_id values 332
Table D-6 – blending_mode_id values 334
Table D-7 – filter_hint_type values 340
Table E-1 – Meaning of sample aspect ratio indicator 346

Table E-2 – Meaning of video_format 347
Table E-3 – Colour primaries 348
Table E-4 – Transfer characteristics 349
Table E-5 – Matrix coefficients 352
Table E-6 – Divisor for computation of $\Delta t_{fi,dpb}(n)$ 354
Table G-1 – Name association to slice_type for NAL units with nal_unit_type equal to 20. 393
Table G-2 – Memory management control operation (memory_management_control_operation) values 401
Table G-3 – Allowed collective macroblock types for slice_type. 403
Table G-4 – Macroblock types for EI slices. 403
Table G-5 – Scale values cS for transform coefficient level scaling 458
Table G-6 – Macroblock type predictors mbTypeILPred 475
Table G-7 – Sub-macroblock type predictors subMbTypeILPred[mbPartIdx] 475
Table G-8 – 16-phase luma interpolation filter for resampling in Intra_Base prediction 483
Table G-9 – Mapping of (nX, nY) to coeffTokenIdx and vice versa 505
Table G-10 - Association of ctxIdx and syntax elements for each slice type in the initialisation process 508
Table G-11 - Values of variables m and n for ctxIdx from 1024 to 1026 508
Table G-12 - Values of variables m and n for ctxIdx from 1027 to 1029 508
Table G-13 - Syntax elements and associated types of binarization, maxBinIdxCtx, and ctxIdxOffset 509
Table G-14 - Assignment of ctxIdxInc to binIdx for the ctxIdxOffset values related to the syntax elements base_mode_flag and residual_prediction_flag 510
Table G-15 – Scalable Baseline profile level limits 516
Table G-16 – Specification of cpbBrVclFactor and cpbBrNalFactor 517

Foreword

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardising telecommunications on a world-wide basis. The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups that, in turn, produce Recommendations on these topics. The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1. In some areas of information technology that fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialised system for world-wide standardisation. National Bodies that are members of ISO and IEC participate in the development of International Standards through technical committees established by the respective organisation to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organisations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75% of the national bodies casting a vote.

This Recommendation | International Standard was prepared jointly by ITU-T SG 16 Q.6, also known as VCEG (Video Coding Experts Group), and by ISO/IEC JTC 1/SC 29/WG 11, also known as MPEG (Moving Picture Experts Group). VCEG was formed in 1997 to maintain prior ITU-T video coding standards and develop new video coding standard(s) appropriate for a wide range of conversational and non-conversational services. MPEG was formed in 1988 to establish standards for coding of moving pictures and associated audio for various applications such as digital storage media, distribution, and communication.

In this Recommendation | International Standard Annexes A through E and G contain normative requirements and are an integral part of this Recommendation | International Standard.

ITU-T Recommendation H.264

Advanced video coding for generic audiovisual services

0 Introduction

This clause does not form an integral part of this Recommendation | International Standard.

0.1 Prologue

This subclause does not form an integral part of this Recommendation | International Standard.

As the costs for both processing power and memory have reduced, network support for coded video data has diversified, and advances in video coding technology have progressed, the need has arisen for an industry standard for compressed video representation with substantially increased coding efficiency and enhanced robustness to network environments. Toward these ends the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG) formed a Joint Video Team (JVT) in 2001 for development of a new Recommendation | International Standard.

0.2 Purpose

This subclause does not form an integral part of this Recommendation | International Standard.

This Recommendation | International Standard was developed in response to the growing need for higher compression of moving pictures for various applications such as videoconferencing, digital storage media, television broadcasting, internet streaming, and communication. It is also designed to enable the use of the coded video representation in a flexible manner for a wide variety of network environments. The use of this Recommendation | International Standard allows motion video to be manipulated as a form of computer data and to be stored on various storage media, transmitted and received over existing and future networks and distributed on existing and future broadcasting channels.

0.3 Applications

This subclause does not form an integral part of this Recommendation | International Standard.

This Recommendation | International Standard is designed to cover a broad range of applications for video content including but not limited to the following:

CATV	Cable TV on optical networks, copper, etc.
DBS	Direct broadcast satellite video services
DSL	Digital subscriber line video services
DTTB	Digital terrestrial television broadcasting
ISM	Interactive storage media (optical disks, etc.)
MMM	Multimedia mailing
MSPN	Multimedia services over packet networks
RTC	Real-time conversational services (videoconferencing, videophone, etc.)
RVS	Remote video surveillance
SSM	Serial storage media (digital VTR, etc.)

0.4 Publication and versions of this specification

This subclause does not form an integral part of this Recommendation | International Standard.

This specification has been jointly developed by ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group. It is published as technically-aligned twin text in both organizations ITU-T and ISO/IEC.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 1 refers to the first approved version of this Recommendation | International Standard. Version 1 was approved by ITU-T on 30 May 2003. The first published version in ISO/IEC corresponded to version 1.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 2 refers to the integrated text containing the corrections specified in the first technical corrigendum. The first fully-published version in the ITU-T was version 2 as approved by ITU-T on 7 May 2004, due to the development of the corrigendum during the publication process. Version 2 was also published in integrated form by ISO/IEC.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 3 refers to the integrated text containing both the first technical corrigendum (2004) and the first amendment, which is referred to as the "Fidelity range extensions". Version 3 was approved by ITU-T on 1 March 2005.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 4 refers to the integrated text containing the first technical corrigendum (2004), the first amendment (the "Fidelity range extensions"), and an additional technical corrigendum (2005). Version 4 was approved by ITU-T on 13 September 2005. In both ITU-T and ISO/IEC, the next complete published version after version 2 was version 4.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 5 refers to the integrated version 4 text with its specification of the High 4:4:4 profile removed.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 6 refers to the integrated version 5 text after its amendment to support additional colour space indicators. In the ITU-T, the changes for versions 5 and 6 were approved on 13 June 2006 and were published as a single amendment.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 7 refers to the integrated version 6 text after its amendment to define five new profiles intended primarily for professional applications (the High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, CAVLC 4:4:4 Intra, and High 4:4:4 Predictive profiles) and two new types of supplemental enhancement information (SEI) messages (the post-filter hint SEI message and the tone mapping information SEI message). Version 7 was approved by ITU-T on 6 April 2007.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 8 (the current specification) refers to the integrated version 7 text after its amendment to specify scalable video coding in three profiles (Scalable Baseline, Scalable High, and Scalable High Intra profiles). Version 8 was approved by the ITU-T on 22 November 2007.

0.5 Profiles and levels

This subclause does not form an integral part of this Recommendation | International Standard.

This Recommendation | International Standard is designed to be generic in the sense that it serves a wide range of applications, bit rates, resolutions, qualities, and services. Applications should cover, among other things, digital storage media, television broadcasting and real-time communications. In the course of creating this Specification, various requirements from typical applications have been considered, necessary algorithmic elements have been developed, and these have been integrated into a single syntax. Hence, this Specification will facilitate video data interchange among different applications.

Considering the practicality of implementing the full syntax of this Specification, however, a limited number of subsets of the syntax are also stipulated by means of "profiles" and "levels". These and other related terms are formally defined in clause 3.

A "profile" is a subset of the entire bitstream syntax that is specified by this Recommendation | International Standard. Within the bounds imposed by the syntax of a given profile it is still possible to require a very large variation in the performance of encoders and decoders depending upon the values taken by syntax elements in the bitstream such as the specified size of the decoded pictures. In many applications, it is currently neither practical nor economic to implement a decoder capable of dealing with all hypothetical uses of the syntax within a particular profile.

In order to deal with this problem, "levels" are specified within each profile. A level is a specified set of constraints imposed on values of the syntax elements in the bitstream. These constraints may be simple limits on values. Alternatively they may take the form of constraints on arithmetic combinations of values (e.g., picture width multiplied by picture height multiplied by number of pictures decoded per second).

Coded video content conforming to this Recommendation | International Standard uses a common syntax. In order to achieve a subset of the complete syntax, flags, parameters, and other syntax elements are included in the bitstream that signal the presence or absence of syntactic elements that occur later in the bitstream.

0.6 Overview of the design characteristics

This subclause does not form an integral part of this Recommendation | International Standard.

The coded representation specified in the syntax is designed to enable a high compression capability for a desired image quality. With the exception of the transform bypass mode of operation for lossless coding in the High 4:4:4 Intra, CAVLC 4:4:4 Intra, and High 4:4:4 Predictive profiles, and the I_PCM mode of operation in all profiles, the algorithm is typically not lossless, as the exact source sample values are typically not preserved through the encoding and decoding processes. A number of techniques may be used to achieve highly efficient compression. Encoding algorithms (not specified in this Recommendation | International Standard) may select between inter and intra coding for block-shaped regions of each picture. Inter coding uses motion vectors for block-based inter prediction to exploit temporal statistical dependencies between different pictures. Intra coding uses various spatial prediction modes to exploit spatial statistical dependencies in the source signal for a single picture. Motion vectors and intra prediction modes may be specified for a variety of block sizes in the picture. The prediction residual is then further compressed using a transform to remove spatial correlation inside the transform block before it is quantised, producing an irreversible process that typically discards less important visual information while forming a close approximation to the source samples. Finally, the motion vectors or intra prediction modes are combined with the quantised transform coefficient information and encoded using either variable length codes or arithmetic coding.

Scalable video coding is specified in Annex G of this specification allowing the construction of bitstreams that contain sub-bitstreams that conform to this specification. For temporal bitstream scalability, i.e., the presence of a sub-bitstream with a smaller temporal sampling rate than the bitstream, complete access units are removed from the bitstream when deriving the sub-bitstream. In this case, high-level syntax and inter prediction reference pictures in the bitstream are constructed accordingly. For spatial and quality bitstream scalability, i.e. the presence of a sub-bitstream with lower spatial resolution or quality than the bitstream, NAL units are removed from the bitstream when deriving the sub-bitstream. In this case, inter-layer prediction, i.e., the prediction of the higher spatial resolution or quality signal by data of the lower spatial resolution or quality signal, is typically used for efficient coding.

Otherwise, the coding algorithm as described in the previous paragraph is used.

0.6.1 Predictive coding

This subclause does not form an integral part of this Recommendation | International Standard.

Because of the conflicting requirements of random access and highly efficient compression, two main coding types are specified. Intra coding is done without reference to other pictures. Intra coding may provide access points to the coded sequence where decoding can begin and continue correctly, but typically also shows only moderate compression efficiency. Inter coding (predictive or bi-predictive) is more efficient using inter prediction of each block of sample values from some previously decoded picture selected by the encoder. In contrast to some other video coding standards, pictures coded using bi-predictive inter prediction may also be used as references for inter coding of other pictures.

The application of the three coding types to pictures in a sequence is flexible, and the order of the decoding process is generally not the same as the order of the source picture capture process in the encoder or the output order from the decoder for display. The choice is left to the encoder and will depend on the requirements of the application. The decoding order is specified such that the decoding of pictures that use inter-picture prediction follows later in decoding order than other pictures that are referenced in the decoding process.

0.6.2 Coding of progressive and interlaced video

This subclause does not form an integral part of this Recommendation | International Standard.

This Recommendation | International Standard specifies a syntax and decoding process for video that originated in either progressive-scan or interlaced-scan form, which may be mixed together in the same sequence. The two fields of an interlaced frame are separated in capture time while the two fields of a progressive frame share the same capture time. Each field may be coded separately or the two fields may be coded together as a frame. Progressive frames are typically coded as a frame. For interlaced video, the encoder can choose between frame coding and field coding. Frame coding or field coding can be adaptively selected on a picture-by-picture basis and also on a more localized basis within a coded frame. Frame coding is typically preferred when the video scene contains significant detail with limited motion. Field coding typically works better when there is fast picture-to-picture motion.

0.6.3 Picture partitioning into macroblocks and smaller partitions

This subclause does not form an integral part of this Recommendation | International Standard.

As in previous video coding Recommendations and International Standards, a macroblock, consisting of a 16x16 block of luma samples and two corresponding blocks of chroma samples, is used as the basic processing unit of the video decoding process.

A macroblock can be further partitioned for inter prediction. The selection of the size of inter prediction partitions is a result of a trade-off between the coding gain provided by using motion compensation with smaller blocks and the quantity of data needed to represent the data for motion compensation. In this Recommendation | International Standard the inter prediction process can form segmentations for motion representation as small as 4x4 luma samples in size, using motion vector accuracy of one-quarter of the luma sample grid spacing displacement. The process for inter prediction of a sample block can also involve the selection of the picture to be used as the reference picture from a number of stored previously-decoded pictures. Motion vectors are encoded differentially with respect to predicted values formed from nearby encoded motion vectors.

Typically, the encoder calculates appropriate motion vectors and other data elements represented in the video data stream. This motion estimation process in the encoder and the selection of whether to use inter prediction for the representation of each region of the video content is not specified in this Recommendation | International Standard.

0.6.4 Spatial redundancy reduction

This subclause does not form an integral part of this Recommendation | International Standard.

Both source pictures and prediction residuals have high spatial redundancy. This Recommendation | International Standard is based on the use of a block-based transform method for spatial redundancy removal. After inter prediction from previously-decoded samples in other pictures or spatial-based prediction from previously-decoded samples within the current picture, the resulting prediction residual is split into 4x4 blocks. These are converted into the transform domain where they are quantised. After quantisation many of the transform coefficients are zero or have low amplitude and can thus be represented with a small amount of encoded data. The processes of transformation and quantisation in the encoder are not specified in this Recommendation | International Standard.

0.7 How to read this specification

This subclause does not form an integral part of this Recommendation | International Standard.

It is suggested that the reader starts with clause 1 (Scope) and moves on to clause 3 (Definitions). Clause 6 should be read for the geometrical relationship of the source, input, and output of the decoder. Clause 7 (Syntax and semantics) specifies the order to parse syntax elements from the bitstream. See subclauses 7.1-7.3 for syntactical order and see subclause 7.4 for semantics; i.e., the scope, restrictions, and conditions that are imposed on the syntax elements. The actual parsing for most syntax elements is specified in clause 9 (Parsing process). Finally, clause 8 (Decoding process) specifies how the syntax elements are mapped into decoded samples. Throughout reading this specification, the reader should refer to clauses 2 (Normative references), 4 (Abbreviations), and 5 (Conventions) as needed. Annexes A through E also form an integral part of this Recommendation | International Standard.

Annex A specifies eleven profiles (Baseline, Main, Extended, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra), each being tailored to certain application domains, and defines the so-called levels of the profiles. Annex B specifies syntax and semantics of a byte stream format for delivery of coded video as an ordered stream of bytes. Annex C specifies the hypothetical reference decoder and its use to check bitstream and decoder conformance. Annex D specifies syntax and semantics for supplemental enhancement information message payloads. Finally, Annex E specifies syntax and semantics of the video usability information parameters of the sequence parameter set.

Annex G specifies scalable video coding (SVC). The reader is referred to Annex G for the entire decoding process for SVC, which is specified there with references being made to clauses 2-9 and Annexes A-E. Subclause G.10 specifies three profiles for SVC (Scalable Baseline, Scalable High, and Scalable High Intra).

Throughout this specification, statements appearing with the preamble "NOTE -" are informative and are not an integral part of this Recommendation | International Standard.

1 Scope

This document specifies ITU-T Recommendation H.264 | ISO/IEC International Standard ISO/IEC 14496-10 video coding.

2 Normative references

The following Recommendations and International Standards contain provisions which, through reference in this text, constitute provisions of this Recommendation | International Standard. At the time of publication, the editions indicated were valid. All Recommendations and Standards are subject to revision, and parties to agreements based on this Recommendation | International Standard are encouraged to investigate the possibility of applying the most recent

edition of the Recommendations and Standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards. The Telecommunication Standardization Bureau of the ITU maintains a list of currently valid ITU-T Recommendations.

- ITU-T Recommendation T.35 (2000), *Procedure for the allocation of ITU-T defined codes for non-standard facilities*.
- ISO/IEC 11578:1996, Annex A, *Universal Unique Identifier*.
- ISO/CIE 10527:1991, *Colorimetric Observers*.

3 Definitions

For the purposes of this Recommendation | International Standard, the following definitions apply.

3.1 **access unit**: A set of *NAL units* always containing exactly one *primary coded picture*. In addition to the *primary coded picture*, an access unit may also contain one or more *redundant coded pictures*, one *auxiliary coded picture*, or other *NAL units* not containing *slices* or *slice data partitions* of a *coded picture*. The decoding of an access unit always results in a *decoded picture*.

3.2 **AC transform coefficient**: Any *transform coefficient* for which the *frequency index* in one or both dimensions is non-zero.

3.3 **adaptive binary arithmetic decoding process**: An entropy *decoding process* that derives the values of *bins* from a *bitstream* produced by an *adaptive binary arithmetic encoding process*.

3.4 **adaptive binary arithmetic encoding process**: An entropy *encoding process*, not normatively specified in this Recommendation | International Standard, that codes a sequence of *bins* and produces a *bitstream* that can be decoded using the *adaptive binary arithmetic decoding process*.

3.5 **alpha blending**: A process not specified by this Recommendation | International Standard, in which an *auxiliary coded picture* is used in combination with a *primary coded picture* and with other data not specified by this Recommendation | International Standard in the *display process*. In an alpha blending process, the samples of an *auxiliary coded picture* are interpreted as indications of the degree of opacity (or, equivalently, the degrees of transparency) associated with the corresponding *luma* samples of the *primary coded picture.*

3.6 **arbitrary slice order (ASO)**: A *decoding order* of *slices* in which the *macroblock address* of the first *macroblock* of some *slice* of a *slice group* may be less than the *macroblock address* of the first *macroblock* of some other preceding *slice* of the same *slice group* or, in the case of a *picture* that is coded using three separate colour planes, some other preceding *slice* of the same *slice group* within the same colour plane, or in which the *slices* of a *slice group* of a picture may be interleaved with the *slices* of one or more other *slice groups* of the *picture* or, in the case of a *picture* that is coded using three separate colour planes, with the *slices* of one or more other *slice groups* within the same colour plane.

3.7 **auxiliary coded picture**: A *picture* that supplements the *primary coded picture* that may be used in combination with other data not specified by this Recommendation | International Standard in the *display process*. An auxiliary coded picture has the same syntactic and semantic restrictions as a monochrome *redundant coded picture*. An auxiliary coded picture must contain the same number of *macroblocks* as the *primary coded picture*. Auxiliary coded pictures have no normative effect on the *decoding process*. See also *primary coded picture* and *redundant coded picture*.

3.8 **B slice**: A *slice* that may be decoded using *intra prediction* or *inter prediction* using at most two *motion vectors* and *reference indices* to *predict* the sample values of each *block*.

3.9 **bin**: One bit of a *bin string*.

3.10 **binarization**: A set of *bin strings* for all possible values of a *syntax element*.

3.11 **binarization process**: A unique mapping process of all possible values of a *syntax element* onto a set of *bin strings*.

3.12 **bin string**: A string of *bins*. A bin string is an intermediate binary representation of values of *syntax elements* from the *binarization* of the *syntax element*.

3.13 **bi-predictive slice:** See *B slice***.**

3.14 **bitstream**: A sequence of bits that forms the representation of *coded pictures* and associated data forming one or more *coded video sequences*. Bitstream is a collective term used to refer either to a *NAL unit stream* or a *byte stream*.

3.15 **block**: An MxN (M-column by N-row) array of samples, or an MxN array of *transform coefficients.*

3.16 **bottom field**: One of two *fields* that comprise a *frame*. Each row of a *bottom field* is spatially located immediately below a corresponding row of a *top field*.

3.17 **bottom macroblock (of a macroblock pair)**: The *macroblock* within a *macroblock pair* that contains the samples in the bottom row of samples for the *macroblock pair*. For a *field macroblock pair*, the bottom macroblock represents the samples from the region of the *bottom field* of the *frame* that lie within the spatial region of the *macroblock pair*. For a *frame macroblock pair*, the bottom macroblock represents the samples of the *frame* that lie within the bottom half of the spatial region of the *macroblock pair*.

3.18 **broken link**: A location in a *bitstream* at which it is indicated that some subsequent *pictures* in *decoding order* may contain serious visual artefacts due to unspecified operations performed in the generation of the *bitstream*.

3.19 **byte**: A sequence of 8 bits, written and read with the most significant bit on the left and the least significant bit on the right. When represented in a sequence of data bits, the most significant bit of a byte is first.

3.20 **byte-aligned**: A position in a *bitstream* is byte-aligned when the position is an integer multiple of 8 bits from the position of the first bit in the *bitstream*. A bit or *byte* or *syntax element* is said to be byte-aligned when the position at which it appears in a *bitstream* is byte-aligned.

3.21 **byte stream**: An encapsulation of a *NAL unit stream* containing *start code prefixes* and *NAL units* as specified in Annex B.

3.22 **can**: A term used to refer to behaviour that is allowed, but not necessarily required.

3.23 **category**: A number associated with each *syntax element*. The category is used to specify the allocation of *syntax elements* to *NAL units* for *slice data partitioning*. It may also be used in a manner determined by the application to refer to classes of *syntax elements* in a manner not specified in this Recommendation | International Standard.

3.24 **chroma**: An adjective specifying that a sample array or single sample is representing one of the two colour difference signals related to the primary colours. The symbols used for a chroma array or sample are Cb and Cr.

NOTE – The term chroma is used rather than the term chrominance in order to avoid the implication of the use of linear light transfer characteristics that is often associated with the term chrominance.

3.25 **coded field**: A *coded representation* of a *field*.

3.26 **coded frame**: A *coded representation* of a *frame*.

3.27 **coded picture**: A *coded representation* of a *picture*. A coded picture may be either a *coded field* or a *coded frame*. Coded picture is a collective term referring to a *primary coded picture* or a *redundant coded picture*, but not to both together.

3.28 **coded picture buffer (CPB)**: A first-in first-out buffer containing *access units* in *decoding order* specified in the *hypothetical reference decoder* in Annex C.

3.29 **coded representation**: A data element as represented in its coded form.

3.30 **coded slice data partition NAL unit**: A *NAL unit* containing a *slice data partition*.

3.31 **coded slice NAL unit**: A *NAL unit* containing a *slice* that is not a *slice* of an *auxiliary coded picture*.

3.32 **coded video sequence**: A sequence of *access units* that consists, in decoding order, of an *IDR access unit* followed by zero or more non-IDR *access units* including all subsequent *access units* up to but not including any subsequent *IDR access unit*.

3.33 **component**: An array or single sample from one of the three arrays (*luma* and two *chroma*) that make up a *field* or *frame* in 4:2:0, 4:2:2, or 4:4:4 colour format or the array or a single sample of the array that make up a *field* or *frame* in monochrome format.

3.34 **complementary field pair:** A collective term for a *complementary reference field pair* or a *complementary non-reference field pair*.

3.35 **complementary non-reference field pair**: Two *non-reference fields* that are in consecutive *access units* in *decoding order* as two *coded fields* of opposite parity where the first *field* is not already a paired *field.*

3.36 **complementary reference field pair**: Two *reference fields* that are in consecutive *access units* in *decoding order* as two *coded fields* and share the same value of the frame_num *syntax element*, where the second *field* in *decoding order* is not an *IDR picture* and does not include a memory_management_control_operation *syntax element* equal to 5.

3.37 **context variable**: A variable specified for the *adaptive binary arithmetic decoding process* of a *bin* by an equation containing recently decoded *bins*.

3.38 **DC transform coefficient**: A *transform coefficient* for which the *frequency index* is zero in all dimensions.

3.39 **decoded picture**: A *decoded picture* is derived by decoding a *coded picture*. A *decoded picture* is either a decoded *frame*, or a decoded *field*. A decoded *field* is either a decoded *top field* or a decoded *bottom field*.

3.40 **decoded picture buffer (DPB)**: A buffer holding *decoded pictures* for reference, output reordering, or output delay specified for the *hypothetical reference decoder* in Annex C.

3.41 **decoder**: An embodiment of a *decoding process*.

3.42 **decoding order**: The order in which *syntax elements* are processed by the *decoding process*.

3.43 **decoding process**: The process specified in this Recommendation | International Standard that reads a *bitstream* and derives *decoded pictures* from it.

3.44 **direct prediction**: An *inter prediction* for a *block* for which no *motion vector* is decoded. Two direct *prediction* modes are specified that are referred to as spatial direct *prediction* and temporal *prediction* mode.

3.45 **display process**: A process not specified in this Recommendation | International Standard having, as its input, the cropped decoded *pictures* that are the output of the *decoding process.*

3.46 **decoder under test (DUT)**: A *decoder* that is tested for conformance to this Recommendation | International Standard by operating the *hypothetical stream scheduler* to deliver a conforming *bitstream* to the *decoder* and to the *hypothetical reference decoder* and comparing the values and timing of the output of the two *decoders*.

3.47 **emulation prevention byte**: A *byte* equal to 0x03 that may be present within a *NAL unit*. The presence of emulation prevention bytes ensures that no sequence of consecutive *byte-aligned bytes* in the *NAL unit* contains a *start code prefix*.

3.48 **encoder**: An embodiment of an *encoding process*.

3.49 **encoding process**: A process, not specified in this Recommendation | International Standard, that produces a *bitstream* conforming to this Recommendation | International Standard.

3.50 **field**: An assembly of alternate rows of a *frame*. A *frame* is composed of two *fields*, a *top field* and a *bottom field*.

3.51 **field macroblock**: A macroblock containing samples from a single *field*. All *macroblocks* of a *coded field* are field macroblocks. When *macroblock-adaptive frame/field decoding* is in use, some *macroblocks* of a *coded frame* may be field macroblocks.

3.52 **field macroblock pair**: A *macroblock pair* decoded as two *field macroblocks.*

3.53 **field scan**: A specific sequential ordering of *transform coefficients* that differs from the *zig-zag scan* by scanning columns more rapidly than rows. Field scan is used for *transform coefficients* in *field macroblocks.*

3.54 **flag**: A variable that can take one of the two possible values 0 and 1.

3.55 **frame**: A *frame* contains an array of *luma* samples in monochrome format or an array of *luma* samples and two corresponding arrays of *chroma* samples in 4:2:0, 4:2:2, and 4:4:4 colour format. A *frame* consists of two *fields*, a *top field* and a *bottom field*.

3.56 **frame macroblock**: A *macroblock* representing samples from the two *fields* of a *coded frame*. When *macroblock-adaptive frame/field decoding* is not in use, all macroblocks of a *coded frame* are frame macroblocks. When *macroblock-adaptive frame/field decoding* is in use, some macroblocks of a *coded frame* may be frame macroblocks.

3.57 **frame macroblock pair**: A *macroblock pair* decoded as two *frame macroblocks.*

3.58 **frequency index**: A one-dimensional or two-dimensional index associated with a *transform coefficient* prior to an *inverse transform* part of the *decoding process.*

3.59 **hypothetical reference decoder (HRD)**: A hypothetical *decoder* model that specifies constraints on the variability of conforming *NAL unit streams* or conforming *byte streams* that an encoding process may produce.

3.60 **hypothetical stream scheduler (HSS)**: A hypothetical delivery mechanism for the timing and data flow of the input of a *bitstream* into the *hypothetical reference decoder*. The HSS is used for checking the conformance of a *bitstream* or a *decoder*.

3.61 **I slice**: A *slice* that is not an *SI slice* that is decoded using *intra prediction* only.

3.62 **informative**: A term used to refer to content provided in this Recommendation | International Standard that is not an integral part of this Recommendation | International Standard. Informative content does not establish any mandatory requirements for conformance to this Recommendation | International Standard.

3.63 **instantaneous decoding refresh (IDR) access unit**: An *access unit* in which the *primary coded picture* is an *IDR picture*.

3.64 **instantaneous decoding refresh (IDR) picture**: A *coded picture* in which all *slices* are *I* or *SI slices* that causes the *decoding process* to mark all *reference pictures* as "unused for reference" immediately after decoding the IDR picture. After the decoding of an IDR picture all following *coded pictures* in *decoding order* can be decoded without *inter prediction* from any *picture* decoded prior to the IDR picture. The first *picture* of each *coded video sequence* is an IDR picture.

3.65 **inter coding**: Coding of a *block*, *macroblock*, *slice*, or *picture* that uses *inter prediction*.

3.66 **inter prediction**: A *prediction* derived from decoded samples of *reference pictures* other than the current *decoded picture*.

3.67 **interpretation sample value**: A possibly-altered value corresponding to a decoded sample value of an *auxiliary coded picture* that may be generated for use in the *display process*. Interpretation sample values are not used in the *decoding process* and have no normative effect on the *decoding process*.

3.68 **intra coding**: Coding of a *block*, *macroblock*, *slice*, or *picture* that uses *intra prediction*.

3.69 **intra prediction**: A *prediction* derived from the decoded samples of the same decoded *slice*.

3.70 **intra slice**: See *I slice*.

3.71 **inverse transform**: A part of the *decoding process* by which a set of *transform coefficients* are converted into spatial-domain values, or by which a set of *transform coefficients* are converted into *DC transform coefficients*.

3.72 **layer**: One of a set of syntactical structures in a non-branching hierarchical relationship. Higher layers contain lower layers. The coding layers are the *coded video sequence*, *picture*, *slice*, and *macroblock* layers.

3.73 **level**: A defined set of constraints on the values that may be taken by the *syntax elements* and variables of this Recommendation | International Standard. The same set of levels is defined for all *profiles*, with most aspects of the definition of each level being in common across different *profiles*. Individual implementations may, within specified constraints, support a different level for each supported *profile*. In a different context, level is the value of a *transform coefficient* prior to *scaling*.

3.74 **list 0 (list 1) motion vector**: A *motion vector* associated with a *reference index* pointing into *reference picture list 0* (*list 1*).

3.75 **list 0 (list 1) prediction**: *Inter prediction* of the content of a *slice* using a *reference index* pointing into *reference picture list 0* (*list 1*).

3.76 **luma**: An adjective specifying that a sample array or single sample is representing the monochrome signal related to the primary colours. The symbol or subscript used for luma is Y or L.

NOTE – The term luma is used rather than the term luminance in order to avoid the implication of the use of linear light transfer characteristics that is often associated with the term luminance. The symbol L is sometimes used instead of the symbol Y to avoid confusion with the symbol y as used for vertical location.

3.77 **macroblock**: A 16x16 *block* of *luma* samples and two corresponding *blocks* of *chroma* samples of a *picture* that has three sample arrays, or a 16x16 *block* of samples of a monochrome *picture* or a *picture* that is coded using three separate colour planes. The division of a *slice* or a *macroblock pair* into macroblocks is a *partitioning*.

3.78 **macroblock-adaptive frame/field decoding**: A *decoding process* for *coded frames* in which some *macroblocks* may be decoded as *frame macroblocks* and others may be decoded as *field macroblocks*.

3.79 **macroblock address**: When *macroblock-adaptive frame/field decoding* is not in use, a macroblock address is the index of a macroblock in a *macroblock raster scan* of the *picture* starting with zero for the top-left *macroblock* in a *picture*. When *macroblock-adaptive frame/field decoding* is in use, the macroblock address of the *top macroblock* of a *macroblock pair* is two times the index of the *macroblock pair* in a *macroblock pair raster scan* of the *picture*, and the macroblock address of the *bottom macroblock* of a *macroblock pair* is the macroblock address of the corresponding *top macroblock* plus 1. The macroblock address of the *top macroblock* of each *macroblock pair* is an even number and the macroblock address of the *bottom macroblock* of each *macroblock pair* is an odd number.

3.80 **macroblock location**: The two-dimensional coordinates of a *macroblock* in a *picture* denoted by (x, y). For the top left *macroblock* of the *picture* (x, y) is equal to (0, 0). x is incremented by 1 for each *macroblock* column from left to right. When *macroblock-adaptive frame/field decoding* is not in use, y is incremented by 1 for each *macroblock* row from top to bottom. When *macroblock-adaptive frame/field decoding* is in use, y is incremented by 2 for each *macroblock pair* row from top to bottom, and is incremented by an additional 1 when a macroblock is a *bottom macroblock*.

3.81 **macroblock pair**: A pair of vertically contiguous *macroblocks* in a *frame* that is coupled for use in *macroblock-adaptive frame/field decoding*. The division of a *slice* into macroblock pairs is a *partitioning*.

3.82 **macroblock partition**: A *block* of *luma* samples and two corresponding *blocks* of *chroma* samples resulting from a *partitioning* of a *macroblock* for *inter prediction* for a *picture* that has three sample arrays or a *block* of *luma* samples resulting from a *partitioning* of a *macroblock* for *inter prediction* for a monochrome *picture* or a *picture* that is coded using three separate colour planes.

3.83 **macroblock to slice group map**: A means of mapping *macroblocks* of a *picture* into *slice groups*. The macroblock to slice group map consists of a list of numbers, one for each coded *macroblock*, specifying the *slice group* to which each coded *macroblock* belongs.

3.84 **map unit to slice group map**: A means of mapping *slice group map units* of a *picture* into *slice groups*. The map unit to slice group map consists of a list of numbers, one for each *slice group map unit*, specifying the *slice group* to which each coded *slice group map unit* belongs.

3.85 **may**: A term used to refer to behaviour that is allowed, but not necessarily required. In some places where the optional nature of the described behaviour is intended to be emphasized, the phrase "may or may not" is used to provide emphasis.

3.86 **memory management control operation**: Seven operations that control *reference picture marking*.

3.87 **motion vector**: A two-dimensional vector used for *inter prediction* that provides an offset from the coordinates in the *decoded picture* to the coordinates in a *reference picture*.

3.88 **must**: A term used in expressing an observation about a requirement or an implication of a requirement that is specified elsewhere in this Recommendation | International Standard. This term is used exclusively in an *informative* context.

3.89 **NAL unit**: A syntax structure containing an indication of the type of data to follow and *bytes* containing that data in the form of an *RBSP* interspersed as necessary with *emulation prevention bytes*.

3.90 **NAL unit stream**: A sequence of *NAL units*.

3.91 **non-paired field**: A collective term for a *non-paired reference field* or a *non-paired non-reference field*.

3.92 **non-paired non-reference field:** A decoded *non-reference field* that is not part of a *complementary non-reference field pair*.

3.93 **non-paired reference field**: A decoded *reference field* that is not part of a *complementary reference field pair*.

3.94 **non-reference field**: A *field* coded with nal_ref_idc equal to 0.

3.95 **non-reference frame**: A *frame* coded with nal_ref_idc equal to 0.

3.96 **non-reference picture**: A *picture* coded with nal_ref_idc equal to 0. A *non-reference picture* is not used for *inter prediction* of any other *pictures*.

3.97 **note**: A term used to prefix *informative* remarks. This term is used exclusively in an *informative* context.

3.98 **opposite parity**: The *opposite parity* of *top* is *bottom*, and vice versa.

3.99 **output order**: The order in which the *decoded pictures* are output from the *decoded picture buffer*.

3.100 **P slice**: A *slice* that is not an *SP slice* that may be decoded using *intra prediction* or *inter prediction* using at most one *motion vector* and *reference index* to *predict* the sample values of each *block*.

3.101 **parameter**: A *syntax element* of a *sequence parameter set* or a *picture parameter set*. Parameter is also used as part of the defined term *quantisation parameter*.

3.102 **parity**: The parity of a *field* can be *top* or *bottom*.

3.103 **partitioning**: The division of a set into subsets such that each element of the set is in exactly one of the subsets.

3.104 **picture**: A collective term for a *field* or a *frame*.

3.105 **picture parameter set**: A *syntax structure* containing *syntax elements* that apply to zero or more entire *coded pictures* as determined by the pic_parameter_set_id *syntax element* found in each *slice header*.

3.106 **picture order count**: A variable having a value that is non-decreasing with increasing *picture* position in output order relative to the previous *IDR picture* in *decoding order* or relative to the previous *picture* containing the *memory management control operation* that marks all *reference pictures* as "unused for reference".

3.107 **prediction**: An embodiment of the *prediction process*.

3.108 **prediction process**: The use of a *predictor* to provide an estimate of the sample value or data element currently being decoded.

3.109 **predictive slice**: See *P slice*.

3.110 **predictor**: A combination of specified values or previously decoded sample values or data elements used in the *decoding process* of subsequent sample values or data elements.

3.111 **primary coded picture**: The coded representation of a *picture* to be used by the *decoding process* for a bitstream conforming to this Recommendation | International Standard. The primary coded picture contains all *macroblocks* of the *picture*. The only *pictures* that have a normative effect on the *decoding process* are primary coded pictures. See also *redundant coded picture.*

3.112 **profile**: A specified subset of the syntax of this Recommendation | International Standard.

3.113 **quantisation parameter**: A variable used by the *decoding process* for *scaling* of *transform coefficient levels*.

3.114 **random access**: The act of starting the decoding process for a *bitstream* at a point other than the beginning of the stream.

3.115 **raster scan**: A mapping of a rectangular two-dimensional pattern to a one-dimensional pattern such that the first entries in the one-dimensional pattern are from the first top row of the two-dimensional pattern scanned from left to right, followed similarly by the second, third, etc., rows of the pattern (going down) each scanned from left to right.

3.116 **raw byte sequence payload (RBSP):** A syntax structure containing an integer number of *bytes* that is encapsulated in a *NAL unit*. An RBSP is either empty or has the form of a *string of data bits* containing *syntax elements* followed by an *RBSP stop bit* and followed by zero or more subsequent bits equal to 0.

3.117 **raw byte sequence payload (RBSP) stop bit:** A bit equal to 1 present within a *raw byte sequence payload (RBSP)* after a *string of data bits*. The location of the end of the *string of data bits* within an *RBSP* can be identified by searching from the end of the *RBSP* for the *RBSP stop bit*, which is the last non-zero bit in the *RBSP*.

3.118 **recovery point**: A point in the *bitstream* at which the recovery of an exact or an approximate representation of the *decoded pictures* represented by the *bitstream* is achieved after a *random access* or *broken link*.

3.119 **redundant coded picture**: A coded representation of a *picture* or a part of a *picture*. The content of a redundant coded picture shall not be used by the *decoding process* for a *bitstream* conforming to this Recommendation | International Standard. A *redundant coded picture* is not required to contain all *macroblocks* in the *primary coded picture*. Redundant coded pictures have no normative effect on the *decoding process*. See also *primary coded picture*.

3.120 **reference field**: A *reference field* may be used for *inter prediction* when *P*, *SP*, and *B slices* of a *coded field* or *field macroblocks* of a *coded frame* are decoded. See also *reference picture*.

3.121 **reference frame**: A *reference frame* may be used for *inter prediction* when *P*, *SP*, and *B slices* of a *coded frame* are decoded. See also *reference picture*.

3.122 **reference index**: An index into a *reference picture list*.

3.123 **reference picture**: A *picture* with nal_ref_idc not equal to 0. A *reference picture* contains samples that may be used for *inter prediction* in the *decoding process* of subsequent *pictures* in *decoding order*.

3.124 **reference picture list**: A list of *reference pictures* that is used for *inter prediction* of a *P*, *B*, or *SP slice*. For the *decoding process* of a *P* or *SP slice*, there is one reference picture list. For the *decoding process* of a *B slice*, there are two reference picture lists.

3.125 **reference picture list 0**: A *reference picture list* used for *inter prediction* of a *P*, *B*, or *SP slice*. All *inter prediction* used for *P* and *SP slices* uses reference picture list 0. Reference picture list 0 is one of two *reference picture lists* used for *inter prediction* for a *B slice*, with the other being *reference picture list 1*.

3.126 **reference picture list 1**: A *reference picture list* used for *inter prediction* of a *B slice*. Reference picture list 1 is one of two lists of *reference picture lists* used for *inter prediction* for a *B slice*, with the other being *reference picture list 0*.

3.127 **reference picture marking**: Specifies, in the bitstream, how the *decoded pictures* are marked for *inter prediction*.

3.128 **reserved**: The term reserved, when used in the clauses specifying some values of a particular *syntax element*, are for future use by ITU-T | ISO/IEC. These values shall not be used in *bitstreams* conforming to this Recommendation | International Standard, but may be used in future extensions of this Recommendation | International Standard by ITU-T | ISO/IEC.

3.129 **residual**: The decoded difference between a *prediction* of a sample or data element and its decoded value.

3.130 **run**: A number of consecutive data elements represented in the decoding process. In one context, the number of zero-valued *transform coefficient levels* preceding a non-zero *transform coefficient level* in the list of *transform coefficient levels* generated by a *zig-zag scan* or a *field scan*. In other contexts, run refers to a number of *macroblocks*.

3.131 **sample aspect ratio**: Specifies, for assisting the display process, which is not specified in this Recommendation | International Standard, the ratio between the intended horizontal distance between the columns and the intended vertical distance between the rows of the *luma* sample array in a *frame*. Sample aspect ratio is expressed as *h*:*v*, where *h* is horizontal width and *v* is vertical height (in arbitrary units of spatial distance).

3.132 **scaling**: The process of multiplying *transform coefficient levels* by a factor, resulting in *transform coefficients*.

3.133 **sequence parameter set**: A *syntax structure* containing *syntax elements* that apply to zero or more entire *coded video sequences* as determined by the content of a seq_parameter_set_id *syntax element* found in the *picture parameter set* referred to by the pic_parameter_set_id *syntax element* found in each *slice header*.

3.134 **shall**: A term used to express mandatory requirements for conformance to this Recommendation | International Standard. When used to express a mandatory constraint on the values of *syntax elements* or on the results obtained by operation of the specified *decoding process*, it is the responsibility of the *encoder* to ensure that the constraint is fulfilled. When used in reference to operations performed by the *decoding process*, any *decoding process* that produces identical results to the *decoding process* described herein conforms to the *decoding process* requirements of this Recommendation | International Standard.

3.135 **should**: A term used to refer to behaviour of an implementation that is encouraged to be followed under anticipated ordinary circumstances, but is not a mandatory requirement for conformance to this Recommendation | International Standard.

3.136 **SI slice**: A *slice* that is coded using *intra prediction* only and using quantisation of the *prediction* samples. An SI slice can be coded such that its decoded samples can be constructed identically to an *SP slice*.

3.137 **skipped macroblock**: A *macroblock* for which no data is coded other than an indication that the *macroblock* is to be decoded as "skipped". This indication may be common to several *macroblocks*.

3.138 **slice**: An integer number of *macroblocks* or *macroblock pairs* ordered consecutively in the *raster scan* within a particular *slice group*. For the *primary coded picture*, the division of each *slice group* into slices is a *partitioning*. Although a slice contains *macroblocks* or *macroblock pairs* that are consecutive in the *raster scan* within a *slice group*, these *macroblocks* or *macroblock pairs* are not necessarily consecutive in the *raster scan* within the *picture*. The *macroblock addresses* are derived from the first *macroblock address* in a slice (as represented in the *slice header*) and the *macroblock to slice group map*, and, when a *picture* is coded using three separate colour planes, a colour plane identifier.

3.139 **slice data partitioning**: A method of *partitioning* selected *syntax elements* into *syntax structures* based on a *category* associated with each *syntax element*.

3.140 **slice group**: A subset of the *macroblocks* or *macroblock pairs* of a *picture*. The division of the *picture* into slice groups is a *partitioning* of the *picture*. The partitioning is specified by the *macroblock to slice group map*.

3.141 **slice group map units**: The units of the *map unit to slice group map*.

3.142 **slice header**: A part of a coded *slice* containing the data elements pertaining to the first or all *macroblocks* represented in the *slice*.

3.143 **source**: Term used to describe the video material or some of its attributes before encoding.

3.144 **SP slice**: A *slice* that may be coded using *intra prediction* or *inter prediction* with quantisation of the *prediction* samples using at most one *motion vector* and *reference index* to *predict* the sample values of each *block*. An SP slice can be coded such that its decoded samples can be constructed identically to another SP slice or an *SI slice*.

3.145 **start code prefix**: A unique sequence of three *bytes* equal to 0x000001 embedded in the *byte stream* as a prefix to each *NAL unit*. The location of a start code prefix can be used by a *decoder* to identify the beginning of a new *NAL unit* and the end of a previous *NAL unit*. Emulation of start code prefixes is prevented within *NAL units* by the inclusion of *emulation prevention bytes*.

3.146 **string of data bits (SODB)**: A sequence of some number of bits representing *syntax elements* present within a *raw byte sequence payload* prior to the *raw byte sequence payload stop bit*. Within an SODB, the left-most bit is considered to be the first and most significant bit, and the right-most bit is considered to be the last and least significant bit.

3.147 **sub-macroblock**: One quarter of the samples of a *macroblock*, i.e., an 8x8 *luma block* and two corresponding *chroma blocks* of which one corner is located at a corner of the *macroblock* for a *picture* that has three sample arrays or an 8x8 *luma block* of which one corner is located at a corner of the *macroblock* for a monochrome *picture* or a *picture* that is coded using three separate colour planes.

3.148 **sub-macroblock partition**: A *block* of *luma* samples and two corresponding *blocks* of *chroma* samples resulting from a *partitioning* of a *sub-macroblock* for *inter prediction* for a *picture* that has three sample arrays or a *block* of *luma* samples resulting from a *partitioning* of a *sub-macroblock* for *inter prediction* for a monochrome *picture* or a *picture* that is coded using three separate colour planes.

3.149 **switching I slice**: See *SI slice*.

3.150 **switching P slice**: See *SP slice*.

3.151 **syntax element**: An element of data represented in the *bitstream*.

3.152 **syntax structure**: Zero or more *syntax elements* present together in the *bitstream* in a specified order.

3.153 **top field**: One of two *fields* that comprise a *frame*. Each row of a *top field* is spatially located immediately above the corresponding row of the *bottom field*.

3.154 **top macroblock (of a macroblock pair)**: The *macroblock* within a *macroblock pair* that contains the samples in the top row of samples for the *macroblock pair*. For a *field macroblock pair*, the top macroblock represents the samples from the region of the *top field* of the *frame* that lie within the spatial region of the *macroblock pair*. For a *frame macroblock pair*, the top macroblock represents the samples of the *frame* that lie within the top half of the spatial region of the *macroblock pair*.

3.155 **transform coefficient**: A scalar quantity, considered to be in a frequency domain, that is associated with a particular one-dimensional or two-dimensional *frequency index* in an *inverse transform* part of the *decoding process*.

3.156 **transform coefficient level**: An integer quantity representing the value associated with a particular two-dimensional frequency index in the *decoding process* prior to *scaling* for computation of a *transform coefficient* value.

3.157 **universal unique identifier (UUID)**: An identifier that is unique with respect to the space of all universal unique identifiers.

3.158 **unspecified:** The term unspecified, when used in the clauses specifying some values of a particular *syntax element*, indicates that the values have no specified meaning in this Recommendation | International Standard and will not have a specified meaning in the future as an integral part of this Recommendation | International Standard.

3.159 **variable length coding (VLC)**: A reversible procedure for entropy coding that assigns shorter bit strings to *symbols* expected to be more frequent and longer bit strings to *symbols* expected to be less frequent.

3.160 **VCL NAL unit**: A collective term for *coded slice NAL units* and *coded slice data partition NAL units*.

3.161 **zig-zag scan**: A specific sequential ordering of *transform coefficient levels* from (approximately) the lowest spatial frequency to the highest. Zig-zag scan is used for *transform coefficient levels* in *frame macroblocks.*

4 Abbreviations

For the purposes of this Recommendation | International Standard, the following abbreviations apply.

CABAC Context-based Adaptive Binary Arithmetic Coding

CAVLC Context-based Adaptive Variable Length Coding

CBR Constant Bit Rate

CPB Coded Picture Buffer

DPB Decoded Picture Buffer

DUT Decoder Under Test

FIFO First-In, First-Out

HRD Hypothetical Reference Decoder

HSS Hypothetical Stream Scheduler

IDR Instantaneous Decoding Refresh

LSB Least Significant Bit

MB Macroblock

MBAFF Macroblock-Adaptive Frame-Field Coding

MSB Most Significant Bit

NAL Network Abstraction Layer

RBSP Raw Byte Sequence Payload

SEI Supplemental Enhancement Information

SODB String Of Data Bits

SVC Scalable Video Coding

UUID Universal Unique Identifier

VBR Variable Bit Rate

VCL Video Coding Layer

VLC Variable Length Coding

VUI Video Usability Information

5 Conventions

NOTE – The mathematical operators used in this Specification are similar to those used in the C programming language. However, integer division and arithmetic shift operations are specifically defined. Numbering and counting conventions generally begin from 0.

5.1 Arithmetic operators

The following arithmetic operators are defined as follows.

\+ Addition

– Subtraction (as a two-argument operator) or negation (as a unary prefix operator)

*	Multiplication
x^y	Exponentiation. Specifies x to the power of y. In other contexts, such notation is used for superscripting not intended for interpretation as exponentiation.
/	Integer division with truncation of the result toward zero. For example, 7/4 and –7/–4 are truncated to 1 and –7/4 and 7/–4 are truncated to –1.
÷	Used to denote division in mathematical equations where no truncation or rounding is intended.
$\frac{x}{y}$	Used to denote division in mathematical equations where no truncation or rounding is intended.
$\sum_{i=x}^{y} f(i)$	The summation of f(i) with i taking all integer values from x up to and including y.
x % y	Modulus. Remainder of x divided by y, defined only for integers x and y with x >= 0 and y > 0.

When order of precedence is not indicated explicitly by use of parenthesis, the following rules apply:

– multiplication and division operations are considered to take place before addition and subtraction;

– multiplication and division operations in sequence are evaluated sequentially from left to right;

– addition and subtraction operations in sequence are evaluated sequentially from left to right.

5.2 Logical operators

The following logical operators are defined as follows:

x && y	Boolean logical "and" of x and y
x || y	Boolean logical "or" of x and y
!	Boolean logical "not"
x ? y : z	If x is TRUE or not equal to 0, evaluates to the value of y; otherwise, evaluates to the value of z

5.3 Relational operators

The following relational operators are defined as follows:

>	Greater than
>=	Greater than or equal to
<	Less than
<=	Less than or equal to
= =	Equal to
!=	Not equal to

When a relational operator is applied to a syntax element or variable that has been assigned the value "na" (not applicable), the value "na" is treated as a distinct value for the syntax element or variable. The value "na" is considered not to be equal to any other value.

5.4 Bit-wise operators

The following bit-wise operators are defined as follows:

&	Bit-wise "and". When operating on integer arguments, operates on a two's complement representation of the integer value. When operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0.
|	Bit-wise "or". When operating on integer arguments, operates on a two's complement representation of the integer value. When operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0.
x >> y	Arithmetic right shift of a two’s complement integer representation of x by y binary digits. This function is defined only for positive integer values of y. Bits shifted into the MSBs as a result of the right shift have a value equal to the MSB of x prior to the shift operation.

x << y Arithmetic left shift of a two's complement integer representation of x by y binary digits. This function is defined only for positive integer values of y. Bits shifted into the LSBs as a result of the left shift have a value equal to 0.

5.5 Assignment operators

The following arithmetic operators are defined as follows:

= Assignment operator.

++ Increment, i.e., x++ is equivalent to $x = x + 1$; when used in an array index, evaluates to the value of the variable prior to the increment operation.

–– Decrement, i.e., x–– is equivalent to $x = x - 1$; when used in an array index, evaluates to the value of the variable prior to the decrement operation.

+= Increment by amount specified, i.e., x += 3 is equivalent to x = x + 3, and x += (-3) is equivalent to x = x + (-3).

–= Decrement by amount specified, i.e., x –= 3 is equivalent to x = x – 3, and x –= (-3) is equivalent to x = x – (-3).

5.6 Range notation

The following notation is used to specify a range of values:

x = y .. z x takes on integer values starting from y to z inclusive, with x, y, and z being integer numbers.

5.7 Mathematical functions

The following mathematical functions are defined as follows:

$$\text{Abs}(x) = \begin{cases} x & ; \quad x >= 0 \\ -x & ; \quad x < 0 \end{cases} \tag{5-1}$$

Ceil(x) the smallest integer greater than or equal to x. (5-2)

$$\text{Clip1}_Y(x) = \text{Clip3}(0, (1 << \text{BitDepth}_Y) - 1, x) \tag{5-3}$$

$$\text{Clip1}_C(x) = \text{Clip3}(0, (1 << \text{BitDepth}_C) - 1, x) \tag{5-4}$$

$$\text{Clip3}(x, y, z) = \begin{cases} x & ; \quad z < x \\ y & ; \quad z > y \\ z & ; \quad \text{otherwise} \end{cases} \tag{5-5}$$

Floor(x) the greatest integer less than or equal to x. (5-6)

$$\text{InverseRasterScan}(a, b, c, d, e) = \begin{cases} (a\%(d/b))*b; & e == 0 \\ (a/(d/b))*c; & e == 1 \end{cases} \tag{5-7}$$

Log2(x) returns the base-2 logarithm of x. (5-8)

Log10(x) returns the base-10 logarithm of x. (5-9)

$$\text{Median}(x, y, z) = x + y + z - \text{Min}(x, \text{Min}(y, z)) - \text{Max}(x, \text{Max}(y, z)) \quad (5\text{-}10)$$

$$\text{Min}(x, y) = \begin{cases} x & ; \quad x <= y \\ y & ; \quad x > y \end{cases} \quad (5\text{-}11)$$

$$\text{Max}(x, y) = \begin{cases} x & ; \quad x >= y \\ y & ; \quad x < y \end{cases} \quad (5\text{-}12)$$

$$\text{Round}(x) = \text{Sign}(x) * \text{Floor}(\text{Abs}(x) + 0.5) \quad (5\text{-}13)$$

$$\text{Sign}(x) = \begin{cases} 1 & ; \quad x >= 0 \\ -1 & ; \quad x < 0 \end{cases} \quad (5\text{-}14)$$

$$\text{Sqrt}(x) = \sqrt{x} \quad (5\text{-}15)$$

5.8 Variables, syntax elements, and tables

Syntax elements in the bitstream are represented in **bold** type. Each syntax element is described by its name (all lower case letters with underscore characters), its one or two syntax categories, and one or two descriptors for its method of coded representation. The decoding process behaves according to the value of the syntax element and to the values of previously decoded syntax elements. When a value of a syntax element is used in the syntax tables or the text, it appears in regular (i.e., not bold) type.

In some cases the syntax tables may use the values of other variables derived from syntax elements values. Such variables appear in the syntax tables, or text, named by a mixture of lower case and upper case letter and without any underscore characters. Variables starting with an upper case letter are derived for the decoding of the current syntax structure and all depending syntax structures. Variables starting with an upper case letter may be used in the decoding process for later syntax structures mentioning the originating syntax structure of the variable. Variables starting with a lower case letter are only used within the subclause in which they are derived.

In some cases, "mnemonic" names for syntax element values or variable values are used interchangeably with their numerical values. Sometimes "mnemonic" names are used without any associated numerical values. The association of values and names is specified in the text. The names are constructed from one or more groups of letters separated by an underscore character. Each group starts with an upper case letter and may contain more upper case letters.

NOTE – The syntax is described in a manner that closely follows the C-language syntactic constructs.

Functions are described by their names, which are constructed as syntax element names, with left and right round parentheses including zero or more variable names (for definition) or values (for usage), separated by commas (if more than one variable).

A one-dimensional array is referred to as a list. A two-dimensional array is referred to as a matrix. Arrays can either be syntax elements or variables. Subscripts or square parentheses are used for the indexing of arrays. In reference to a visual depiction of a matrix, the first subscript is used as a row (vertical) index and the second subscript is used as a column (horizontal) index. The indexing order is reversed when using square parentheses rather than subscripts for indexing. Thus, an element of a matrix s at horizontal position x and vertical position y may be denoted either as s[x, y] or as s_{yx}.

Binary notation is indicated by enclosing the string of bit values by single quote marks. For example, '01000001' represents an eight-bit string having only its second and its last bits equal to 1.

Hexadecimal notation, indicated by prefixing the hexadecimal number by "0x", may be used instead of binary notation when the number of bits is an integer multiple of 4. For example, 0x41 represents an eight-bit string having only its second and its last bits equal to 1.

Numerical values not enclosed in single quotes and not prefixed by "0x" are decimal values.

A value equal to 0 represents a FALSE condition in a test statement. The value TRUE is represented by any other value different than zero.

5.9 Text description of logical operations

In the text, a statement of logical operations as would be described in pseudo-code as

```
if( condition 0 )
  statement 0
else if ( condition 1 )
  statement 1
…
else /* informative remark on remaining condition */
  statement n
```

may be described in the following manner:

... as follows / ... the following applies.

- If condition 0, statement 0
- Otherwise, if condition 1, statement 1
- …
- Otherwise (informative remark on remaining condition), statement n

Each "If...Otherwise, if...Otherwise, ..." statement in the text is introduced with "... as follows" or "... the following applies" immediately followed by "If ... ". The last condition of the "If...Otherwise, if...Otherwise, ..." is always an "Otherwise, ...". Interleaved "If...Otherwise, if...Otherwise, ..." statements can be identified by matching "... as follows" or "... the following applies" with the ending "Otherwise, ...".

In the text, a statement of logical operations as would be described in pseudo-code as

```
if( condition 0a  &&  condition 0b )
  statement 0
else if ( condition 1a  ||  condition 1b )
  statement 1
…
else
  statement n
```

may be described in the following manner:

... as follows / ... the following applies.

- If all of the following conditions are true, statement 0
  - condition 0a
  - condition 0b
- Otherwise, if any of the following conditions are true, statement 1
  - condition 1a
  - condition 1b
- …
- Otherwise, statement n

In the text, a statement of logical operations as would be described in pseudo-code as

```
if( condition 0 )
  statement 0
if ( condition 1 )
  statement 1
```

may be described in the following manner:

When condition 0, statement 0

When condition 1, statement 1

5.10 Processes

Processes are used to describe the decoding of syntax elements. A process has a separate specification and invoking. All syntax elements and upper case variables that pertain to the current syntax structure and depending syntax structures are available in the process specification and invoking. A process specification may also have a lower case variable explicitly specified as the input. Each process specification has explicitly specified an output. The output is a variable that can either be an upper case variable or a lower case variable.

The assignment of variables is specified as follows:

- If invoking a process, variables are explicitly assigned to lower case input or output variables of the process specification in case these do not have the same name.
- Otherwise (when the variables at the invoking and specification have the same name), assignment is implied.

In the specification of a process, a specific macroblock may be referred to by the variable name having a value equal to the address of the specific macroblock.

6 Source, coded, decoded and output data formats, scanning processes, and neighbouring relationships

6.1 Bitstream formats

This subclause specifies the relationship between the NAL unit stream and byte stream, either of which are referred to as the bitstream.

The bitstream can be in one of two formats: the NAL unit stream format or the byte stream format. The NAL unit stream format is conceptually the more "basic" type. It consists of a sequence of syntax structures called NAL units. This sequence is ordered in decoding order. There are constraints imposed on the decoding order (and contents) of the NAL units in the NAL unit stream.

The byte stream format can be constructed from the NAL unit stream format by ordering the NAL units in decoding order and prefixing each NAL unit with a start code prefix and zero or more zero-valued bytes to form a stream of bytes. The NAL unit stream format can be extracted from the byte stream format by searching for the location of the unique start code prefix pattern within this stream of bytes. Methods of framing the NAL units in a manner other than use of the byte stream format are outside the scope of this Recommendation | International Standard. The byte stream format is specified in Annex B.

6.2 Source, decoded, and output picture formats

This subclause specifies the relationship between source and decoded frames and fields that is given via the bitstream.

The video source that is represented by the bitstream is a sequence of either or both frames or fields (called collectively pictures) in decoding order.

The source and decoded pictures (frames or fields) are each comprised of one or more sample arrays:

- Luma (Y) only (monochrome), with or without an auxiliary array.
- Luma and two Chroma (YCbCr or YCgCo), with or without an auxiliary array.
- Green, Blue and Red (GBR, also known as RGB), with or without an auxiliary array.
- Arrays representing other unspecified monochrome or tri-stimulus colour samplings (for example, YZX, also known as XYZ), with or without an auxiliary array.

For convenience of notation and terminology in this specification, the variables and terms associated with these arrays are referred to as luma (or L or Y) and chroma, where the two chroma arrays are referred to as Cb and Cr; regardless of the actual colour representation method in use. The actual colour representation method in use can be indicated in syntax that is specified in Annex E. The (monochrome) auxiliary arrays, which may or may not be present as auxiliary pictures in a coded video sequence, are optional for decoding and can be used for such purposes as alpha blending.

The variables SubWidthC, and SubHeightC are specified in Table 6-1, depending on the chroma format sampling structure, which is specified through chroma_format_idc and separate_colour_plane_flag. An entry marked as "-" in Table 6-1 denotes an undefined value for SubWidthC or SubHeightC. Other values of chroma_format_idc, SubWidthC, and SubHeightC may be specified in the future by ITU-T | ISO/IEC.

Table 6-1 – SubWidthC, and SubHeightC values derived from chroma_format_idc and separate_colour_plane_flag

chroma_format_idc	separate_colour_plane_flag	Chroma Format	SubWidthC	SubHeightC
0	0	monochrome	–	–
1	0	4:2:0	2	2
2	0	4:2:2	2	1
3	0	4:4:4	1	1
3	1	4:4:4	-	-

In monochrome sampling there is only one sample array, which is nominally considered the luma array.

In 4:2:0 sampling, each of the two chroma arrays has half the height and half the width of the luma array.

In 4:2:2 sampling, each of the two chroma arrays has the same height and half the width of the luma array.

In 4:4:4 sampling, depending on the value of separate_colour_plane_flag, the following applies.

– If separate_colour_plane_flag is equal to 0, each of the two chroma arrays has the same height and width as the luma array.

– Otherwise (separate_colour_plane_flag is equal to 1), the three colour planes are separately processed as monochrome sampled pictures.

The width and height of the luma sample arrays are each an integer multiple of 16. In coded video sequences using 4:2:0 chroma sampling, the width and height of chroma sample arrays are each an integer multiple of 8. In coded vide sequences using 4:2:2 sampling, the width of the chroma sample arrays is an integer multiple of 8 and the height is an integer multiple of 16. The height of a luma array that is coded as two separate fields or in macroblock-adaptive frame-field coding (see below) is an integer multiple of 32. In coded video sequences using 4:2:0 chroma sampling, the height of each chroma array that is coded as two separate fields or in macroblock-adaptive frame-field coding (see below) is an integer multiple of 16. The width or height of pictures output from the decoding process need not be an integer multiple of 16 and can be specified using a cropping rectangle.

The syntax for the luma and (when present) chroma arrays are ordered such when data for all three colour components is present, the data for the luma array is first, followed by any data for the Cb array, followed by any data for the Cr array, unless otherwise specified.

The width of fields coded referring to a specific sequence parameter set is the same as that of frames coded referring to the same sequence parameter set (see below). The height of fields coded referring to a specific sequence parameter set is half that of frames coded referring to the same sequence parameter set (see below).

The number of bits necessary for the representation of each of the samples in the luma and chroma arrays in a video sequence is in the range of 8 to 14, and the number of bits used in the luma array may differ from the number of bits used in the chroma arrays.

When the value of chroma_format_idc is equal to 1, the nominal vertical and horizontal relative locations of luma and chroma samples in frames are shown in Figure 6-1. Alternative chroma sample relative locations may be indicated in video usability information (see Annex E).

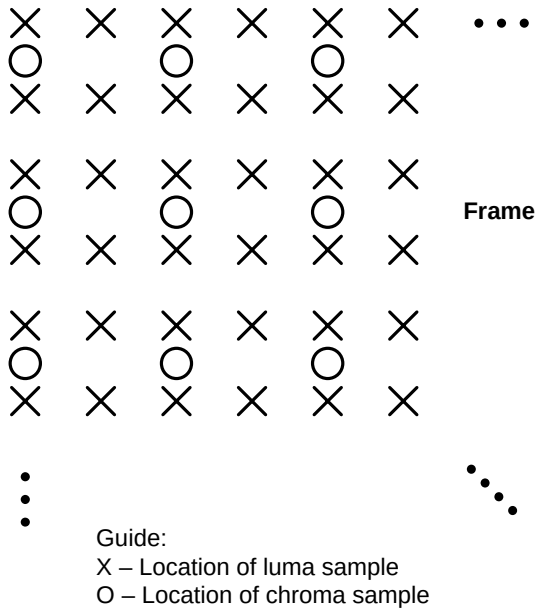


Figure 6-1 – Nominal vertical and horizontal locations of 4:2:0 luma and chroma samples in a frame

A frame consists of two fields as described below. A coded picture may represent a coded frame or an individual coded field. A coded video sequence conforming to this Recommendation | International Standard may contain arbitrary combinations of coded frames and coded fields. The decoding process is also specified in a manner that allows smaller regions of a coded frame to be coded either as a frame or field region, by use of macroblock-adaptive frame-field coding.

Source and decoded fields are one of two types: top field or bottom field. When two fields are output at the same time, or are combined to be used as a reference frame (see below), the two fields (which shall be of opposite parity) are interleaved. The first (i.e., top), third, fifth, etc., rows of a decoded frame are the top field rows. The second, fourth, sixth, etc., rows of a decoded frame are the bottom field rows. A top field consists of only the top field rows of a decoded frame. When the top field or bottom field of a decoded frame is used as a reference field (see below) only the even rows (for a top field) or the odd rows (for a bottom field) of the decoded frame are used.

When the value of chroma_format_idc is equal to 1, the nominal vertical and horizontal relative locations of luma and chroma samples in top and bottom fields are shown in Figure 6-2. The nominal vertical sampling relative locations of the chroma samples in a top field are specified as shifted up by one-quarter luma sample height relative to the field-sampling grid. The vertical sampling locations of the chroma samples in a bottom field are specified as shifted down by one-quarter luma sample height relative to the field-sampling grid. Alternative chroma sample relative locations may be indicated in the video usability information (see Annex E).

NOTE – The shifting of the chroma samples is in order for these samples to align vertically to the usual location relative to the full-frame sampling grid as shown in Figure 6-1.

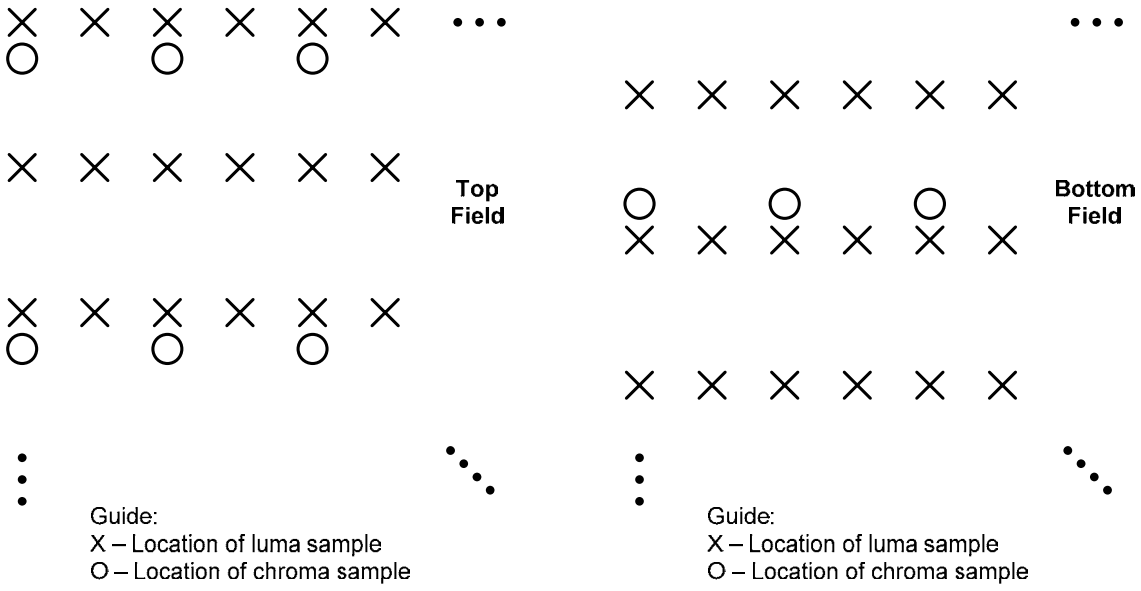


Figure 6-2 – Nominal vertical and horizontal sampling locations of 4:2:0 samples in top and bottom fields

When the value of chroma_format_idc is equal to 2, the chroma samples are co-sited with the corresponding luma samples and the nominal locations in a frame and in fields are as shown in Figure 6-3 and Figure 6-4, respectively.

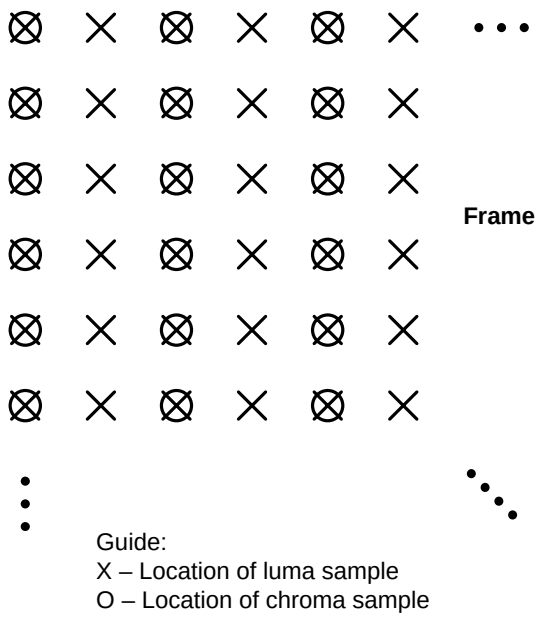


Figure 6-3 – Nominal vertical and horizontal locations of 4:2:2 luma and chroma samples in a frame

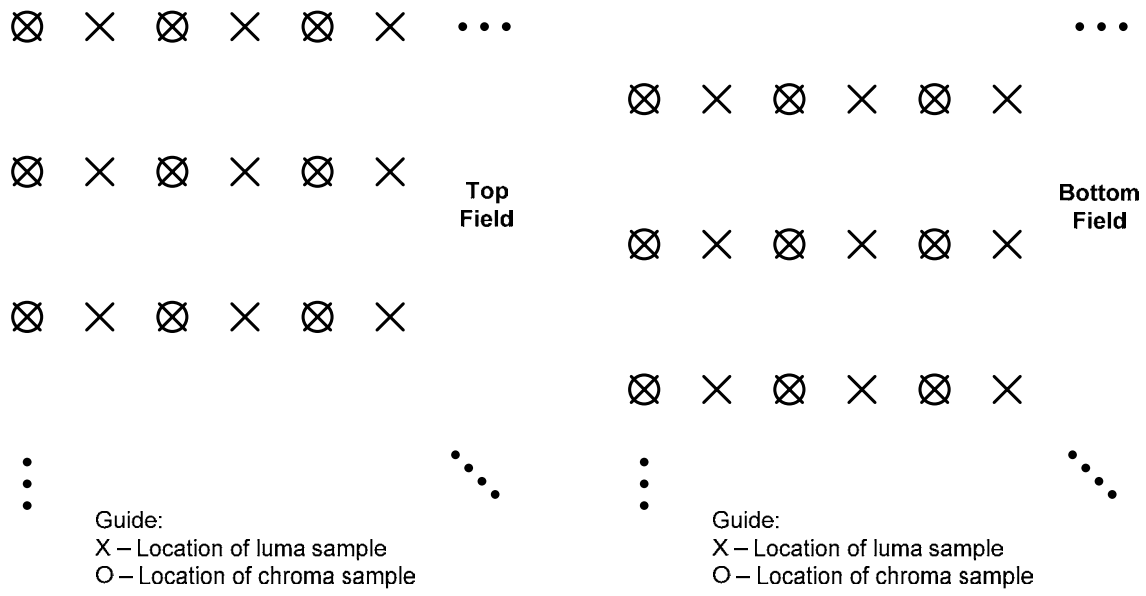


Figure 6-4 – Nominal vertical and horizontal sampling locations of 4:2:2 samples top and bottom fields

When the value of chroma_format_idc is equal to 3, all array samples are co-sited for all cases of frames and fields and the nominal locations in a frame and in fields are as shown in Figure 6-5 and 6-6, respectively.

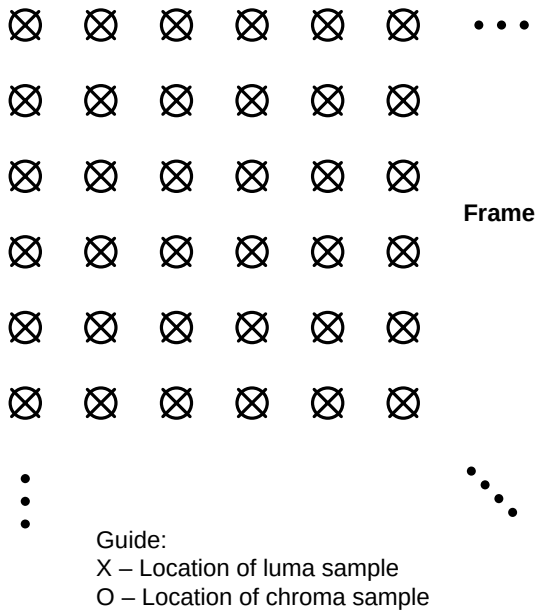


Figure 6-5 – Nominal vertical and horizontal locations of 4:4:4 luma and chroma samples in a frame

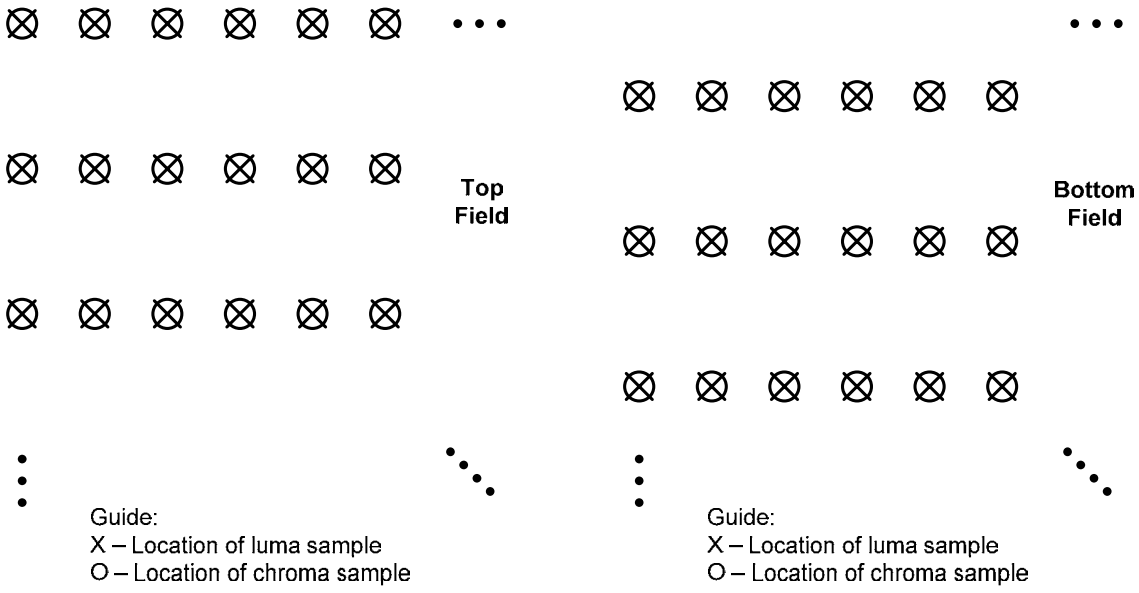


Figure 6-6 – Nominal vertical and horizontal sampling locations of 4:4:4 samples top and bottom fields

The samples are processed in units of macroblocks. The luma array for each macroblock is 16 samples in both width and height. The variables MbWidthC and MbHeightC, which specify the width and height, respectively, of the chroma arrays for each macroblock, are derived as follows.

– If chroma_format_idc is equal to 0 (monochrome) or separate_colour_plane_flag is equal to 1, MbWidthC and MbHeightC are both equal to 0.

– Otherwise, MbWidthC and MbHeightC are derived as

$$MbWidthC = 16 / SubWidthC \tag{6-1}$$

$$MbHeightC = 16 / SubHeightC \tag{6-2}$$

6.3 Spatial subdivision of pictures and slices

This subclause specifies how a picture is partitioned into slices and macroblocks. Pictures are divided into slices. A slice is a sequence of macroblocks, or, when macroblock-adaptive frame/field decoding is in use, a sequence of macroblock pairs.

Each macroblock is comprised of one 16x16 luma array and, when the chroma sampling format is not equal to 4:0:0 and separate_colour_plane_flag is equal to 0, two corresponding chroma sample arrays. When separate_colour_plane_flag is equal to 1, each macroblock is comprised of one 16x16 luma or chroma sample array. When macroblock-adaptive frame/field decoding is not in use, each macroblock represents a spatial rectangular region of the picture. For example, a picture may be divided into two slices as shown in Figure 6-7.

When a picture is coded using three separate colour planes (separate_colour_plane_flag is equal to 1), a slice contains only macroblocks of one colour component being identified by the corresponding value of colour_plane_id, and each colour component array of a picture consists of slices having the same colour_plane_id value. Coded slices with different values of colour_plane_id within an access unit can be interleaved with each other under the constraint that for each value of colour_plane_id, the coded slice NAL units with that value colour_plane_id shall be in the order of increasing macroblock address for the first macroblock of each coded slice NAL unit.

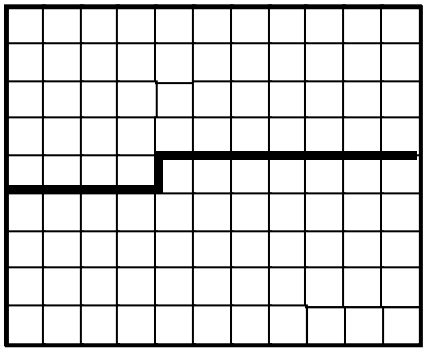


Figure 6-7 – A picture with 11 by 9 macroblocks that is partitioned into two slices

When macroblock-adaptive frame/field decoding is in use, the picture is partitioned into slices containing an integer number of macroblock pairs as shown in Figure 6-8. Each macroblock pair consists of two macroblocks.

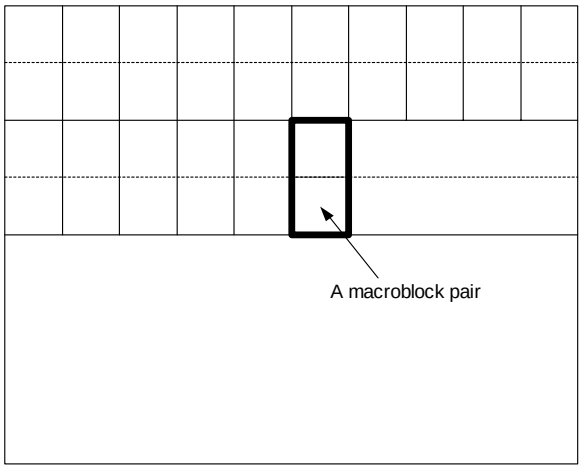


Figure 6-8 – Partitioning of the decoded frame into macroblock pairs

6.4 Inverse scanning processes and derivation processes for neighbours

This subclause specifies inverse scanning processes; i.e., the mapping of indices to locations, and derivation processes for neighbours.

6.4.1 Inverse macroblock scanning process

Input to this process is a macroblock address mbAddr.

Output of this process is the location (x, y) of the upper-left luma sample for the macroblock with address mbAddr relative to the upper-left sample of the picture.

The inverse macroblock scanning process is specified as follows.

– If MbaffFrameFlag is equal to 0,

$$x = InverseRasterScan(mbAddr, 16, 16, PicWidthInSamples_L, 0) \quad (6\text{-}3)$$

$$y = InverseRasterScan(mbAddr, 16, 16, PicWidthInSamples_L, 1) \quad (6\text{-}4)$$

– Otherwise (MbaffFrameFlag is equal to 1), the following applies.

$$xO = InverseRasterScan(mbAddr / 2, 16, 32, PicWidthInSamples_L, 0) \quad (6\text{-}5)$$

$$yO = InverseRasterScan(mbAddr / 2, 16, 32, PicWidthInSamples_L, 1) \quad (6\text{-}6)$$

Depending on the current macroblock the following applies.

– If the current macroblock is a frame macroblock

$$x = xO \quad (6\text{-}7)$$

$$y = yO + (mbAddr \% 2) * 16 \quad (6\text{-}8)$$

– Otherwise (the current macroblock is a field macroblock),

$$x = xO \quad (6\text{-}9)$$

$$y = yO + (mbAddr \% 2) \quad (6\text{-}10)$$

6.4.2 Inverse macroblock partition and sub-macroblock partition scanning process

Macroblocks or sub-macroblocks may be partitioned, and the partitions are scanned for inter prediction as shown in Figure 6-9. The outer rectangles refer to the samples in a macroblock or sub-macroblock, respectively. The rectangles refer to the partitions. The number in each rectangle specifies the index of the inverse macroblock partition scan or inverse sub-macroblock partition scan.

The functions MbPartWidth( ), MbPartHeight( ), SubMbPartWidth( ), and SubMbPartHeight( ) describing the width and height of macroblock partitions and sub-macroblock partitions are specified in Tables 7-13, 7-14, 7-17, and 7-18. MbPartWidth( ) and MbPartHeight( ) are set to appropriate values for each macroblock, depending on the macroblock type. SubMbPartWidth( ) and SubMbPartHeight( ) are set to appropriate values for each sub-macroblock of a macroblock with mb_type equal to P_8x8, P_8x8ref0, or B_8x8, depending on the sub-macroblock type.

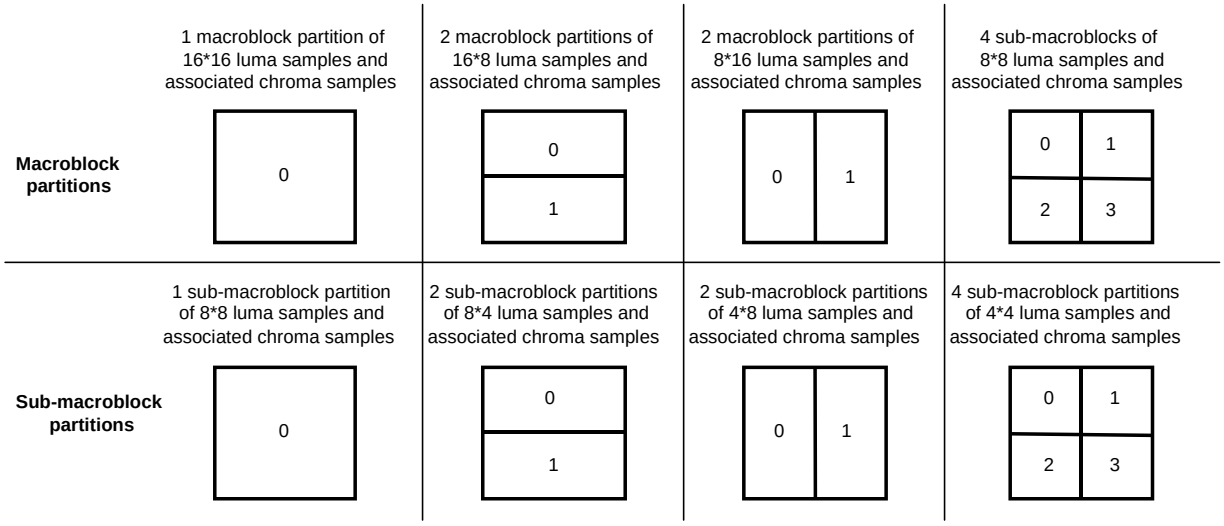


Figure 6-9 – Macroblock partitions, sub-macroblock partitions, macroblock partition scans, and sub-macroblock partition scans

6.4.2.1 Inverse macroblock partition scanning process

Input to this process is the index of a macroblock partition mbPartIdx.

Output of this process is the location (x, y) of the upper-left luma sample for the macroblock partition mbPartIdx relative to the upper-left sample of the macroblock.

The inverse macroblock partition scanning process is specified by

$$x = \text{InverseRasterScan}(\text{mbPartIdx}, \text{MbPartWidth}(\text{mb\_type}), \text{MbPartHeight}(\text{mb\_type}), 16, 0) \quad (6\text{-}11)$$

$$y = \text{InverseRasterScan}(\text{mbPartIdx}, \text{MbPartWidth}(\text{mb\_type}), \text{MbPartHeight}(\text{mb\_type}), 16, 1) \quad (6\text{-}12)$$

6.4.2.2 Inverse sub-macroblock partition scanning process

Inputs to this process are the index of a macroblock partition mbPartIdx and the index of a sub-macroblock partition subMbPartIdx.

Output of this process is the location (x, y) of the upper-left luma sample for the sub-macroblock partition subMbPartIdx relative to the upper-left sample of the sub-macroblock.

The inverse sub-macroblock partition scanning process is specified as follows.

– If mb_type is equal to P_8x8, P_8x8ref0, or B_8x8,

$$x = \text{InverseRasterScan}(\text{subMbPartIdx}, \text{SubMbPartWidth}(\text{sub\_mb\_type}[\text{mbPartIdx}]), \text{SubMbPartHeight}(\text{sub\_mb\_type}[\text{mbPartIdx}]), 8, 0) \quad (6\text{-}13)$$

$$y = \text{InverseRasterScan}(\text{subMbPartIdx}, \text{SubMbPartWidth}(\text{sub\_mb\_type}[\text{mbPartIdx}]), \text{SubMbPartHeight}(\text{sub\_mb\_type}[\text{mbPartIdx}]), 8, 1) \quad (6\text{-}14)$$

– Otherwise,

$$x = \text{InverseRasterScan}(\text{subMbPartIdx}, 4, 4, 8, 0) \quad (6\text{-}15)$$

$$y = \text{InverseRasterScan}(\text{subMbPartIdx}, 4, 4, 8, 1) \quad (6\text{-}16)$$

6.4.3 Inverse 4x4 luma block scanning process

Input to this process is the index of a 4x4 luma block luma4x4BlkIdx.

Output of this process is the location (x, y) of the upper-left luma sample for the 4x4 luma block with index luma4x4BlkIdx relative to the upper-left luma sample of the macroblock.

Figure 6-10 shows the scan for the 4x4 luma blocks.

0	1	4	5
2	3	6	7
8	9	12	13
10	11	14	15

Figure 6-10 – Scan for 4x4 luma blocks

The inverse 4x4 luma block scanning process is specified by

x = InverseRasterScan(luma4x4BlkIdx / 4, 8, 8, 16, 0) + InverseRasterScan(luma4x4BlkIdx % 4, 4, 4, 8, 0) (6-17)

y = InverseRasterScan(luma4x4BlkIdx / 4, 8, 8, 16, 1) + InverseRasterScan(luma4x4BlkIdx % 4, 4, 4, 8, 1) (6-18)

6.4.4 Inverse 4x4 Cb or Cr block scanning process for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The inverse 4x4 chroma block scanning process is identical to inverse 4x4 luma block scanning process as specified in subclause 6.4.3 when substituting the term “luma” with the term “Cb” or the term “Cr”, and substituting the term “luma4x4BlkIdx” with the term “cb4x4BlkIdx” or the term “cr4x4BlkIdx” in all places in subclause 6.4.3.

6.4.5 Inverse 8x8 luma block scanning process

Input to this process is the index of an 8x8 luma block luma8x8BlkIdx.

Output of this process is the location (x, y) of the upper-left luma sample for the 8x8 luma block with index luma8x8BlkIdx relative to the upper-left luma sample of the macroblock.

Figure 6-11 shows the scan for the 8x8 luma blocks.

0	1
2	3

Figure 6-11 – Scan for 8x8 luma blocks

The inverse 8x8 luma block scanning process is specified by

x = InverseRasterScan(luma8x8BlkIdx, 8, 8, 16, 0) (6-19)

y = InverseRasterScan(luma8x8BlkIdx, 8, 8, 16, 1) (6-20)

6.4.6 Inverse 8x8 Cb or Cr block scanning process for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The inverse 8x8 chroma block scanning process is identical to inverse 8x8 luma block scanning process as specified in subclause 6.4.5 when substituting the term “luma” with the term “Cb” or the term “Cr”, and substituting the term “luma8x8BlkIdx” with the term “cb8x8BlkIdx” or the term “cr8x8BlkIdx” in all places in subclause 6.4.5.

6.4.7 Derivation process of the availability for macroblock addresses

Input to this process is a macroblock address mbAddr.

Output of this process is the availability of the macroblock mbAddr.

NOTE – The meaning of availability is determined when this process is invoked.

The macroblock is marked as available, unless one of the following conditions is true in which case the macroblock is marked as not available:

– mbAddr < 0

– mbAddr > CurrMbAddr

– the macroblock with address mbAddr belongs to a different slice than the macroblock with address CurrMbAddr

6.4.8 Derivation process for neighbouring macroblock addresses and their availability

This process can only be invoked when MbaffFrameFlag is equal to 0.

The outputs of this process are:

– mbAddrA: the address and availability status of the macroblock to the left of the current macroblock.

– mbAddrB: the address and availability status of the macroblock above the current macroblock.

– mbAddrC: the address and availability status of the macroblock above-right of the current macroblock.

– mbAddrD: the address and availability status of the macroblock above-left of the current macroblock.

Figure 6-12 shows the relative spatial locations of the macroblocks with mbAddrA, mbAddrB, mbAddrC, and mbAddrD relative to the current macroblock with CurrMbAddr.

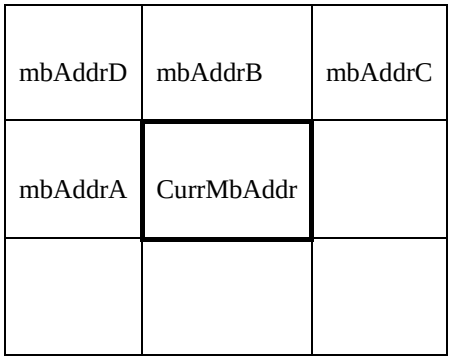


Figure 6-12 – Neighbouring macroblocks for a given macroblock

Input to the process in subclause 6.4.7 is mbAddrA = CurrMbAddr – 1 and the output is whether the macroblock mbAddrA is available. In addition, mbAddrA is marked as not available when CurrMbAddr % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.7 is mbAddrB = CurrMbAddr – PicWidthInMbs and the output is whether the macroblock mbAddrB is available.

Input to the process in subclause 6.4.7 is mbAddrC = CurrMbAddr – PicWidthInMbs + 1 and the output is whether the macroblock mbAddrC is available. In addition, mbAddrC is marked as not available when (CurrMbAddr + 1) % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.7 is mbAddrD = CurrMbAddr – PicWidthInMbs - 1 and the output is whether the macroblock mbAddrD is available. In addition, mbAddrD is marked as not available when CurrMbAddr % PicWidthInMbs is equal to 0.

6.4.9 Derivation process for neighbouring macroblock addresses and their availability in MBAFF frames

This process can only be invoked when MbaffFrameFlag is equal to 1.

The outputs of this process are

– mbAddrA: the address and availability status of the top macroblock of the macroblock pair to the left of the current macroblock pair.

– mbAddrB: the address and availability status of the top macroblock of the macroblock pair above the current macroblock pair.

– mbAddrC: the address and availability status of the top macroblock of the macroblock pair above-right of the current macroblock pair.

– mbAddrD: the address and availability status of the top macroblock of the macroblock pair above-left of the current macroblock pair.

Figure 6-13 shows the relative spatial locations of the macroblocks with mbAddrA, mbAddrB, mbAddrC, and mbAddrD relative to the current macroblock with CurrMbAddr.

mbAddrA, mbAddrB, mbAddrC, and mbAddrD have identical values regardless whether the current macroblock is the top or the bottom macroblock of a macroblock pair.

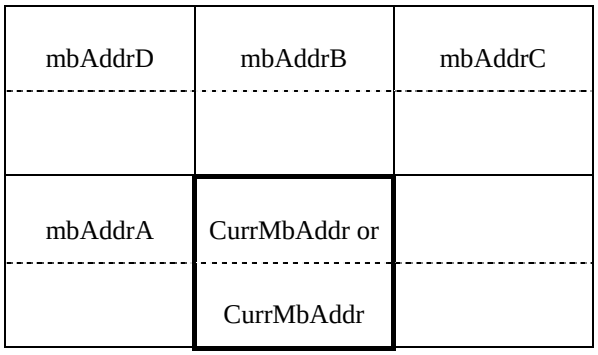


Figure 6-13 – Neighbouring macroblocks for a given macroblock in MBAFF frames

Input to the process in subclause 6.4.7 is mbAddrA = 2 * (CurrMbAddr / 2 – 1) and the output is whether the macroblock mbAddrA is available. In addition, mbAddrA is marked as not available when (CurrMbAddr / 2) % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.7 is mbAddrB = 2 * (CurrMbAddr / 2 – PicWidthInMbs) and the output is whether the macroblock mbAddrB is available.

Input to the process in subclause 6.4.7 is mbAddrC = 2 * (CurrMbAddr / 2 – PicWidthInMbs + 1) and the output is whether the macroblock mbAddrC is available. In addition, mbAddrC is marked as not available when (CurrMbAddr / 2 + 1) % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.7 is mbAddrD = 2 * (CurrMbAddr / 2 – PicWidthInMbs - 1) and the output is whether the macroblock mbAddrD is available. In addition, mbAddrD is marked as not available when (CurrMbAddr / 2) % PicWidthInMbs is equal to 0.

6.4.10 Derivation processes for neighbouring macroblocks, blocks, and partitions

Subclause 6.4.10.1 specifies the derivation process for neighbouring macroblocks.

Subclause 6.4.10.2 specifies the derivation process for neighbouring 8x8 luma blocks.

Subclause 6.4.10.3 specifies the derivation process for neighbouring 8x8 chroma blocks for ChromaArrayType equal to 3.

Subclause 6.4.10.4 specifies the derivation process for neighbouring 4x4 luma blocks.

Subclause 6.4.10.5 specifies the derivation process for neighbouring 4x4 chroma blocks.

Subclause 6.4.10.6 specifies the derivation process for neighbouring 4x4 chroma blocks for ChromaArrayType equal to 3.

Subclause 6.4.10.7 specifies the derivation process for neighbouring partitions.

Table 6-2 specifies the values for the difference of luma location (xD, yD) for the input and the replacement for N in mbAddrN, mbPartIdxN, subMbPartIdxN, luma8x8BlkIdxN, cb8x8BlkIdxN, cr8x8BlkIdxN, luma4x4BlkIdxN, cb4x4BlkIdxN, cr4x4BlkIdxN, and chroma4x4BlkIdxN for the output. These input and output assignments are used in subclauses 6.4.10.1 to 6.4.10.7. The variable predPartWidth is specified when Table 6-2 is referred to.

Table 6-2 – Specification of input and output assignments for subclauses 6.4.10.1 to 6.4.10.7

N	xD	yD
A	-1	0
B	0	-1
C	predPartWidth	-1
D	-1	-1

Figure 6-14 illustrates the relative location of the neighbouring macroblocks, blocks, or partitions A, B, C, and D to the current macroblock, partition, or block, when the current macroblock, partition, or block is in frame coding mode.

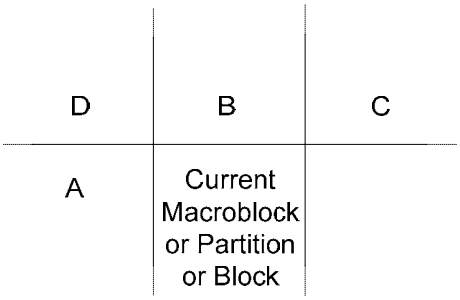


Figure 6-14 – Determination of the neighbouring macroblock, blocks, and partitions (informative)

6.4.10.1 Derivation process for neighbouring macroblocks

Outputs of this process are

– mbAddrA: the address of the macroblock to the left of the current macroblock and its availability status and

– mbAddrB: the address of the macroblock above the current macroblock and its availability status.

mbAddrN (with N being A or B) is derived as follows:

– The difference of luma location (xD, yD) is set according to Table 6-2.

– The derivation process for neighbouring locations as specified in subclause 6.4.11 is invoked for luma locations with (xN, yN) equal to (xD, yD), and the output is assigned to mbAddrN.

6.4.10.2 Derivation process for neighbouring 8x8 luma block

Input to this process is an 8x8 luma block index luma8x8BlkIdx.

The luma8x8BlkIdx specifies the 8x8 luma blocks of a macroblock in a raster scan.

Outputs of this process are

– mbAddrA: either equal to CurrMbAddr or the address of the macroblock to the left of the current macroblock and its availability status,

– luma8x8BlkIdxA: the index of the 8x8 luma block to the left of the 8x8 block with index luma8x8BlkIdx and its availability status,

– mbAddrB: either equal to CurrMbAddr or the address of the macroblock above the current macroblock and its availability status,

– luma8x8BlkIdxB: the index of the 8x8 luma block above the 8x8 block with index luma8x8BlkIdx and its availability status.

mbAddrN and luma8x8BlkIdxN (with N being A or B) are derived as follows.

– The difference of luma location (xD, yD) is set according to Table 6-2.

– The luma location (xN, yN) is specified by

$$xN = (luma8x8BlkIdx \% 2) * 8 + xD \quad (6\text{-}21)$$

$$yN = (luma8x8BlkIdx / 2) * 8 + yD \quad (6\text{-}22)$$

– The derivation process for neighbouring locations as specified in subclause 6.4.11 is invoked for luma locations with (xN, yN) as the input and the output is assigned to mbAddrN and (xW, yW).

– The variable luma8x8BlkIdxN is derived as follows.

  – If mbAddrN is not available, luma8x8BlkIdxN is marked as not available.

  – Otherwise (mbAddrN is available), the 8x8 luma block in the macroblock mbAddrN covering the luma location (xW, yW) is assigned to luma8x8BlkIdxN.

6.4.10.3 Derivation process for neighbouring 8x8 chroma blocks for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The derivation process for neighbouring 8x8 chroma block is identical to the derivation process for neighbouring 8x8 luma block as specified in subclause 6.4.10.2 when substituting the term “luma” with the term “Cb” or the term “Cr”, and substituting the term “luma8x8BlkIdx” with the term “cb8x8BlkIdx” or the term “cr8x8BlkIdx” in all places in subclause 6.4.10.2.

6.4.10.4 Derivation process for neighbouring 4x4 luma blocks

Input to this process is a 4x4 luma block index luma4x4BlkIdx.

Outputs of this process are

– mbAddrA: either equal to CurrMbAddr or the address of the macroblock to the left of the current macroblock and its availability status,

– luma4x4BlkIdxA: the index of the 4x4 luma block to the left of the 4x4 block with index luma4x4BlkIdx and its availability status,

– mbAddrB: either equal to CurrMbAddr or the address of the macroblock above the current macroblock and its availability status,

– luma4x4BlkIdxB: the index of the 4x4 luma block above the 4x4 block with index luma4x4BlkIdx and its availability status.

mbAddrN and luma4x4BlkIdxN (with N being A or B) are derived as follows.

– The difference of luma location (xD, yD) is set according to Table 6-2.

– The inverse 4x4 luma block scanning process as specified in subclause 6.4.3 is invoked with luma4x4BlkIdx as the input and (x, y) as the output.

– The luma location (xN, yN) is specified by

$$xN = x + xD \quad (6\text{-}23)$$

$$yN = y + yD \quad (6\text{-}24)$$

– The derivation process for neighbouring locations as specified in subclause 6.4.11 is invoked for luma locations with (xN, yN) as the input and the output is assigned to mbAddrN and (xW, yW).

– The variable luma4x4BlkIdxN is derived as follows:

  – If mbAddrN is not available, luma4x4BlkIdxN is marked as not available.

  – Otherwise (mbAddrN is available), the 4x4 luma block in the macroblock mbAddrN covering the luma location (xW, yW) is assigned to luma4x4BlkIdxN.

6.4.10.5 Derivation process for neighbouring 4x4 chroma blocks

Input to this process is a 4x4 chroma block index chroma4x4BlkIdx.

Outputs of this process are

– mbAddrA (either equal to CurrMbAddr or the address of the macroblock to the left of the current macroblock) and its availability status,

– chroma4x4BlkIdxA (the index of the 4x4 chroma block to the left of the 4x4 chroma block with index chroma4x4BlkIdx) and its availability status,

– mbAddrB (either equal to CurrMbAddr or the address of the macroblock above the current macroblock) and its availability status,

– chroma4x4BlkIdxB (the index of the 4x4 chroma block above the 4x4 chroma block with index chroma4x4BlkIdx) and its availability status.

mbAddrN and chroma4x4BlkIdxN (with N being A or B) are derived as follows:

– The difference of chroma location (xD, yD) is set according to Table 6-2.

– The position (x, y) of the upper-left sample of the 4x4 chroma block with index chroma4x4BlkIdx is derived by

$$x = \text{InverseRasterScan}(\text{chroma4x4BlkIdx}, 4, 4, 8, 0) \quad (6\text{-}25)$$

$$y = \text{InverseRasterScan}(\text{chroma4x4BlkIdx}, 4, 4, 8, 1) \quad (6\text{-}26)$$

– The chroma location (xN, yN) is specified by

$$xN = x + xD \quad (6\text{-}27)$$

$$yN = y + yD \quad (6\text{-}28)$$

– The derivation process for neighbouring locations as specified in subclause 6.4.11 is invoked for chroma locations with (xN, yN) as the input and the output is assigned to mbAddrN and (xW, yW).

– The variable chroma4x4BlkIdxN is derived as follows.

  – If mbAddrN is not available, chroma4x4BlkIdxN is marked as not available.

  – Otherwise (mbAddrN is available), the 4x4 chroma block in the macroblock mbAddrN covering the chroma location (xW, yW) is assigned to chroma4x4BlkIdxN.

6.4.10.6 Derivation process for neighbouring 4x4 chroma blocks for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The derivation process for neighbouring 4x4 chroma block in 4:4:4 chroma format is identical to the derivation process for neighbouring 4x4 luma block as specified in subclause 6.4.10.4 when substituting the term “luma” with the term “Cb” or the term “Cr”, and substituting the term “luma4x4BlkIdx” with the term “cb4x4BlkIdx” or the term “cr4x4BlkIdx” in all places in subclause 6.4.10.4.

6.4.10.7 Derivation process for neighbouring partitions

Inputs to this process are

– a macroblock partition index mbPartIdx

– a current sub-macroblock type currSubMbType

– a sub-macroblock partition index subMbPartIdx

Outputs of this process are

– mbAddrA\mbPartIdxA\subMbPartIdxA: specifying the macroblock or sub-macroblock partition to the left of the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status,

– mbAddrB\mbPartIdxB\subMbPartIdxB: specifying the macroblock or sub-macroblock partition above the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status,

– mbAddrC\mbPartIdxC\subMbPartIdxC: specifying the macroblock or sub-macroblock partition to the right-above of the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status,

– mbAddrD\mbPartIdxD\subMbPartIdxD: specifying the macroblock or sub-macroblock partition to the left-above of the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status.

mbAddrN, mbPartIdxN, and subMbPartIdxN (with N being A, B, C, or D) are derived as follows.

– The inverse macroblock partition scanning process as described in subclause 6.4.2.1 is invoked with mbPartIdx as the input and (x, y) as the output.

– The location of the upper-left luma sample inside a macroblock partition (xS, yS) is derived as follows.

  — If mb_type is equal to P_8x8, P_8x8ref0 or B_8x8, the inverse sub-macroblock partition scanning process as described in subclause 6.4.2.2 is invoked with subMbPartIdx as the input and (xS, yS) as the output.

  — Otherwise, (xS, yS) are set to (0, 0).

– The variable predPartWidth in Table 6-2 is specified as follows.

  – If mb_type is equal to P_Skip, B_Skip, or B_Direct_16x16, predPartWidth = 16.

  – Otherwise, if mb_type is equal to B_8x8, the following applies.

    – If currSubMbType is equal to B_Direct_8x8, predPartWidth = 16.

      NOTE 1 – When currSubMbType is equal to B_Direct_8x8 and direct_spatial_mv_pred_flag is equal to 1, the predicted motion vector is the predicted motion vector for the complete macroblock.

    – Otherwise, predPartWidth = SubMbPartWidth(sub_mb_type[mbPartIdx]).

  – Otherwise, if mb_type is equal to P_8x8 or P_8x8ref0, predPartWidth = SubMbPartWidth(sub_mb_type[mbPartIdx]).

  – Otherwise, predPartWidth = MbPartWidth(mb_type).

– The difference of luma location (xD, yD) is set according to Table 6-2.

– The neighbouring luma location (xN, yN) is specified by

$$xN = x + xS + xD \tag{6-29}$$

$$yN = y + yS + yD \tag{6-30}$$

– The derivation process for neighbouring locations as specified in subclause 6.4.11 is invoked for luma locations with (xN, yN) as the input and the output is assigned to mbAddrN and (xW, yW).

– Depending on mbAddrN, the following applies.

  – If mbAddrN is not available, the macroblock or sub-macroblock partition – mbAddrN\mbPartIdxN\subMbPartIdxN is marked as not available.

  – Otherwise (mbAddrN is available), the following applies.

    – The macroblock partition in the macroblock mbAddrN covering the luma location (xW, yW) is assigned to mbPartIdxN and the sub-macroblock partition inside the macroblock partition mbPartIdxN covering the sample (xW, yW) in the macroblock mbAddrN is assigned to subMbPartIdxN.

    – When the partition given by mbPartIdxN and subMbPartIdxN is not yet decoded, the macroblock partition mbPartIdxN and the sub-macroblock partition subMbPartIdxN are marked as not available.

NOTE 2 – The latter condition is, for example, the case when mbPartIdx = 2, subMbPartIdx = 3, xD = 4, yD = -1, i.e., when neighbour C of the last 4x4 luma block of the third sub-macroblock is requested.

6.4.11 Derivation process for neighbouring locations

Input to this process is a luma or chroma location (xN, yN) expressed relative to the upper left corner of the current macroblock.

Outputs of this process are

– mbAddrN: either equal to CurrMbAddr or to the address of neighbouring macroblock that contains (xN, yN) and its availability status,

– (xW, yW): the location (xN, yN) expressed relative to the upper-left corner of the macroblock mbAddrN (rather than relative to the upper-left corner of the current macroblock).

Let maxW and maxH be variables specifying maximum values of the location components xN, xW, and yN, yW, respectively. maxW and maxH are derived as follows:

– If this process is invoked for neighbouring luma locations,

$$maxW = maxH = 16 \tag{6-31}$$

– Otherwise (this process is invoked for neighbouring chroma locations),

$$maxW = MbWidthC \tag{6-32}$$

$$maxH = MbHeightC \tag{6-33}$$

Depending on the variable MbaffFrameFlag, the neighbouring locations are derived as follows:

– If MbaffFrameFlag is equal to 0, the specification for neighbouring locations in fields and non-MBAFF frames as described in subclause 6.4.11.1 is applied.

– Otherwise (MbaffFrameFlag is equal to 1), the specification for neighbouring locations in MBAFF frames as described in subclause 6.4.11.2 is applied.

6.4.11.1 Specification for neighbouring locations in fields and non-MBAFF frames

The specifications in this subclause are applied when MbaffFrameFlag is equal to 0.

The derivation process for neighbouring macroblock addresses and their availability in subclause 6.4.8 is invoked with mbAddrA, mbAddrB, mbAddrC, and mbAddrD as well as their availability status as the output.

Table 6-3 specifies mbAddrN depending on (xN, yN).

Table 6-3 – Specification of mbAddrN

xN	**yN**	**mbAddrN**
< 0	< 0	mbAddrD
< 0	0 .. maxH - 1	mbAddrA
0 .. maxW - 1	< 0	mbAddrB
0 .. maxW - 1	0 .. maxH - 1	CurrMbAddr
> maxW - 1	< 0	mbAddrC
> maxW - 1	0 .. maxH - 1	not available
	> maxH - 1	not available

The neighbouring location (xW, yW) relative to the upper-left corner of the macroblock mbAddrN is derived as

$$xW = (xN + maxW) \% maxW \quad (6\text{-}34)$$

$$yW = (yN + maxH) \% maxH \quad (6\text{-}35)$$

6.4.11.2 Specification for neighbouring locations in MBAFF frames

The specifications in this subclause are applied when MbaffFrameFlag is equal to 1.

The derivation process for neighbouring macroblock addresses and their availability in subclause 6.4.9 is invoked with mbAddrA, mbAddrB, mbAddrC, and mbAddrD as well as their availability status as the output.

Table 6-4 specifies the macroblock addresses mbAddrN and yM in two ordered steps:

1. Specification of a macroblock address mbAddrX depending on (xN, yN) and the following variables:
   - The variable currMbFrameFlag is derived as follows.
     - If the macroblock with address CurrMbAddr is a frame macroblock, currMbFrameFlag is set equal to 1,
     - Otherwise (the macroblock with address CurrMbAddr is a field macroblock), currMbFrameFlag is set equal to 0.
   - The variable mbIsTopMbFlag is derived as follows.
     - If the macroblock with address CurrMbAddr is a top macroblock (CurrMbAddr % 2 is equal to 0), mbIsTopMbFlag is set equal to 1;
     - Otherwise (the macroblock with address CurrMbAddr is a bottom macroblock, CurrMbAddr % 2 is equal to 1), mbIsTopMbFlag is set equal to 0.
2. Depending on the availability of mbAddrX, the following applies:
   - If mbAddrX is not available, mbAddrN is marked as not available.
   - Otherwise (mbAddrX is available), mbAddrN is marked as available and Table 6-4 specifies mbAddrN and yM depending on (xN, yN), currMbFrameFlag, mbIsTopMbFlag, and the variable mbAddrXFrameFlag, which is derived as follows.
     - If the macroblock mbAddrX is a frame macroblock, mbAddrXFrameFlag is set equal to 1,
     - Otherwise (the macroblock mbAddrX is a field macroblock), mbAddrXFrameFlag is set equal to 0.

Unspecified values (na) of the above flags in Table 6-4 indicate that the value of the corresponding flag is not relevant for the current table rows.

Table 6-4 – Specification of mbAddrN and yM

xN	yN	currMbFrameFlag	mbIsTopMbFlag	mbAddrX	mbAddrXFrameFlag	additional condition	mbAddrN	yM
< 0	< 0	1	1	mbAddrD			mbAddrD + 1	yN
			0	mbAddrA	1		mbAddrA	yN
					0		mbAddrA + 1	(yN + maxH) >> 1
		0	1	mbAddrD	1		mbAddrD + 1	2*yN
					0		mbAddrD	yN
			0	mbAddrD			mbAddrD + 1	yN
< 0	0 .. maxH - 1	1	1	mbAddrA	1		mbAddrA	yN
					0	yN % 2 = = 0	mbAddrA	yN >> 1
						yN % 2 != 0	mbAddrA + 1	yN >> 1
			0	mbAddrA	1		mbAddrA + 1	yN
					0	yN % 2 = = 0	mbAddrA	(yN + maxH) >> 1
						yN % 2 != 0	mbAddrA + 1	(yN + maxH) >> 1
		0	1	mbAddrA	1	yN < (maxH / 2)	mbAddrA	yN <<1
						yN >= (maxH / 2)	mbAddrA + 1	(yN <<1) - maxH
					0		mbAddrA	yN
			0	mbAddrA	1	yN < (maxH / 2)	mbAddrA	(yN <<1) + 1
						yN >= (maxH / 2)	mbAddrA + 1	(yN <<1) + 1 – maxH
					0		mbAddrA + 1	yN
0 .. maxW – 1	< 0	1	1	mbAddrB			mbAddrB + 1	yN
			0	CurrMbAddr			CurrMbAddr - 1	yN
		0	1	mbAddrB	1		mbAddrB + 1	2 * yN
					0		mbAddrB	yN
			0	mbAddrB			mbAddrB + 1	yN
0 .. maxW – 1	0 .. maxH - 1			CurrMbAddr			CurrMbAddr	yN
> maxW – 1	<0	1	1	mbAddrC			mbAddrC + 1	yN
			0	not available			not available	na
		0	1	mbAddrC	1		mbAddrC + 1	2 * yN
					0		mbAddrC	yN
			0	mbAddrC			mbAddrC + 1	yN
> maxW – 1	0 .. maxH - 1			not available			not available	na
	> maxH - 1			not available			not available	na

The neighbouring luma location (xW, yW) relative to the upper-left corner of the macroblock mbAddrN is derived as

$$xW = (xN + maxW) \% maxW \quad (6\text{-}36)$$

$$yW = (yM + maxH) \% maxH \quad (6\text{-}37)$$

7 Syntax and semantics

7.1 Method of specifying syntax in tabular form

The syntax tables specify a superset of the syntax of all allowed bitstreams. Additional constraints on the syntax may be specified, either directly or indirectly, in other clauses.

NOTE – An actual decoder should implement means for identifying entry points into the bitstream and means to identify and handle non-conforming bitstreams. The methods for identifying and handling errors and other such situations are not specified here.

The following table lists examples of pseudo code used to describe the syntax. When **syntax_element** appears, it specifies that a syntax element is parsed from the bitstream and the bitstream pointer is advanced to the next position beyond the syntax element in the bitstream parsing process.

	C	Descriptor
/* A statement can be a syntax element with an associated syntax category and descriptor or can be an expression used to specify conditions for the existence, type, and quantity of syntax elements, as in the following two examples */		
syntax_element	3	ue(v)
conditioning statement		
/* A group of statements enclosed in curly brackets is a compound statement and is treated functionally as a single statement. */		
{		
statement		
statement		
…		
}		
/* A "while" structure specifies a test of whether a condition is true, and if true, specifies evaluation of a statement (or compound statement) repeatedly until the condition is no longer true */		
while(condition)		
statement		
/* A "do … while" structure specifies evaluation of a statement once, followed by a test of whether a condition is true, and if true, specifies repeated evaluation of the statement until the condition is no longer true */		
do		
statement		
while(condition)		
/* An "if … else" structure specifies a test of whether a condition is true, and if the condition is true, specifies evaluation of a primary statement, otherwise, specifies evaluation of an alternative statement. The "else" part of the structure and the associated alternative statement is omitted if no alternative statement evaluation is needed */		
if(condition)		
primary statement		
else		
alternative statement		
/* A "for" structure specifies evaluation of an initial statement, followed by a test of a condition, and if the condition is true, specifies repeated evaluation of a primary statement followed by a subsequent statement until the condition is no longer true. */		
for(initial statement; condition; subsequent statement)		
primary statement		

7.2 Specification of syntax functions, categories, and descriptors

The functions presented here are used in the syntactical description. These functions assume the existence of a bitstream pointer with an indication of the position of the next bit to be read by the decoding process from the bitstream.

byte_aligned( ) is specified as follows:

- If the current position in the bitstream is on a byte boundary, i.e., the next bit in the bitstream is the first bit in a byte, the return value of byte_aligned( ) is equal to TRUE.
- Otherwise, the return value of byte_aligned( ) is equal to FALSE.

more_data_in_byte_stream( ), which is used only in the byte stream NAL unit syntax structure specified in Annex B, is specified as follows:

- If more data follow in the byte stream, the return value of more_data_in_byte_stream( ) is equal to TRUE.
- Otherwise, the return value of more_data_in_byte_stream( ) is equal to FALSE.

more_rbsp_data( ) is specified as follows:

- If there is more data in an RBSP before rbsp_trailing_bits( ), the return value of more_rbsp_data( ) is equal to TRUE.
- Otherwise, the return value of more_rbsp_data( ) is equal to FALSE.

  The method for enabling determination of whether there is more data in the RBSP is specified by the application (or in Annex B for applications that use the byte stream format).

more_rbsp_trailing_data( ) is specified as follows:

- If there is more data in an RBSP, the return value of more_rbsp_trailing_data( ) is equal to TRUE.
- Otherwise, the return value of more_rbsp_trailing_data( ) is equal to FALSE.

next_bits(n) provides the next bits in the bitstream for comparison purposes, without advancing the bitstream pointer. Provides a look at the next n bits in the bitstream with n being its argument. When used within the byte stream as specified in Annex B, next_bits(n) returns a value of 0 if fewer than n bits remain within the byte stream.

read_bits(n) reads the next n bits from the bitstream and advances the bitstream pointer by n bit positions. When n is equal to 0, read_bits(n) is specified to return a value equal to 0 and to not advance the bitstream pointer.

Categories (labelled in the table as **C**) specify the partitioning of slice data into at most three slice data partitions. Slice data partition A contains all syntax elements of category 2. Slice data partition B contains all syntax elements of category 3. Slice data partition C contains all syntax elements of category 4. The meaning of other category values is not specified. For some syntax elements, two category values, separated by a vertical bar, are used. In these cases, the category value to be applied is further specified in the text. For syntax structures used within other syntax structures, the categories of all syntax elements found within the included syntax structure are listed, separated by a vertical bar. A syntax element or syntax structure with category marked as "All" is present within all syntax structures that include that syntax element or syntax structure. For syntax structures used within other syntax structures, a numeric category value provided in a syntax table at the location of the inclusion of a syntax structure containing a syntax element with category marked as "All" is considered to apply to the syntax elements with category "All".

The following descriptors specify the parsing process of each syntax element. For some syntax elements, two descriptors, separated by a vertical bar, are used. In these cases, the left descriptors apply when entropy_coding_mode_flag is equal to 0 and the right descriptor applies when entropy_coding_mode_flag is equal to 1.

- ae(v): context-adaptive arithmetic entropy-coded syntax element. The parsing process for this descriptor is specified in subclause 9.3.
- b(8): byte having any pattern of bit string (8 bits). The parsing process for this descriptor is specified by the return value of the function read_bits(8).
- ce(v): context-adaptive variable-length entropy-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.2.
- f(n): fixed-pattern bit string using n bits written (from left to right) with the left bit first. The parsing process for this descriptor is specified by the return value of the function read_bits(n).
- i(n): signed integer using n bits. When n is "v" in the syntax table, the number of bits varies in a manner dependent on the value of other syntax elements. The parsing process for this descriptor is specified by the

return value of the function read_bits(n) interpreted as a two's complement integer representation with most significant bit written first.

– me(v): mapped Exp-Golomb-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.1.

– se(v): signed integer Exp-Golomb-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.1.

– te(v): truncated Exp-Golomb-coded syntax element with left bit first. The parsing process for this descriptor is specified in subclause 9.1.

– u(n): unsigned integer using n bits. When n is "v" in the syntax table, the number of bits varies in a manner dependent on the value of other syntax elements. The parsing process for this descriptor is specified by the return value of the function read_bits(n) interpreted as a binary representation of an unsigned integer with most significant bit written first.

– ue(v): unsigned integer Exp-Golomb-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.1.

7.3 Syntax in tabular form

7.3.1 NAL unit syntax

nal_unit(NumBytesInNALunit) {	C	Descriptor
forbidden_zero_bit	All	f(1)
nal_ref_idc	All	u(2)
nal_unit_type	All	u(5)
NumBytesInRBSP = 0		
nalUnitHeaderBytes = 1		
if(nal_unit_type = = 14 || nal_unit_type = = 20) {		
nal_unit_header_svc_extension( ) /* specified in Annex G */		
nalUnitHeaderBytes += 3		
}		
for(i = nalUnitHeaderBytes; i < NumBytesInNALunit; i++) {		
if(i + 2 < NumBytesInNALunit && next_bits(24) = = 0x000003) {		
rbsp_byte[NumBytesInRBSP++ **]**	All	b(8)
rbsp_byte[NumBytesInRBSP++ **]**	All	b(8)
i += 2		
emulation_prevention_three_byte /* equal to 0x03 */	All	f(8)
} else		
rbsp_byte[NumBytesInRBSP++ **]**	All	b(8)
}		
}		

7.3.2 Raw byte sequence payloads and RBSP trailing bits syntax

7.3.2.1 Sequence parameter set RBSP syntax

seq_parameter_set_rbsp( ) {	C	Descriptor
seq_parameter_set_data( )	0	
rbsp_trailing_bits( )	0	
}		

7.3.2.1.1 Sequence parameter set data syntax

seq_parameter_set_data( ) {	C	Descriptor
profile_idc	0	u(8)
constraint_set0_flag	0	u(1)
constraint_set1_flag	0	u(1)
constraint_set2_flag	0	u(1)
constraint_set3_flag	0	u(1)
reserved_zero_4bits /* equal to 0 */	0	u(4)
level_idc	0	u(8)
seq_parameter_set_id	0	ue(v)
if(profile_idc = = 100 || profile_idc = = 110 || profile_idc = = 122 || profile_idc = = 244 || profile_idc = = 44 || profile_idc = = 83 || profile_idc = = 86) {		
chroma_format_idc	0	ue(v)
if(chroma_format_idc = = 3)		
separate_colour_plane_flag	0	u(1)
bit_depth_luma_minus8	0	ue(v)
bit_depth_chroma_minus8	0	ue(v)
qpprime_y_zero_transform_bypass_flag	0	u(1)
seq_scaling_matrix_present_flag	0	u(1)
if(seq_scaling_matrix_present_flag)		
for(i = 0; i < ((chroma_format_idc != 3) ? 8 : 12); i++) {		
seq_scaling_list_present_flag[i **]**	0	u(1)
if(seq_scaling_list_present_flag[i])		
if(i < 6)		
scaling_list(ScalingList4x4[i], 16, UseDefaultScalingMatrix4x4Flag[i])	0	
else		
scaling_list(ScalingList8x8[i – 6], 64, UseDefaultScalingMatrix8x8Flag[i – 6])	0	
}		
}		
log2_max_frame_num_minus4	0	ue(v)
pic_order_cnt_type	0	ue(v)
if(pic_order_cnt_type = = 0)		
log2_max_pic_order_cnt_lsb_minus4	0	ue(v)
else if(pic_order_cnt_type = = 1) {		
delta_pic_order_always_zero_flag	0	u(1)
offset_for_non_ref_pic	0	se(v)
offset_for_top_to_bottom_field	0	se(v)
num_ref_frames_in_pic_order_cnt_cycle	0	ue(v)
for(i = 0; i < num_ref_frames_in_pic_order_cnt_cycle; i++)		
offset_for_ref_frame[i **]**	0	se(v)
}		
num_ref_frames	0	ue(v)
gaps_in_frame_num_value_allowed_flag	0	u(1)
pic_width_in_mbs_minus1	0	ue(v)
pic_height_in_map_units_minus1	0	ue(v)
frame_mbs_only_flag	0	u(1)

if(!frame_mbs_only_flag)		
mb_adaptive_frame_field_flag	0	u(1)
direct_8x8_inference_flag	0	u(1)
frame_cropping_flag	0	u(1)
if(frame_cropping_flag) {		
frame_crop_left_offset	0	ue(v)
frame_crop_right_offset	0	ue(v)
frame_crop_top_offset	0	ue(v)
frame_crop_bottom_offset	0	ue(v)
}		
vui_parameters_present_flag	0	u(1)
if(vui_parameters_present_flag)		
vui_parameters( )	0	
}		

7.3.2.1.1.1 Scaling list syntax

scaling_list(scalingList, sizeOfScalingList, useDefaultScalingMatrixFlag) {	**C**	**Descriptor**
lastScale = 8		
nextScale = 8		
for(j = 0; j < sizeOfScalingList; j++) {		
if(nextScale != 0) {		
delta_scale	0 | 1	se(v)
nextScale = (lastScale + delta_scale + 256) % 256		
useDefaultScalingMatrixFlag = (j == 0 && nextScale == 0)		
}		
scalingList[j] = (nextScale == 0) ? lastScale : nextScale		
lastScale = scalingList[j]		
}		
}		

7.3.2.1.2 Sequence parameter set extension RBSP syntax

seq_parameter_set_extension_rbsp( ) {	**C**	**Descriptor**
seq_parameter_set_id	10	ue(v)
aux_format_idc	10	ue(v)
if(aux_format_idc != 0) {		
bit_depth_aux_minus8	10	ue(v)
alpha_incr_flag	10	u(1)
alpha_opaque_value	10	u(v)
alpha_transparent_value	10	u(v)
}		
additional_extension_flag	10	u(1)
rbsp_trailing_bits()	10	
}		

7.3.2.2 Picture parameter set RBSP syntax

pic_parameter_set_rbsp( ) {	C	Descriptor
pic_parameter_set_id	1	ue(v)
seq_parameter_set_id	1	ue(v)
entropy_coding_mode_flag	1	u(1)
pic_order_present_flag	1	u(1)
num_slice_groups_minus1	1	ue(v)
if(num_slice_groups_minus1 > 0) {		
slice_group_map_type	1	ue(v)
if(slice_group_map_type = = 0)		
for(iGroup = 0; iGroup <= num_slice_groups_minus1; iGroup++)		
run_length_minus1[iGroup **]**	1	ue(v)
else if(slice_group_map_type = = 2)		
for(iGroup = 0; iGroup < num_slice_groups_minus1; iGroup++) {		
top_left[iGroup **]**	1	ue(v)
bottom_right[iGroup **]**	1	ue(v)
}		
else if(slice_group_map_type = = 3 || slice_group_map_type = = 4 || slice_group_map_type = = 5) {		
slice_group_change_direction_flag	1	u(1)
slice_group_change_rate_minus1	1	ue(v)
} else if(slice_group_map_type = = 6) {		
pic_size_in_map_units_minus1	1	ue(v)
for(i = 0; i <= pic_size_in_map_units_minus1; i++)		
slice_group_id[i **]**	1	u(v)
}		
}		
num_ref_idx_l0_active_minus1	1	ue(v)
num_ref_idx_l1_active_minus1	1	ue(v)
weighted_pred_flag	1	u(1)
weighted_bipred_idc	1	u(2)
pic_init_qp_minus26 /* relative to 26 */	1	se(v)
pic_init_qs_minus26 /* relative to 26 */	1	se(v)
chroma_qp_index_offset	1	se(v)
deblocking_filter_control_present_flag	1	u(1)
constrained_intra_pred_flag	1	u(1)
redundant_pic_cnt_present_flag	1	u(1)
if(more_rbsp_data( )) {		
transform_8x8_mode_flag	1	u(1)
pic_scaling_matrix_present_flag	1	u(1)
if(pic_scaling_matrix_present_flag)		
for(i = 0; i < 6 + ((chroma_format_idc != 3) ? 2 : 6) * transform_8x8_mode_flag; i++) {		
pic_scaling_list_present_flag[i **]**	1	u(1)
if(pic_scaling_list_present_flag[i])		
if(i < 6)		

scaling_list(ScalingList4x4[i], 16, UseDefaultScalingMatrix4x4Flag[i])	1	
else		
scaling_list(ScalingList8x8[i – 6], 64, UseDefaultScalingMatrix8x8Flag[i – 6])	1	
}		
second_chroma_qp_index_offset	1	se(v)
}		
rbsp_trailing_bits( )	1	
}		

7.3.2.3 Supplemental enhancement information RBSP syntax

sei_rbsp( ) {	C	Descriptor
do		
sei_message( )	5	
while(more_rbsp_data( ))		
rbsp_trailing_bits( )	5	
}		

7.3.2.3.1 Supplemental enhancement information message syntax

sei_message( ) {	C	Descriptor
payloadType = 0		
while(next_bits(8) = = 0xFF) {		
ff_byte /* equal to 0xFF */	5	f(8)
payloadType += 255		
}		
last_payload_type_byte	5	u(8)
payloadType += last_payload_type_byte		
payloadSize = 0		
while(next_bits(8) = = 0xFF) {		
ff_byte /* equal to 0xFF */	5	f(8)
payloadSize += 255		
}		
last_payload_size_byte	5	u(8)
payloadSize += last_payload_size_byte		
sei_payload(payloadType, payloadSize)	5	
}		

7.3.2.4 Access unit delimiter RBSP syntax

access_unit_delimiter_rbsp( ) {	C	Descriptor
primary_pic_type	6	u(3)
rbsp_trailing_bits( )	6	
}		

7.3.2.5 End of sequence RBSP syntax

end_of_seq_rbsp( ) {	C	Descriptor
}		

7.3.2.6 End of stream RBSP syntax

end_of_stream_rbsp( ) {	C	Descriptor
}		

7.3.2.7 Filler data RBSP syntax

filler_data_rbsp( ) {	C	Descriptor
while(next_bits(8) = = 0xFF)		
ff_byte /* equal to 0xFF */	9	f(8)
rbsp_trailing_bits( )	9	
}		

7.3.2.8 Slice layer without partitioning RBSP syntax

slice_layer_without_partitioning_rbsp( ) {	C	Descriptor
slice_header( )	2	
slice_data( ) /* all categories of slice_data( ) syntax */	2 | 3 | 4	
rbsp_slice_trailing_bits( )	2	
}		

7.3.2.9 Slice data partition RBSP syntax

7.3.2.9.1 Slice data partition A RBSP syntax

slice_data_partition_a_layer_rbsp( ) {	C	Descriptor
slice_header( )	2	
slice_id	All	ue(v)
slice_data( ) /* only category 2 parts of slice_data( ) syntax */	2	
rbsp_slice_trailing_bits( )	2	
}		

7.3.2.9.2 Slice data partition B RBSP syntax

slice_data_partition_b_layer_rbsp( ) {	C	Descriptor
slice_id	All	ue(v)
if(separate_colour_plane_flag = = 1)		
colour_plane_id	All	u(2)
if(redundant_pic_cnt_present_flag)		
redundant_pic_cnt	All	ue(v)
slice_data( ) /* only category 3 parts of slice_data( ) syntax */	3	
rbsp_slice_trailing_bits( )	3	
}		

7.3.2.9.3 Slice data partition C RBSP syntax

slice_data_partition_c_layer_rbsp( ) {	C	Descriptor
slice_id	All	ue(v)
if(separate_colour_plane_flag = = 1)		
colour_plane_id	All	u(2)
if(redundant_pic_cnt_present_flag)		
redundant_pic_cnt	All	ue(v)
slice_data( ) /* only category 4 parts of slice_data( ) syntax */	4	
rbsp_slice_trailing_bits( )	4	
}		

7.3.2.10 RBSP slice trailing bits syntax

rbsp_slice_trailing_bits( ) {	C	Descriptor
rbsp_trailing_bits( )	All	
if(entropy_coding_mode_flag)		
while(more_rbsp_trailing_data( ))		
cabac_zero_word /* equal to 0x0000 */	All	f(16)
}		

7.3.2.11 RBSP trailing bits syntax

rbsp_trailing_bits( ) {	C	Descriptor
rbsp_stop_one_bit /* equal to 1 */	All	f(1)
while(!byte_aligned( ))		
rbsp_alignment_zero_bit /* equal to 0 */	All	f(1)
}		

7.3.3 Slice header syntax

slice_header( ) {	C	Descriptor
first_mb_in_slice	2	ue(v)
slice_type	2	ue(v)
pic_parameter_set_id	2	ue(v)
if(separate_colour_plane_flag = = 1)		
colour_plane_id	2	u(2)
frame_num	2	u(v)
if(!frame_mbs_only_flag) {		
field_pic_flag	2	u(1)
if(field_pic_flag)		
bottom_field_flag	2	u(1)
}		
if(nal_unit_type = = 5)		
idr_pic_id	2	ue(v)
if(pic_order_cnt_type = = 0) {		
pic_order_cnt_lsb	2	u(v)
if(pic_order_present_flag && !field_pic_flag)		
delta_pic_order_cnt_bottom	2	se(v)
}		
if(pic_order_cnt_type = = 1 && !delta_pic_order_always_zero_flag) {		
delta_pic_order_cnt[0 **]**	2	se(v)
if(pic_order_present_flag && !field_pic_flag)		
delta_pic_order_cnt[1 **]**	2	se(v)
}		
if(redundant_pic_cnt_present_flag)		
redundant_pic_cnt	2	ue(v)
if(slice_type = = B)		
direct_spatial_mv_pred_flag	2	u(1)
if(slice_type = = P || slice_type = = SP || slice_type = = B) {		
num_ref_idx_active_override_flag	2	u(1)
if(num_ref_idx_active_override_flag) {		
num_ref_idx_l0_active_minus1	2	ue(v)
if(slice_type = = B)		
num_ref_idx_l1_active_minus1	2	ue(v)
}		
}		
ref_pic_list_reordering( )	2	
if((weighted_pred_flag && (slice_type = = P || slice_type = = SP)) || (weighted_bipred_idc = = 1 && slice_type = = B))		
pred_weight_table( )	2	
if(nal_ref_idc != 0)		
dec_ref_pic_marking( )	2	
if(entropy_coding_mode_flag && slice_type != I && slice_type != SI)		
cabac_init_idc	2	ue(v)
slice_qp_delta	2	se(v)
if(slice_type = = SP || slice_type = = SI) {		

if(slice_type = = SP)		
sp_for_switch_flag	2	u(1)
slice_qs_delta	2	se(v)
}		
if(deblocking_filter_control_present_flag) {		
disable_deblocking_filter_idc	2	ue(v)
if(disable_deblocking_filter_idc != 1) {		
slice_alpha_c0_offset_div2	2	se(v)
slice_beta_offset_div2	2	se(v)
}		
}		
if(num_slice_groups_minus1 > 0 && slice_group_map_type >= 3 && slice_group_map_type <= 5)		
slice_group_change_cycle	2	u(v)
}		

7.3.3.1 Reference picture list reordering syntax

ref_pic_list_reordering( ) {	C	Descriptor
if(slice_type % 5 != 2 && slice_type % 5 != 4) {		
ref_pic_list_reordering_flag_l0	2	u(1)
if(ref_pic_list_reordering_flag_l0)		
do {		
reordering_of_pic_nums_idc	2	ue(v)
if(reordering_of_pic_nums_idc = = 0 || reordering_of_pic_nums_idc = = 1)		
abs_diff_pic_num_minus1	**2**	**ue(v)**
else if(reordering_of_pic_nums_idc = = 2)		
long_term_pic_num	2	ue(v)
} while(reordering_of_pic_nums_idc != 3)		
}		
if(slice_type % 5 = = 1) {		
ref_pic_list_reordering_flag_l1	2	u(1)
if(ref_pic_list_reordering_flag_l1)		
do {		
reordering_of_pic_nums_idc	2	ue(v)
if(reordering_of_pic_nums_idc = = 0 || reordering_of_pic_nums_idc = = 1)		
abs_diff_pic_num_minus1	**2**	**ue(v)**
else if(reordering_of_pic_nums_idc = = 2)		
long_term_pic_num	2	ue(v)
} while(reordering_of_pic_nums_idc != 3)		
}		
}		

7.3.3.2 Prediction weight table syntax

pred_weight_table( ) {	C	Descriptor
luma_log2_weight_denom	2	ue(v)
if(ChromaArrayType != 0)		
chroma_log2_weight_denom	2	ue(v)
for(i = 0; i <= num_ref_idx_l0_active_minus1; i++) {		
luma_weight_l0_flag	2	u(1)
if(luma_weight_l0_flag) {		
luma_weight_l0[i **]**	2	se(v)
luma_offset_l0[i **]**	2	se(v)
}		
if (ChromaArrayType != 0) {		
chroma_weight_l0_flag	2	u(1)
if(chroma_weight_l0_flag)		
for(j =0; j < 2; j++) {		
chroma_weight_l0[i **][** j **]**	2	se(v)
chroma_offset_l0[i **][** j **]**	2	se(v)
}		
}		
}		
if(slice_type % 5 = = 1)		
for(i = 0; i <= num_ref_idx_l1_active_minus1; i++) {		
luma_weight_l1_flag	2	u(1)
if(luma_weight_l1_flag) {		
luma_weight_l1[i **]**	2	se(v)
luma_offset_l1[i **]**	2	se(v)
}		
if(ChromaArrayType != 0) {		
chroma_weight_l1_flag	2	u(1)
if(chroma_weight_l1_flag)		
for(j = 0; j < 2; j++) {		
chroma_weight_l1[i **][** j **]**	2	se(v)
chroma_offset_l1[i **][** j **]**	2	se(v)
}		
}		
}		
}		

7.3.3.3 Decoded reference picture marking syntax

dec_ref_pic_marking( ) {	C	Descriptor
if(IdrPicFlag) {		
no_output_of_prior_pics_flag	2 | 5	u(1)
long_term_reference_flag	2 | 5	u(1)
} else {		
adaptive_ref_pic_marking_mode_flag	2 | 5	u(1)
if(adaptive_ref_pic_marking_mode_flag)		
do {		
memory_management_control_operation	2 | 5	ue(v)
if(memory_management_control_operation = = 1 || memory_management_control_operation = = 3)		
difference_of_pic_nums_minus1	2 | 5	ue(v)
if(memory_management_control_operation = = 2)		
long_term_pic_num	2 | 5	ue(v)
if(memory_management_control_operation = = 3 || memory_management_control_operation = = 6)		
long_term_frame_idx	2 | 5	ue(v)
if(memory_management_control_operation = = 4)		
max_long_term_frame_idx_plus1	2 | 5	ue(v)
} while(memory_management_control_operation != 0)		
}		
}		

7.3.4 Slice data syntax

slice_data( ) {	C	Descriptor
if(entropy_coding_mode_flag)		
while(!byte_aligned( ))		
cabac_alignment_one_bit	2	f(1)
CurrMbAddr = first_mb_in_slice * (1 + MbaffFrameFlag)		
moreDataFlag = 1		
prevMbSkipped = 0		
do {		
if(slice_type != I && slice_type != SI)		
if(!entropy_coding_mode_flag) {		
mb_skip_run	2	ue(v)
prevMbSkipped = (mb_skip_run > 0)		
for(i=0; i<mb_skip_run; i++)		
CurrMbAddr = NextMbAddress(CurrMbAddr)		
moreDataFlag = more_rbsp_data( )		
} else {		
mb_skip_flag	2	ae(v)
moreDataFlag = !mb_skip_flag		
}		
if(moreDataFlag) {		
if(MbaffFrameFlag && (CurrMbAddr % 2 = = 0 || (CurrMbAddr % 2 = = 1 && prevMbSkipped)))		
mb_field_decoding_flag	2	u(1) | ae(v)
macroblock_layer( )	2 | 3 | 4	
}		
if(!entropy_coding_mode_flag)		
moreDataFlag = more_rbsp_data( )		
else {		
if(slice_type != I && slice_type != SI)		
prevMbSkipped = mb_skip_flag		
if(MbaffFrameFlag && CurrMbAddr % 2 = = 0)		
moreDataFlag = 1		
else {		
end_of_slice_flag	2	ae(v)
moreDataFlag = !end_of_slice_flag		
}		
}		
CurrMbAddr = NextMbAddress(CurrMbAddr)		
} while(moreDataFlag)		
}		

7.3.5 Macroblock layer syntax

macroblock_layer( ) {	C	Descriptor
mb_type	2	ue(v) | ae(v)
if(mb_type = = I_PCM) {		
while(!byte_aligned( ))		
pcm_alignment_zero_bit	3	f(1)
for(i = 0; i < 256; i++)		
pcm_sample_luma[i **]**	3	u(v)
for(i = 0; i < 2 * MbWidthC * MbHeightC; i++)		
pcm_sample_chroma[i **]**	3	u(v)
} else {		
noSubMbPartSizeLessThan8x8Flag = 1		
if(mb_type != I_NxN && MbPartPredMode(mb_type, 0) != Intra_16x16 && NumMbPart(mb_type) = = 4) {		
sub_mb_pred(mb_type)	2	
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if(sub_mb_type[mbPartIdx] != B_Direct_8x8) {		
if(NumSubMbPart(sub_mb_type[mbPartIdx]) > 1)		
noSubMbPartSizeLessThan8x8Flag = 0		
} else if(!direct_8x8_inference_flag)		
noSubMbPartSizeLessThan8x8Flag = 0		
} else {		
if(transform_8x8_mode_flag && mb_type = = I_NxN)		
transform_size_8x8_flag	2	u(1) | ae(v)
mb_pred(mb_type)	2	
}		
if(MbPartPredMode(mb_type, 0) != Intra_16x16) {		
coded_block_pattern	2	me(v) | ae(v)
if(CodedBlockPatternLuma > 0 && transform_8x8_mode_flag && mb_type != I_NxN && noSubMbPartSizeLessThan8x8Flag && (mb_type != B_Direct_16x16 || direct_8x8_inference_flag))		
transform_size_8x8_flag	2	u(1) | ae(v)
}		
if(CodedBlockPatternLuma > 0 || CodedBlockPatternChroma > 0 || MbPartPredMode(mb_type, 0) = = Intra_16x16) {		
mb_qp_delta	2	se(v) | ae(v)
residual(0, 0, 15)	3 | 4	
}		
}		
}		

7.3.5.1 Macroblock prediction syntax

mb_pred(mb_type) {	C	Descriptor
if(MbPartPredMode(mb_type, 0) = = Intra_4x4 || MbPartPredMode(mb_type, 0) = = Intra_8x8 || MbPartPredMode(mb_type, 0) = = Intra_16x16) {		
if(MbPartPredMode(mb_type, 0) = = Intra_4x4)		
for(luma4x4BlkIdx=0; luma4x4BlkIdx<16; luma4x4BlkIdx++) {		
prev_intra4x4_pred_mode_flag[luma4x4BlkIdx **]**	2	u(1) | ae(v)
if(!prev_intra4x4_pred_mode_flag**[** luma4x4BlkIdx **]**)		
rem_intra4x4_pred_mode[luma4x4BlkIdx **]**	2	u(3) | ae(v)
}		
if(MbPartPredMode(mb_type, 0) = = Intra_8x8)		
for(luma8x8BlkIdx=0; luma8x8BlkIdx<4; luma8x8BlkIdx++) {		
prev_intra8x8_pred_mode_flag[luma8x8BlkIdx **]**	2	u(1) | ae(v)
if(!prev_intra8x8_pred_mode_flag[luma8x8BlkIdx])		
rem_intra8x8_pred_mode[luma8x8BlkIdx **]**	2	u(3) | ae(v)
}		
if(ChromaArrayType = = 1 || ChromaArrayType = = 2)		
intra_chroma_pred_mode	2	ue(v) | ae(v)
} else if(MbPartPredMode(mb_type, 0) != Direct) {		
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if((num_ref_idx_l0_active_minus1 > 0 || mb_field_decoding_flag) && MbPartPredMode(mb_type, mbPartIdx) != Pred_L1)		
ref_idx_l0[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if((num_ref_idx_l1_active_minus1 > 0 || mb_field_decoding_flag) && MbPartPredMode(mb_type, mbPartIdx) != Pred_L0)		
ref_idx_l1[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if(MbPartPredMode (mb_type, mbPartIdx) != Pred_L1)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l0[mbPartIdx **][** 0 **][** compIdx **]**	2	se(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if(MbPartPredMode(mb_type, mbPartIdx) != Pred_L0)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l1[mbPartIdx **][** 0 **][** compIdx **]**	2	se(v) | ae(v)
}		
}		

7.3.5.2 Sub-macroblock prediction syntax

sub_mb_pred(mb_type) {	C	Descriptor
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
sub_mb_type[mbPartIdx **]**	2	ue(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if((num_ref_idx_l0_active_minus1 > 0 || mb_field_decoding_flag) && mb_type != P_8x8ref0 && sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L1)		
ref_idx_l0[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if((num_ref_idx_l1_active_minus1 > 0 || mb_field_decoding_flag) && sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L0)		
ref_idx_l1[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if(sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L1)		
for(subMbPartIdx = 0; subMbPartIdx < NumSubMbPart(sub_mb_type[mbPartIdx]); subMbPartIdx++)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l0[mbPartIdx **][** subMbPartIdx **][** compIdx **]**	2	se(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if(sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L0)		
for(subMbPartIdx = 0; subMbPartIdx < NumSubMbPart(sub_mb_type[mbPartIdx]); subMbPartIdx++)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l1[mbPartIdx **][** subMbPartIdx **][** compIdx **]**	2	se(v) | ae(v)
}		

7.3.5.3 Residual data syntax

residual(bmFlag, startIdx, endIdx) {	C	Descriptor
if(!entropy_coding_mode_flag)		
residual_block = residual_block_cavlc		
else		
residual_block = residual_block_cabac		
residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8, bmFlag, startIdx, endIdx)		
Intra16x16DCLevel = i16x16DClevel		
Intra16x16ACLevel = i16x16AClevel		
LumaLevel = level		
LumaLevel8x8 = level8x8		
if(ChromaArrayType == 1 || ChromaArrayType == 2) {		
NumC8x8 = 4 / (SubWidthC * SubHeightC)		
for(iCbCr = 0; iCbCr < 2; iCbCr++)		
if((CodedBlockPatternChroma & 3) && startIdx == 0) /* chroma DC residual present */		
residual_block(ChromaDCLevel[iCbCr], 0, 4 * NumC8x8 - 1, 4 * NumC8x8)	3 | 4	
else		
for(i = 0; i < 4 * NumC8x8; i++)		
ChromaDCLevel[iCbCr][i] = 0		
for(iCbCr = 0; iCbCr < 2; iCbCr++)		
for(i8x8 = 0; i8x8 < NumC8x8; i8x8++)		
for(i4x4 = 0; i4x4 < 4; i4x4++)		
if((CodedBlockPatternChroma & 2) && endIdx > 0) /* chroma AC residual present */		
residual_block(ChromaACLevel[iCbCr][i8x8*4+i4x4], max(0, startIdx – 1), endIdx – 1, 15)	3 | 4	
else		
for(i = 0; i < 15; i++)		
ChromaACLevel[iCbCr][i8x8*4+i4x4][i] = 0		
} else if(ChromaArrayType == 3) {		
residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8, bmFlag, startIdx, endIdx)		
CbIntra16x16DCLevel = i16x16DClevel		
CbIntra16x16ACLevel = i16x16AClevel		
CbLevel = level		
CbLevel8x8 = level8x8		
residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8, bmFlag, startIdx, endIdx)		
CrIntra16x16DCLevel = i16x16DClevel		
CrIntra16x16ACLevel = i16x16AClevel		
CrLevel = level		
CrLevel8x8 = level8x8		
}		

7.3.5.3.1 Residual luma syntax

residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8, bmFlag, startIdx, endIdx) {	C	Descriptor
if(!entropy_coding_mode_flag)		
residual_block = residual_block_cavlc		
else		
residual_block = residual_block_cabac		
if(!bmFlag && startIdx = = 0 && MbPartPredMode(mb_type, 0) = = Intra_16x16)		
residual_block(i16x16DClevel, 0, 15, 16)	3	
for(i8x8 = 0; i8x8 < 4; i8x8++)		
if(!transform_size_8x8_flag || !entropy_coding_mode_flag)		
for(i4x4 = 0; i4x4 < 4; i4x4++) {		
if(CodedBlockPatternLuma & (1 << i8x8))		
if(!bmFlag && endIdx > 0 && MbPartPredMode(mb_type, 0) = = Intra_16x16)		
residual_block(i16x16AClevel[i8x8*4+ i4x4], max(0, startIdx – 1), endIdx – 1, 15)	3	
else		
residual_block(level[i8x8 * 4 + i4x4], startIdx, endIdx, 16)	3 | 4	
else if(!bmFlag && MbPartPredMode(mb_type, 0) = = Intra_16x16)		
for(i = 0; i < 15; i++)		
i16x16AClevel[i8x8 * 4 + i4x4][i] = 0		
else		
for(i = 0; i < 16; i++)		
level[i8x8 * 4 + i4x4][i] = 0		
if(!entropy_coding_mode_flag && transform_size_8x8_flag)		
for(i = 0; i < 16; i++)		
level8x8[i8x8][4 * i + i4x4] = level[i8x8 * 4 + i4x4][i]		
}		
else if(CodedBlockPatternLuma & (1 << i8x8))		
residual_block(level8x8[i8x8], 4 * startIdx, 4 * endIdx + 3, 64)	3 | 4	
else		
for(i = 0; i < 64; i++)		
level8x8[i8x8][i] = 0		
}		

7.3.5.3.2 Residual block CAVLC syntax

residual_block_cavlc(coeffLevel, startIdx, endIdx, maxNumCoeff) {	C	Descriptor
for(i = 0; i < maxNumCoeff; i++)		
coeffLevel[i] = 0		
coeff_token	3 | 4	ce(v)
if(TotalCoeff(coeff_token) > 0) {		
if(TotalCoeff(coeff_token) > 10 && TrailingOnes(coeff_token) < 3)		
suffixLength = 1		
else		
suffixLength = 0		
for(i = 0; i < TotalCoeff(coeff_token); i++)		
if(i < TrailingOnes(coeff_token)) {		
trailing_ones_sign_flag	3 | 4	u(1)
level[i] = 1 – 2 * trailing_ones_sign_flag		
} else {		
level_prefix	3 | 4	ce(v)
levelCode = (Min(15, level_prefix) << suffixLength)		
if(suffixLength > 0 || level_prefix >= 14) {		
level_suffix	3 | 4	u(v)
levelCode += level_suffix		
}		
if(level_prefix >= 15 && suffixLength == 0)		
levelCode += 15		
if(level_prefix >= 16)		
levelCode += (1 << (level_prefix – 3)) – 4096		
if(i == TrailingOnes(coeff_token) && TrailingOnes(coeff_token) < 3)		
levelCode += 2		
if(levelCode % 2 == 0)		
level[i] = (levelCode + 2) >> 1		
else		
level[i] = (–levelCode – 1) >> 1		
if(suffixLength == 0)		
suffixLength = 1		
if(Abs(level[i]) > (3 << (suffixLength – 1)) && suffixLength < 6)		
suffixLength++		
}		
if(TotalCoeff(coeff_token) < endIdx – startIdx + 1) {		
total_zeros	3 | 4	ce(v)
zerosLeft = total_zeros		
} else		
zerosLeft = 0		
for(i = 0; i < TotalCoeff(coeff_token) – 1; i++) {		
if(zerosLeft > 0) {		
run_before	3 | 4	ce(v)
run[i] = run_before		
} else		
run[i] = 0		

zerosLeft = zerosLeft – run[i]		
}		
run[TotalCoeff(coeff_token) – 1] = zerosLeft		
coeffNum = -1		
for(i = TotalCoeff(coeff_token) – 1; i >= 0; i--) {		
coeffNum += run[i] + 1		
coeffLevel[startIdx + coeffNum] = level[i]		
}		
}		
}		

7.3.5.3.3 Residual block CABAC syntax

residual_block_cabac(coeffLevel, startIdx, endIdx, maxNumCoeff) {	C	Descriptor
if(maxNumCoeff = = 64 || (ChromaArrayType = = 3)))		
coded_block_flag	3 | 4	ae(v)
for(i = 0; i < maxNumCoeff; i++)		
coeffLevel[i] = 0		
if(coded_block_flag) {		
numCoeff = endIdx + 1		
i = startIdx		
do {		
significant_coeff_flag[i **]**	3 | 4	ae(v)
if(significant_coeff_flag[i]) {		
last_significant_coeff_flag[i **]**	3 | 4	ae(v)
if(last_significant_coeff_flag[i])		
numCoeff = i + 1		
}		
i++		
} while(i < numCoeff – 1)		
coeff_abs_level_minus1[numCoeff – 1 **]**	3 | 4	ae(v)
coeff_sign_flag[numCoeff – 1 **]**	3 | 4	ae(v)
coeffLevel[numCoeff – 1] = (coeff_abs_level_minus1[numCoeff – 1] + 1) * (1 – 2 * coeff_sign_flag[numCoeff – 1])		
for(i = numCoeff – 2; i >= 0; i--)		
if(significant_coeff_flag[i]) {		
coeff_abs_level_minus1[i **]**	3 | 4	ae(v)
coeff_sign_flag[i **]**	3 | 4	ae(v)
coeffLevel[i] = (coeff_abs_level_minus1[i] + 1) * (1 – 2 * coeff_sign_flag[i])		
}		
}		
}		

7.4 Semantics

Semantics associated with the syntax structures and with the syntax elements within these structures are specified in this subclause. When the semantics of a syntax element are specified using a table or a set of tables, any values that are not specified in the table(s) shall not be present in the bitstream unless otherwise specified in this Recommendation | International Standard.

7.4.1 NAL unit semantics

NOTE 1 – The VCL is specified to efficiently represent the content of the video data. The NAL is specified to format that data and provide header information in a manner appropriate for conveyance on a variety of communication channels or storage media. All data are contained in NAL units, each of which contains an integer number of bytes. A NAL unit specifies a generic format for use in both packet-oriented and bitstream systems. The format of NAL units for both packet-oriented transport and byte stream is identical except that each NAL unit can be preceded by a start code prefix and extra padding bytes in the byte stream format.

NumBytesInNALunit specifies the size of the NAL unit in bytes. This value is required for decoding of the NAL unit. Some form of demarcation of NAL unit boundaries is necessary to enable inference of NumBytesInNALunit. One such demarcation method is specified in Annex B for the byte stream format. Other methods of demarcation may be specified outside of this Recommendation | International Standard.

forbidden_zero_bit shall be equal to 0.

nal_ref_idc not equal to 0 specifies that the content of the NAL unit contains a sequence parameter set, a sequence parameter set extension, a subset sequence parameter set, a picture parameter set, a slice of a reference picture, a slice data partition of a reference picture, or a prefix NAL unit preceding a slice of a reference picture.

For coded video sequences conforming to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9, nal_ref_idc equal to 0 for a NAL unit containing a slice or slice data partition indicates that the slice or slice data partition is part of a non-reference picture.

nal_ref_idc shall not be equal to 0 for sequence parameter set or sequence parameter set extension or subset sequence parameter set or picture parameter set NAL units. When nal_ref_idc is equal to 0 for one NAL unit with nal_unit_type in the range of 1 to 4, inclusive, of a particular picture, it shall be equal to 0 for all NAL units with nal_unit_type in the range of 1 to 4, inclusive, of the picture.

nal_ref_idc shall not be equal to 0 for NAL units with nal_unit_type equal to 5.

nal_ref_idc shall be equal to 0 for all NAL units having nal_unit_type equal to 6, 9, 10, 11, or 12.

nal_unit_type specifies the type of RBSP data structure contained in the NAL unit as specified in Table 7-1.

The column marked "C" in Table 7-1 lists the categories of the syntax elements that may be present in the NAL unit. In addition, syntax elements with syntax category "All" may be present, as determined by the syntax and semantics of the RBSP data structure. The presence or absence of any syntax elements of a particular listed category is determined from the syntax and semantics of the associated RBSP data structure. nal_unit_type shall not be equal to 3 or 4 unless at least one syntax element is present in the RBSP data structure having a syntax element category value equal to the value of nal_unit_type and not categorized as "All".

For coded video sequences conforming to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9, VCL and non-VCL NAL units are specified in Table 7-1 in the column labelled "Annex A NAL unit type class". For coded video sequences conforming to one or more of the profiles specified in Annex G that are decoded using the decoding process specified in Annex G, VCL and non-VCL NAL units are specified in Table 7-1 in the column labelled "Annex G NAL unit type class". The entry "suffix dependent" for nal_unit_type equal to 14, specifies the following.

– If the NAL unit directly following in decoding order a NAL unit with nal_unit_type equal to 14 is a NAL unit with nal_unit_type equal to 1 or 5, the NAL unit with nal_unit_type equal to 14 is a VCL NAL unit.

– Otherwise, if the NAL unit directly following in decoding order a NAL unit with nal_unit_type equal to 14 is a NAL unit with nal_unit_type equal to 12, the NAL unit with nal_unit_type equal to 14 is a non-VCL NAL unit.

– Otherwise (the NAL unit directly following in decoding order a NAL unit with nal_unit_type equal to 14 is a NAL unit with nal_unit_type not equal to 1, 5, or 12), the NAL unit with nal_unit_type equal to 14 is a non-VCL NAL unit and decoders shall ignore (remove from the bitstream and discard) the NAL unit with nal_unit_type equal to 14 and the NAL unit directly following in decoding order the NAL unit with nal_unit_type equal to 14.

Table 7-1 – NAL unit type codes, syntax element categories, and NAL unit type classes

nal_unit_type	Content of NAL unit and RBSP syntax structure	C	Annex A NAL unit type class	Annex G NAL unit type class
0	Unspecified		non-VCL	non-VCL
1	Coded slice of a non-IDR picture slice_layer_without_partitioning_rbsp( )	2, 3, 4	VCL	VCL
2	Coded slice data partition A slice_data_partition_a_layer_rbsp( )	2	VCL	not applicable
3	Coded slice data partition B slice_data_partition_b_layer_rbsp( )	3	VCL	not applicable
4	Coded slice data partition C slice_data_partition_c_layer_rbsp( )	4	VCL	not applicable
5	Coded slice of an IDR picture slice_layer_without_partitioning_rbsp( )	2, 3	VCL	VCL
6	Supplemental enhancement information (SEI) sei_rbsp( )	5	non-VCL	non-VCL
7	Sequence parameter set seq_parameter_set_rbsp( )	0	non-VCL	non-VCL
8	Picture parameter set pic_parameter_set_rbsp( )	1	non-VCL	non-VCL
9	Access unit delimiter access_unit_delimiter_rbsp( )	6	non-VCL	non-VCL
10	End of sequence end_of_seq_rbsp( )	7	non-VCL	non-VCL
11	End of stream end_of_stream_rbsp( )	8	non-VCL	non-VCL
12	Filler data filler_data_rbsp( )	9	non-VCL	non-VCL
13	Sequence parameter set extension seq_parameter_set_extension_rbsp( )	10	non-VCL	non-VCL
14	Prefix NAL unit in scalable extension prefix_nal_unit_rbsp( ) /* specified in Annex G */	2	non-VCL	suffix dependent
15	Subset sequence parameter set subset_seq_parameter_set_rbsp( ) /* specified in Annex G */	0	non-VCL	non-VCL
16..18	Reserved		non-VCL	non-VCL
19	Coded slice of an auxiliary coded picture without partitioning slice_layer_without_partitioning_rbsp( )	2, 3, 4	non-VCL	non-VCL
20	Coded slice in scalable extension slice_layer_in_scalable_extension_rbsp( ) /* specified in Annex G */	2, 3, 4	non-VCL	VCL
21..23	Reserved		non-VCL	non-VCL
24..31	Unspecified		non-VCL	non-VCL

NAL units having nal_unit_type equal to 13 or 19 may be discarded by decoders without affecting the decoding process for NAL units having nal_unit_type not equal to 13 or 19 and without affecting conformance to this Recommendation | International Standard.

NAL units having nal_unit_type equal to 14, 15, or 20 may be discarded by decoders without affecting the decoding process for NAL units having nal_unit_type not equal to 14, 15, or 20 and without affecting conformance to profiles specified in Annex A.

NAL units that use nal_unit_type equal to 0 or in the range of 24..31, inclusive, shall not affect the decoding process specified in this Recommendation | International Standard.

NOTE 2 – NAL unit types 0 and 24..31 may be used as determined by the application. No decoding process for these values of nal_unit_type is specified in this Recommendation | International Standard.

Decoders shall ignore (remove from the bitstream and discard) the contents of all NAL units that use reserved values of nal_unit_type.

NOTE 3 – This requirement allows future definition of compatible extensions to this Recommendation | International Standard.

In the text, coded slice NAL unit collectively refers to a coded slice of a non-IDR picture NAL unit or to a coded slice of an IDR picture NAL unit. The following flag is specified:

$$IdrPicFlag = (nal\_unit\_type == 5 \ ? \ 1 : 0) \quad (7\text{-}1)$$

When the value of nal_unit_type is equal to 5 for a NAL unit containing a slice of a particular picture, the picture shall not contain NAL units with nal_unit_type in the range of 1 to 4, inclusive. For coded video sequences conforming to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9, such a picture is referred to as an IDR picture.

NOTE 4 – Slice data partitioning cannot be used for IDR pictures.

rbsp_byte[i **]** is the i-th byte of an RBSP. An RBSP is specified as an ordered sequence of bytes as follows.

The RBSP contains an SODB as follows.

– If the SODB is empty (i.e., zero bits in length), the RBSP is also empty.

– Otherwise, the RBSP contains the SODB as follows.

1) The first byte of the RBSP contains the (most significant, left-most) eight bits of the SODB; the next byte of the RBSP shall contain the next eight bits of the SODB, etc., until fewer than eight bits of the SODB remain.

2) rbsp_trailing_bits( ) are present after the SODB as follows:

   i) The first (most significant, left-most) bits of the final RBSP byte contains the remaining bits of the SODB, (if any)

   ii) The next bit consists of a single rbsp_stop_one_bit equal to 1, and

   iii) When the rbsp_stop_one_bit is not the last bit of a byte-aligned byte, one or more rbsp_alignment_zero_bit is present to result in byte alignment.

3) One or more cabac_zero_word 16-bit syntax elements equal to 0x0000 may be present in some RBSPs after the rbsp_trailing_bits( ) at the end of the RBSP.

Syntax structures having these RBSP properties are denoted in the syntax tables using an "_rbsp" suffix. These structures shall be carried within NAL units as the content of the rbsp_byte[i] data bytes. The association of the RBSP syntax structures to the NAL units shall be as specified in Table 7-1.

NOTE 5 – When the boundaries of the RBSP are known, the decoder can extract the SODB from the RBSP by concatenating the bits of the bytes of the RBSP and discarding the rbsp_stop_one_bit, which is the last (least significant, right-most) bit equal to 1, and discarding any following (less significant, farther to the right) bits that follow it, which are equal to 0. The data necessary for the decoding process is contained in the SODB part of the RBSP.

emulation_prevention_three_byte is a byte equal to 0x03. When an emulation_prevention_three_byte is present in the NAL unit, it shall be discarded by the decoding process.

The last byte of the NAL unit shall not be equal to 0x00.

Within the NAL unit, the following three-byte sequences shall not occur at any byte-aligned position:

– 0x000000

– 0x000001

– 0x000002

Within the NAL unit, any four-byte sequence that starts with 0x000003 other than the following sequences shall not occur at any byte-aligned position:

– 0x00000300

– 0x00000301

– 0x00000302

– 0x00000303

NOTE 6 – When nal_unit_type is equal to 0, particular care must be exercised in the design of encoders to avoid the presence of the above-listed three-byte and four-byte patterns at the beginning of the NAL unit syntax structure, as the syntax element emulation_prevention_three_byte cannot be the third byte of a NAL unit.

7.4.1.1 Encapsulation of an SODB within an RBSP (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

The form of encapsulation of an SODB within an RBSP and the use of the emulation_prevention_three_byte for encapsulation of an RBSP within a NAL unit is specified for the following purposes:

– to prevent the emulation of start codes within NAL units while allowing any arbitrary SODB to be represented within a NAL unit,

– to enable identification of the end of the SODB within the NAL unit by searching the RBSP for the rbsp_stop_one_bit starting at the end of the RBSP, and

– to enable a NAL unit to have a size larger than that of the SODB under some circumstances (using one or more cabac_zero_word).

The encoder can produce a NAL unit from an RBSP by the following procedure:

The RBSP data is searched for byte-aligned bits of the following binary patterns:

'00000000 00000000 000000xx' (where xx represents any 2 bit pattern: 00, 01, 10, or 11),

and a byte equal to 0x03 is inserted to replace these bit patterns with the patterns.

'00000000 00000000 00000011 000000xx',

and finally, when the last byte of the RBSP data is equal to 0x00 (which can only occur when the RBSP ends in a cabac_zero_word), a final byte equal to 0x03 is appended to the end of the data.

The resulting sequence of bytes is then prefixed with the first byte of the NAL unit containing the indication of the type of RBSP data structure it contains. This results in the construction of the entire NAL unit.

This process can allow any SODB to be represented in a NAL unit while ensuring that

– no byte-aligned start code prefix is emulated within the NAL unit, and

– no sequence of 8 zero-valued bits followed by a start code prefix, regardless of byte-alignment, is emulated within the NAL unit.

7.4.1.2 Order of NAL units and association to coded pictures, access units, and video sequences

This subclause specifies constraints on the order of NAL units in the bitstream.

Any order of NAL units in the bitstream obeying these constraints is referred to in the text as the decoding order of NAL units. Within a NAL unit, the syntax in subclauses 7.3, D.1, and E.1 specifies the decoding order of syntax elements. Decoders conforming to this Recommendation | International Standard shall be capable of receiving NAL units and their syntax elements in decoding order.

7.4.1.2.1 Order of sequence and picture parameter set RBSPs and their activation

This subclause specifies the activation process of picture and sequence parameter sets for coded video sequences that conform to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9.

NOTE 1 – The sequence and picture parameter set mechanism decouples the transmission of infrequently changing information from the transmission of coded macroblock data. Sequence and picture parameter sets may, in some applications, be conveyed "out-of-band" using a reliable transport mechanism.

A picture parameter set RBSP includes parameters that can be referred to by the coded slice NAL units or coded slice data partition A NAL units of one or more coded pictures. Each picture parameter set RBSP is initially considered not active at the start of the operation of the decoding process. At most one picture parameter set RBSP is considered active at any given moment during the operation of the decoding process, and the activation of any particular picture parameter set RBSP results in the deactivation of the previously-active picture parameter set RBSP (if any).

When a picture parameter set RBSP (with a particular value of pic_parameter_set_id) is not active and it is referred to by a coded slice NAL unit or coded slice data partition A NAL unit (using that value of pic_parameter_set_id), it is activated. This picture parameter set RBSP is called the active picture parameter set RBSP until it is deactivated by the

activation of another picture parameter set RBSP. A picture parameter set RBSP, with that particular value of pic_parameter_set_id, shall be available to the decoding process prior to its activation.

Any picture parameter set NAL unit containing the value of pic_parameter_set_id for the active picture parameter set RBSP shall have the same content as that of the active picture parameter set RBSP unless it follows the last VCL NAL unit of a coded picture and precedes the first VCL NAL unit of another coded picture.

A sequence parameter set RBSP includes parameters that can be referred to by one or more picture parameter set RBSPs or one or more SEI NAL units containing a buffering period SEI message. Each sequence parameter set RBSP is initially considered not active at the start of the operation of the decoding process. At most one sequence parameter set RBSP is considered active at any given moment during the operation of the decoding process, and the activation of any particular sequence parameter set RBSP results in the deactivation of the previously-active sequence parameter set RBSP (if any).

When a sequence parameter set RBSP (with a particular value of seq_parameter_set_id) is not already active and it is referred to by activation of a picture parameter set RBSP (using that value of seq_parameter_set_id) or is referred to by an SEI NAL unit containing a buffering period SEI message (using that value of seq_parameter_set_id), it is activated. This sequence parameter set RBSP is called the active sequence parameter set RBSP until it is deactivated by the activation of another sequence parameter set RBSP. A sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation. An activated sequence parameter set RBSP shall remain active for the entire coded video sequence.

NOTE 2 – Because an IDR access unit begins a new coded video sequence and an activated sequence parameter set RBSP must remain active for the entire coded video sequence, a sequence parameter set RBSP can only be activated by a buffering period SEI message when the buffering period SEI message is part of an IDR access unit.

Any sequence parameter set NAL unit containing the value of seq_parameter_set_id for the active sequence parameter set RBSP shall have the same content as that of the active sequence parameter set RBSP unless it follows the last access unit of a coded video sequence and precedes the first VCL NAL unit and the first SEI NAL unit containing a buffering period SEI message (when present) of another coded video sequence.

NOTE 3 – If picture parameter set RBSP or sequence parameter set RBSP are conveyed within the bitstream, these constraints impose an order constraint on the NAL units that contain the picture parameter set RBSP or sequence parameter set RBSP, respectively. Otherwise (picture parameter set RBSP or sequence parameter set RBSP are conveyed by other means not specified in this Recommendation | International Standard), they must be available to the decoding process in a timely fashion such that these constraints are obeyed.

When present, a sequence parameter set extension RBSP includes parameters having a similar function to those of a sequence parameter set RBSP. For purposes of establishing constraints on the syntax elements of the sequence parameter set extension RBSP and for purposes of determining activation of a sequence parameter set extension RBSP, the sequence parameter set extension RBSP shall be considered part of the preceding sequence parameter set RBSP with the same value of seq_parameter_set_id. When a sequence parameter set RBSP is present that is not followed by a sequence parameter set extension RBSP with the same value of seq_parameter_set_id prior to the activation of the sequence parameter set RBSP, the sequence parameter set extension RBSP and its syntax elements shall be considered not present for the active sequence parameter set RBSP.

All constraints that are expressed on the relationship between the values of the syntax elements (and the values of variables derived from those syntax elements) in sequence parameter sets and picture parameter sets and other syntax elements are expressions of constraints that apply only to the active sequence parameter set and the active picture parameter set. If any sequence parameter set RBSP is present that is not activated in the bitstream, its syntax elements shall have values that would conform to the specified constraints if it were activated by reference in an otherwise-conforming bitstream. If any picture parameter set RBSP is present that is not ever activated in the bitstream, its syntax elements shall have values that would conform to the specified constraints if it were activated by reference in an otherwise-conforming bitstream.

During operation of the decoding process (see clause 8), the values of parameters of the active picture parameter set and the active sequence parameter set shall be considered in effect. For interpretation of SEI messages, the values of the parameters of the picture parameter set and sequence parameter set that are active for the operation of the decoding process for the VCL NAL units of the primary coded picture in the same access unit shall be considered in effect unless otherwise specified in the SEI message semantics.

7.4.1.2.2 Order of access units and association to coded video sequences

A bitstream conforming to this Recommendation | International Standard consists of one or more coded video sequences.

A coded video sequence consists of one or more access units. For coded video sequences that conform to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9, the order of NAL units and coded pictures and their association to access units is described in subclause 7.4.1.2.3.

The first access unit of each coded video sequence is an IDR access unit. All subsequent access units in the coded video sequence are non-IDR access units.

The values of picture order count for the coded pictures in consecutive access units in decoding order containing non-reference pictures shall be non-decreasing.

When present, an access unit following an access unit that contains an end of sequence NAL unit shall be an IDR access unit.

When an SEI NAL unit contains data that pertain to more than one access unit (for example, when the SEI NAL unit has a coded video sequence as its scope), it shall be contained in the first access unit to which it applies.

When an end of stream NAL unit is present in an access unit, this access unit shall be the last access unit in the bitstream and the end of stream NAL unit shall be the last NAL unit in that access unit.

7.4.1.2.3 Order of NAL units and coded pictures and association to access units

This subclause specifies the order of NAL units and coded pictures and association to access unit for coded video sequences that conform to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9.

An access unit consists of one primary coded picture, zero or more corresponding redundant coded pictures, and zero or more non-VCL NAL units. The association of VCL NAL units to primary or redundant coded pictures is described in subclause 7.4.1.2.5.

The first access unit in the bitstream starts with the first NAL unit of the bitstream.

The first of any of the following NAL units after the last VCL NAL unit of a primary coded picture specifies the start of a new access unit.

– access unit delimiter NAL unit (when present)

– sequence parameter set NAL unit (when present)

– picture parameter set NAL unit (when present)

– SEI NAL unit (when present)

– NAL units with nal_unit_type in the range of 14 to 18, inclusive

– first VCL NAL unit of a primary coded picture (always present)

The constraints for the detection of the first VCL NAL unit of a primary coded picture are specified in subclause 7.4.1.2.4.

The following constraints shall be obeyed by the order of the coded pictures and non-VCL NAL units within an access unit.

– When an access unit delimiter NAL unit is present, it shall be the first NAL unit. There shall be at most one access unit delimiter NAL unit in any access unit.

– When any SEI NAL units are present, they shall precede the primary coded picture.

– When an SEI NAL unit containing a buffering period SEI message is present, the buffering period SEI message shall be the first SEI message payload of the first SEI NAL unit in the access unit.

– The primary coded picture shall precede the corresponding redundant coded pictures.

– When redundant coded pictures are present, they shall be ordered in ascending order of the value of redundant_pic_cnt.

– When a sequence parameter set extension NAL unit is present, it shall be the next NAL unit after a sequence parameter set NAL unit having the same value of seq_parameter_set_id as in the sequence parameter set extension NAL unit.

– When one or more coded slice of an auxiliary coded picture without partitioning NAL units is present, they shall follow the primary coded picture and all redundant coded pictures (if any).

– When an end of sequence NAL unit is present, it shall follow the primary coded picture and all redundant coded pictures (if any) and all coded slice of an auxiliary coded picture without partitioning NAL units (if any).

– When an end of stream NAL unit is present, it shall be the last NAL unit.

– NAL units having nal_unit_type equal to 0, 12, or in the range of 20 to 31, inclusive, shall not precede the first VCL NAL unit of the primary coded picture.

NOTE 1 – Sequence parameter set NAL units or picture parameter set NAL units may be present in an access unit, but cannot follow the last VCL NAL unit of the primary coded picture within the access unit, as this condition would specify the start of a new access unit.

NOTE 2 – When a NAL unit having nal_unit_type equal to 7 or 8 is present in an access unit, it may or may not be referred to in the coded pictures of the access unit in which it is present, and may be referred to in coded pictures of subsequent access units.

The structure of access units not containing any NAL units with nal_unit_type equal to 0, 7, 8, or in the range of 12 to 18, inclusive, or in the range of 20 to 31, inclusive, is shown in Figure 7-1.

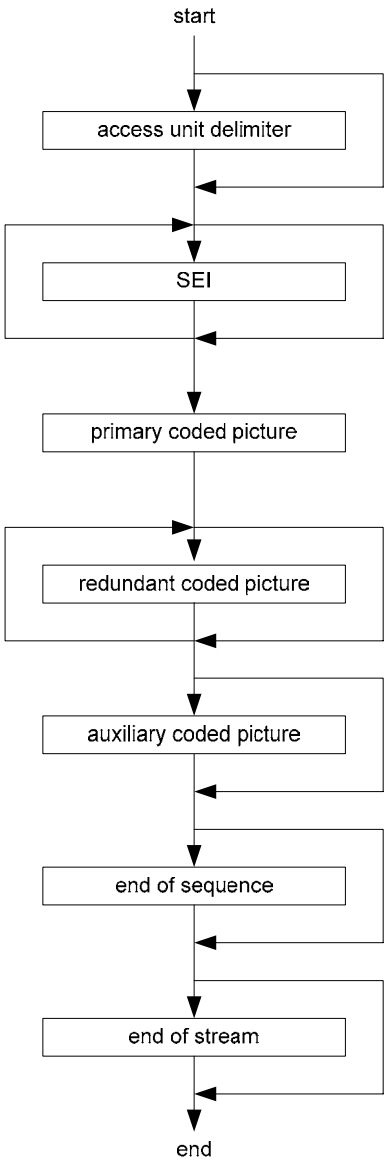


Figure 7-1 – Structure of an access unit not containing any NAL units with nal_unit_type equal to 0, 7, 8, or in the range of 12 to 18, inclusive, or in the range of 20 to 31, inclusive

7.4.1.2.4 Detection of the first VCL NAL unit of a primary coded picture

This subclause specifies constraints on VCL NAL unit syntax that are sufficient to enable the detection of the first VCL NAL unit of each primary coded picture for coded video sequences that conform to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9.

Any coded slice NAL unit or coded slice data partition A NAL unit of the primary coded picture of the current access unit shall be different from any coded slice NAL unit or coded slice data partition A NAL unit of the primary coded picture of the previous access unit in one or more of the following ways.

– frame_num differs in value. The value of frame_num used to test this condition is the value of frame_num that appears in the syntax of the slice header, regardless of whether that value is inferred to have been equal to 0 for subsequent use in the decoding process due to the presence of memory_management_control_operation equal to 5.

  NOTE 1 – A consequence of the above statement is that a primary coded picture having frame_num equal to 1 cannot contain a memory_management_control_operation equal to 5 unless some other condition listed below is fulfilled for the next primary coded picture that follows after it (if any).

– pic_parameter_set_id differs in value.

– field_pic_flag differs in value.

– bottom_field_flag is present in both and differs in value.

– nal_ref_idc differs in value with one of the nal_ref_idc values being equal to 0.

– pic_order_cnt_type is equal to 0 for both and either pic_order_cnt_lsb differs in value, or delta_pic_order_cnt_bottom differs in value.

– pic_order_cnt_type is equal to 1 for both and either delta_pic_order_cnt[0] differs in value, or delta_pic_order_cnt[1] differs in value.

– IdrPicFlag differs in value.

– IdrPicFlag is equal to 1 for both and idr_pic_id differs in value.

NOTE 2 – Some of the VCL NAL units in redundant coded pictures or some non-VCL NAL units (e.g., an access unit delimiter NAL unit) may also be used for the detection of the boundary between access units, and may therefore aid in the detection of the start of a new primary coded picture.

7.4.1.2.5 Order of VCL NAL units and association to coded pictures

This subclause specifies the order of VCL NAL units and association to coded pictures for coded video sequences that conform to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9.

Each VCL NAL unit is part of a coded picture.

The order of the VCL NAL units within a coded IDR picture is constrained as follows.

– If arbitrary slice order is allowed as specified in Annex A, coded slice of an IDR picture NAL units may have any order relative to each other.

– Otherwise (arbitrary slice order is not allowed), the following applies.

  – If separate_colour_plane_flag is equal to 0, coded slice of an IDR picture NAL units of a slice group shall not be interleaved with coded slice of an IDR picture NAL units of another slice group and the order of coded slice of an IDR picture NAL units within a slice group shall be in the order of increasing macroblock address for the first macroblock of each coded slice of an IDR picture NAL unit of the particular slice group.

  – Otherwise (separate_colour_plane_flag is equal to 1), coded slice of an IDR picture NAL units of a slice group for a particular value of colour_plane_id shall not be interleaved with coded slice of an IDR picture NAL units of another slice group with the same value of colour_plane_id and the order of coded slices of IDR picture NAL units within a slice group for a particular value of colour_plane_id shall be in the order of increasing macroblock address for the first macroblock of each coded slice of an IDR picture NAL unit of the particular slice group having the particular value of colour_plane_id.

    NOTE 1 – When separate_colour_plane_flag is equal to 1, the relative ordering of coded slices having different values of colour_plane_id is not constrained.

The order of the VCL NAL units within a coded non-IDR picture is constrained as follows.

– If arbitrary slice order is allowed as specified in Annex A, coded slice of a non-IDR picture NAL units or coded slice data partition A NAL units may have any order relative to each other. A coded slice data partition A NAL unit with a particular value of slice_id shall precede any present coded slice data partition B NAL unit with the same value of slice_id. A coded slice data partition A NAL unit with a particular value of slice_id shall precede any present coded slice data partition C NAL unit with the same value of slice_id. When a coded slice data partition B NAL unit with a particular value of slice_id is present, it shall precede any present coded slice data partition C NAL unit with the same value of slice_id.

– Otherwise (arbitrary slice order is not allowed), the following applies.

  – If separate_colour_plane_flag is equal to 0, coded slice of a non-IDR picture NAL units or coded slice data partition NAL units of a slice group shall not be interleaved with coded slice of a non-IDR picture NAL units or coded slice data partition NAL units of another slice group and the order of coded slice of a non-IDR picture NAL units or coded slice data partition A NAL units within a slice group shall be in the order of increasing macroblock address for the first macroblock of each coded slice of a non-IDR picture NAL unit or coded slice data partition A NAL unit of the particular slice group. A coded slice data partition A NAL unit with a particular value of slice_id shall immediately precede any present coded slice data partition B NAL unit with the same value of slice_id. A coded slice data partition A NAL unit with a particular value of slice_id shall immediately precede any present coded slice data partition C NAL unit with the same value of slice_id, when a coded slice data partition B NAL unit with the same value of slice_id is not present. When a coded slice data partition B NAL unit with a particular value of slice_id is present, it shall immediately precede any present coded slice data partition C NAL unit with the same value of slice_id.

  – Otherwise (separate_colour_plane_flag is equal to 1), coded slice of a non-IDR picture NAL units or coded slice data partition NAL units of a slice group for a particular value of colour_plane_id shall not be interleaved with coded slice of a non-IDR picture NAL units or coded slice data partition NAL units of another slice group with the same value of colour_plane_id and the order of coded slice of a non-IDR picture NAL units or coded slice data partition A NAL units within a slice group for particular value of colour_plane_id shall be in the order of increasing macroblock address for the first macroblock of each coded slice of a non-IDR picture NAL unit or coded slice data partition A NAL unit of the particular slice group having the particular value of colour_plane_id. A coded slice data partition A NAL unit associated with a particular value of slice_id and colour_plane_id shall immediately precede any present coded slice data partition B NAL unit with the same value of slice_id and colour_plane_id. A coded slice data partition A NAL unit associated with a particular value of slice_id and colour_plane_id shall immediately precede any present coded slice data partition C NAL unit with the same value of slice_id and colour_plane_id, when a coded slice data partition B NAL unit with the same value of slice_id and colour_plane_id is not present. When a coded slice data partition B NAL unit with a particular value of slice_id and colour_plane_id is present, it shall immediately precede any present coded slice data partition C NAL unit with the same value of slice_id and colour_plane_id.

    NOTE 2 – When separate_colour_plane_flag is equal to 1, the relative ordering of coded slices having different values of colour_plane_id is not constrained.

NAL units having nal_unit_type equal to 12 may be present in the access unit but shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

NAL units having nal_unit_type equal to 0 or in the range of 24 to 31, inclusive, which are unspecified, may be present in the access unit but shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

NAL units having nal_unit_type in the range of 20 to 23, inclusive, shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

7.4.2 Raw byte sequence payloads and RBSP trailing bits semantics

7.4.2.1 Sequence parameter set RBSP semantics

7.4.2.1.1 Sequence parameter set data semantics

profile_idc and **level_idc** indicate the profile and level to which the coded video sequence conforms.

constraint_set0_flag equal to 1 indicates that the coded video sequence obeys all constraints specified in subclause A.2.1. constraint_set0_flag equal to 0 indicates that the coded video sequence may or may not obey all constraints specified in subclause A.2.1.

constraint_set1_flag equal to 1 indicates that the coded video sequence obeys all constraints specified in subclause A.2.2. constraint_set1_flag equal to 0 indicates that the coded video sequence may or may not obey all constraints specified in subclause A.2.2.

constraint_set2_flag equal to 1 indicates that the coded video sequence obeys all constraints specified in subclause A.2.3. constraint_set2_flag equal to 0 indicates that the coded video sequence may or may not obey all constraints specified in subclause A.2.3.

NOTE 1 – When one or more than one of constraint_set0_flag, constraint_set1_flag, or constraint_set2_flag are equal to 1, the coded video sequence must obey the constraints of all of the indicated subclauses of subclause A.2. When profile_idc is equal to 44, 100, 110, 122, or 244, the values of constraint_set0_flag, constraint_set1_flag, and constraint_set2_flag must all be equal to 0.

constraint_set3_flag indicates the following.

– If profile_idc is equal to 66, 77, or 88 and level_idc is equal to 11, constraint_set3_flag equal to 1 indicates that the coded video sequence obeys all constraints specified in Annex A for level 1b and constraint_set3_flag equal to 0 indicates that the coded video sequence may or may not obey all constraints specified in Annex A for level 1b.

– Otherwise, if profile_idc is equal to 100 or 110, constraint_set3_flag equal to 1 indicates that the coded video sequence obeys all constraints specified in Annex A for the High 10 Intra profile, and constraint_set3_flag equal to 0 indicates that the coded video sequence may or may not obey these corresponding constraints.

– Otherwise, if profile_idc is equal to 122, constraint_set3_flag equal to 1 indicates that the coded video sequence obeys all constraints specified in Annex A for the High 4:2:2 Intra profile, and constraint_set3_flag equal to 0 indicates that the coded video sequence may or may not obey these corresponding constraints.

– Otherwise, if profile_idc is equal to 44, constraint_set3_flag shall be equal to 1. When profile_idc is equal to 44, the value of 0 for constraint_set3_flag is forbidden.

– Otherwise, if profile_idc is equal to 244, constraint_set3_flag equal to 1 indicates that the coded video sequence obeys all constraints specified in Annex A for the High 4:4:4 Intra profile, and constraint_set3_flag equal to 0 indicates that the coded video sequence may or may not obey these corresponding constraints.

– Otherwise (profile_idc is equal to 66, 77, or 88 and level_idc is not equal to 11), the value of 1 for constraint_set3_flag is reserved for future use by ITU-T | ISO/IEC. constraint_set3_flag shall be equal to 0 for coded video sequences with profile_idc equal to 66, 77, or 88 and level_idc not equal to 11 in bitstreams conforming to this Recommendation | International Standard. Decoders conforming to this Recommendation | International Standard shall ignore the value of constraint_set3_flag when profile_idc is equal to 66, 77, or 88 and level_idc is not equal to 11.

reserved_zero_4bits shall be equal to 0. Other values of reserved_zero_4bits may be specified in the future by ITU-T | ISO/IEC. Decoders shall ignore the value of reserved_zero_4bits.

seq_parameter_set_id identifies the sequence parameter set that is referred to by the picture parameter set. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

NOTE 2 – When feasible, encoders should use distinct values of seq_parameter_set_id when the values of other sequence parameter set syntax elements differ rather than changing the values of the syntax elements associated with a specific value of seq_parameter_set_id.

chroma_format_idc specifies the chroma sampling relative to the luma sampling as specified in subclause 6.2. The value of chroma_format_idc shall be in the range of 0 to 3, inclusive. When chroma_format_idc is not present, it shall be inferred to be equal to 1 (4:2:0 chroma format).

separate_colour_plane_flag equal to 1 specifies that the three colour components of the 4:4:4 chroma format are coded separately. separate_colour_plane_flag equal to 0 specifies that the colour components are not coded separately. When separate_colour_plane_flag is not present, it shall be inferred to be equal to 0. When separate_colour_plane_flag is equal to 1, the primary coded picture consists of three separate components, each of which consists of coded samples of one colour plane (Y, Cb or Cr) that each use the monochrome coding syntax. In this case, each colour plane is associated with a specific colour_plane_id value.

NOTE 3 – There is no dependency in decoding processes between the colour planes having different colour_plane_id values. For example, the decoding process of a monochrome picture with one value of colour_plane_id does not use any data from monochrome pictures having different values of colour_plane_id for inter prediction.

Depending on the value of separate_colour_plane_flag, the value of the variable ChromaArrayType is assigned as follows.

– If separate_colour_plane_flag is equal to 0, ChromaArrayType is set equal to chroma_format_idc.

– Otherwise (separate_colour_plane_flag is equal to 1), ChromaArrayType is set equal to 0.

bit_depth_luma_minus8 specifies the bit depth of the samples of the luma array and the value of the luma quantisation parameter range offset $QpBdOffset_Y$, as specified by

$$BitDepth_Y = 8 + bit\_depth\_luma\_minus8 \quad (7\text{-}2)$$

$$QpBdOffset_Y = 6 * bit\_depth\_luma\_minus8 \quad (7\text{-}3)$$

When bit_depth_luma_minus8 is not present, it shall be inferred to be equal to 0. bit_depth_luma_minus8 shall be in the range of 0 to 6, inclusive.

bit_depth_chroma_minus8 specifies the bit depth of the samples of the chroma arrays and the value of the chroma quantisation parameter range offset $QpBdOffset_C$, as specified by

$$BitDepth_C = 8 + bit\_depth\_chroma\_minus8 \quad (7\text{-}4)$$

$$QpBdOffset_C = 6 * (bit\_depth\_chroma\_minus8 + residual\_colour\_transform\_flag) \quad (7\text{-}5)$$

When bit_depth_chroma_minus8 is not present, it shall be inferred to be equal to 0. bit_depth_chroma_minus8 shall be in the range of 0 to 6, inclusive.

NOTE 4 – The value of bit_depth_chroma_minus8 is not used in the decoding process when ChromaArrayType is equal to 0. In particular, when separate_colour_plane_flag is equal to 1, each colour plane is decoded as a distinct monochrome picture using the luma component decoding process (except for the selection of scaling matrices) and the luma bit depth is used for all three colour components.

The variable RawMbBits is derived as

$$RawMbBits = 256 * BitDepth_Y + 2 * MbWidthC * MbHeightC * BitDepth_C \quad (7\text{-}6)$$

qpprime_y_zero_transform_bypass_flag equal to 1 specifies that, when QP'_Y is equal to 0, a transform bypass operation for the transform coefficient decoding process and picture construction process prior to deblocking filter process as specified in subclause 8.5 shall be applied. qpprime_y_zero_transform_bypass_flag equal to 0 specifies that the transform coefficient decoding process and picture construction process prior to deblocking filter process shall not use the transform bypass operation. When qpprime_y_zero_transform_bypass_flag is not present, it shall be inferred to be equal to 0.

seq_scaling_matrix_present_flag equal to 1 specifies that the flags seq_scaling_list_present_flag[i] for i = 0..7 or i = 0..11 are present. seq_scaling_matrix_present_flag equal to 0 specifies that these flags are not present and the sequence-level scaling list specified by Flat_4x4_16 shall be inferred for i = 0..5 and the sequence-level scaling list specified by Flat_8x8_16 shall be inferred for i = 6..11. When seq_scaling_matrix_present_flag is not present, it shall be inferred to be equal to 0.

The scaling lists Flat_4x4_16 and Flat_8x8_16 are specified as follows:

$$Flat\_4x4\_16[i] = 16, \quad \text{with } i = 0..15, \quad (7\text{-}7)$$

$$Flat\_8x8\_16[i] = 16, \quad \text{with } i = 0..63. \quad (7\text{-}8)$$

seq_scaling_list_present_flag[i **]** equal to 1 specifies that the syntax structure for scaling list i is present in the sequence parameter set. seq_scaling_list_present_flag[i] equal to 0 specifies that the syntax structure for scaling list i is not present in the sequence parameter set and the scaling list fall-back rule set A specified in Table 7-2 shall be used to infer the sequence-level scaling list for index i.

Table 7-2 – Assignment of mnemonic names to scaling list indices and specification of fall-back rule

Value of scaling list index	Mnemonic name	Block size	MB prediction type	Component	Scaling list fall-back rule set A	Scaling list fall-back rule set B	Default scaling list
0	Sl_4x4_Intra_Y	4x4	Intra	Y	default scaling list	sequence-level scaling list	Default_4x4_Intra
1	Sl_4x4_Intra_Cb	4x4	Intra	Cb	scaling list for i = 0	scaling list for i = 0	Default_4x4_Intra
2	Sl_4x4_Intra_Cr	4x4	Intra	Cr	scaling list for i = 1	scaling list for i = 1	Default_4x4_Intra
3	Sl_4x4_Inter_Y	4x4	Inter	Y	default scaling list	sequence-level scaling list	Default_4x4_Inter
4	Sl_4x4_Inter_Cb	4x4	Inter	Cb	scaling list for i = 3	scaling list for i = 3	Default_4x4_Inter
5	Sl_4x4_Inter_Cr	4x4	Inter	Cr	scaling list for i = 4	scaling list for i = 4	Default_4x4_Inter
6	Sl_8x8_Intra_Y	8x8	Intra	Y	default scaling list	sequence-level scaling list	Default_8x8_Intra
7	Sl_8x8_Inter_Y	8x8	Inter	Y	default scaling list	sequence-level scaling list	Default_8x8_Inter
8	Sl_8x8_Intra_Cb	8x8	Intra	Cb	scaling list for i = 6	scaling list for i = 6	Default_8x8_Intra
9	Sl_8x8_Inter_Cb	8x8	Inter	Cb	scaling list for i = 7	scaling list for i = 7	Default_8x8_Inter
10	Sl_8x8_Intra_Cr	8x8	Intra	Cr	scaling list for i = 8	scaling list for i = 8	Default_8x8_Intra
11	Sl_8x8_Inter_Cr	8x8	Inter	Cr	scaling list for i = 9	scaling list for i = 9	Default_8x8_Inter

Table 7-3 specifies the default scaling lists Default_4x4_Intra and Default_4x4_Inter. Table 7-4 specifies the default scaling lists Default_8x8_Intra and Default_8x8_Inter.

Table 7-3 – Specification of default scaling lists Default_4x4_Intra and Default_4x4_Inter

idx	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Default_4x4_Intra[idx]	6	13	13	20	20	20	28	28	28	28	32	32	32	37	37	42
Default_4x4_Inter[idx]	10	14	14	20	20	20	24	24	24	24	27	27	27	30	30	34

Table 7-4 – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter

idx	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Default_8x8_Intra[idx]	6	10	10	13	11	13	16	16	16	16	18	18	18	18	18	23
Default_8x8_Inter[idx]	9	13	13	15	13	15	17	17	17	17	19	19	19	19	19	21

Table 7-4 (continued) – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter

idx	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Default_8x8_Intra[idx]	23	23	23	23	23	25	25	25	25	25	25	25	27	27	27	27
Default_8x8_Inter[idx]	21	21	21	21	21	22	22	22	22	22	22	22	24	24	24	24

Table 7-4 (continued) – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter

idx	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
Default_8x8_Intra[idx]	27	27	27	27	29	29	29	29	29	29	29	31	31	31	31	31
Default_8x8_Inter[idx]	24	24	24	24	25	25	25	25	25	25	25	27	27	27	27	27

Table 7-4 (concluded) – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter

idx	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
Default_8x8_Intra[idx]	31	33	33	33	33	33	36	36	36	36	38	38	38	40	40	42
Default_8x8_Inter[idx]	27	28	28	28	28	28	30	30	30	30	32	32	32	33	33	35

log2_max_frame_num_minus4 specifies the value of the variable MaxFrameNum that is used in frame_num related derivations as follows:

$$MaxFrameNum = 2^{(log2\_max\_frame\_num\_minus4 + 4)} \quad (7\text{-}9)$$

The value of log2_max_frame_num_minus4 shall be in the range of 0 to 12, inclusive.

pic_order_cnt_type specifies the method to decode picture order count (as specified in subclause 8.2.1). The value of pic_order_cnt_type shall be in the range of 0 to 2, inclusive.

pic_order_cnt_type shall not be equal to 2 in a coded video sequence that contains any of the following:

- an access unit containing a non-reference frame followed immediately by an access unit containing a non-reference picture;
- two access units each containing a field with the two fields together forming a complementary non-reference field pair followed immediately by an access unit containing a non-reference picture;
- an access unit containing a non-reference field followed immediately by an access unit containing another non-reference picture that does not form a complementary non-reference field pair with the first of the two access units.

log2_max_pic_order_cnt_lsb_minus4 specifies the value of the variable MaxPicOrderCntLsb that is used in the decoding process for picture order count as specified in subclause 8.2.1 as follows:

$$MaxPicOrderCntLsb = 2^{(log2\_max\_pic\_order\_cnt\_lsb\_minus4 + 4)} \quad (7\text{-}10)$$

The value of log2_max_pic_order_cnt_lsb_minus4 shall be in the range of 0 to 12, inclusive.

delta_pic_order_always_zero_flag equal to 1 specifies that delta_pic_order_cnt[0] and delta_pic_order_cnt[1] are not present in the slice headers of the sequence and shall be inferred to be equal to 0. delta_pic_order_always_zero_flag

equal to 0 specifies that delta_pic_order_cnt[0] is present in the slice headers of the sequence and delta_pic_order_cnt[1] may be present in the slice headers of the sequence.

offset_for_non_ref_pic is used to calculate the picture order count of a non-reference picture as specified in 8.2.1. The value of offset_for_non_ref_pic shall be in the range of -2^{31} to $2^{31} - 1$, inclusive.

offset_for_top_to_bottom_field is used to calculate the picture order count of a bottom field as specified in subclause 8.2.1. The value of offset_for_top_to_bottom_field shall be in the range of -2^{31} to $2^{31} - 1$, inclusive.

num_ref_frames_in_pic_order_cnt_cycle is used in the decoding process for picture order count as specified in subclause 8.2.1. The value of num_ref_frames_in_pic_order_cnt_cycle shall be in the range of 0 to 255, inclusive.

offset_for_ref_frame[i **]** is an element of a list of num_ref_frames_in_pic_order_cnt_cycle values used in the decoding process for picture order count as specified in subclause 8.2.1. The value of offset_for_ref_frame[i] shall be in the range of -2^{31} to $2^{31} - 1$, inclusive.

num_ref_frames specifies the maximum number of short-term and long-term reference frames, complementary reference field pairs, and non-paired reference fields that may be used by the decoding process for inter prediction of any picture in the sequence. num_ref_frames also determines the size of the sliding window operation as specified in subclause 8.2.5.3. The value of num_ref_frames shall be in the range of 0 to MaxDpbSize (as specified in subclause A.3.1 or A.3.2), inclusive.

gaps_in_frame_num_value_allowed_flag specifies the allowed values of frame_num as specified in subclause 7.4.3 and the decoding process in case of an inferred gap between values of frame_num as specified in subclause 8.2.5.2.

pic_width_in_mbs_minus1 plus 1 specifies the width of each decoded picture in units of macroblocks.

The variable for the picture width in units of macroblocks is derived as follows:

$$PicWidthInMbs = pic\_width\_in\_mbs\_minus1 + 1 \quad (7\text{-}11)$$

The variable for picture width for the luma component is derived as follows:

$$PicWidthInSamples_L = PicWidthInMbs * 16 \quad (7\text{-}12)$$

The variable for picture width for the chroma components is derived as follows:

$$PicWidthInSamples_C = PicWidthInMbs * MbWidthC \quad (7\text{-}13)$$

pic_height_in_map_units_minus1 plus 1 specifies the height in slice group map units of a decoded frame or field.

The variables PicHeightInMapUnits and PicSizeInMapUnits are derived as follows:

$$PicHeightInMapUnits = pic\_height\_in\_map\_units\_minus1 + 1 \quad (7\text{-}14)$$

$$PicSizeInMapUnits = PicWidthInMbs * PicHeightInMapUnits \quad (7\text{-}15)$$

frame_mbs_only_flag equal to 0 specifies that coded pictures of the coded video sequence may either be coded fields or coded frames. frame_mbs_only_flag equal to 1 specifies that every coded picture of the coded video sequence is a coded frame containing only frame macroblocks.

The allowed range of values for pic_width_in_mbs_minus1, pic_height_in_map_units_minus1, and frame_mbs_only_flag is specified by constraints in Annex A.

Depending on frame_mbs_only_flag, semantics are assigned to pic_height_in_map_units_minus1 as follows:

– If frame_mbs_only_flag is equal to 0, pic_height_in_map_units_minus1 plus 1 is the height of a field in units of macroblocks.

– Otherwise (frame_mbs_only_flag is equal to 1), pic_height_in_map_units_minus1 plus 1 is the height of a frame in units of macroblocks.

The variable FrameHeightInMbs is derived as follows:

$$FrameHeightInMbs = (2 - frame\_mbs\_only\_flag) * PicHeightInMapUnits \quad (7\text{-}16)$$

mb_adaptive_frame_field_flag equal to 0 specifies no switching between frame and field macroblocks within a picture. mb_adaptive_frame_field_flag equal to 1 specifies the possible use of switching between frame and field macroblocks within frames. When mb_adaptive_frame_field_flag is not present, it shall be inferred to be equal to 0.

direct_8x8_inference_flag specifies the method used in the derivation process for luma motion vectors for B_Skip, B_Direct_16x16 and B_Direct_8x8 as specified in subclause 8.4.1.2. When frame_mbs_only_flag is equal to 0, direct_8x8_inference_flag shall be equal to 1.

frame_cropping_flag equal to 1 specifies that the frame cropping offset parameters follow next in the sequence parameter set. frame_cropping_flag equal to 0 specifies that the frame cropping offset parameters are not present.

frame_crop_left_offset, frame_crop_right_offset, frame_crop_top_offset, frame_crop_bottom_offset specify the samples of the pictures in the coded video sequence that are output from the decoding process, in terms of a rectangular region specified in frame coordinates for output.

The variables CropUnitX and CropUnitY are derived as follows:

— If ChromaArrayType is equal to 0, CropUnitX and CropUnitY are derived as

$$CropUnitX = 1 \tag{7-17}$$

$$CropUnitY = 2 - frame\_mbs\_only\_flag \tag{7-18}$$

— Otherwise (ChromaArrayType is equal to 1, 2, or 3), CropUnitX and CropUnitY are derived as

$$CropUnitX = SubWidthC \tag{7-19}$$

$$CropUnitY = SubHeightC * (2 - frame\_mbs\_only\_flag) \tag{7-20}$$

The frame cropping rectangle contains luma samples with horizontal frame coordinates from CropUnitX * frame_crop_left_offset to $PicWidthInSamples_L$ – (CropUnitX * frame_crop_right_offset + 1) and vertical frame coordinates from CropUnitY * frame_crop_top_offset to (16 * FrameHeightInMbs) – (CropUnitY * frame_crop_bottom_offset + 1), inclusive. The value of frame_crop_left_offset shall be in the range of 0 to ($PicWidthInSamples_L$ / CropUnitX) – (frame_crop_right_offset + 1), inclusive; and the value of frame_crop_top_offset shall be in the range of 0 to (16 * FrameHeightInMbs / CropUnitY) – (frame_crop_bottom_offset + 1), inclusive.

When frame_cropping_flag is equal to 0, the values of frame_crop_left_offset, frame_crop_right_offset, frame_crop_top_offset, and frame_crop_bottom_offset shall be inferred to be equal to 0.

When ChromaArrayType is not equal to 0, the corresponding specified samples of the two chroma arrays are the samples having frame coordinates (x / SubWidthC, y / SubHeightC), where (x, y) are the frame coordinates of the specified luma samples.

For decoded fields, the specified samples of the decoded field are the samples that fall within the rectangle specified in frame coordinates.

vui_parameters_present_flag equal to 1 specifies that the vui_parameters( ) syntax structure as specified in Annex E is present. vui_parameters_present_flag equal to 0 specifies that the vui_parameters( ) syntax structure as specified in Annex E is not present.

7.4.2.1.1.1 Scaling list semantics

delta_scale is used to derive the j-th element of the scaling list for j in the range of 0 to sizeOfScalingList - 1, inclusive. The value of delta_scale shall be in the range of -128 to +127, inclusive.

When useDefaultScalingMatrixFlag is derived to be equal to 1, the scaling list shall be inferred to be equal to the default scaling list as specified in Table 7-2.

7.4.2.1.2 Sequence parameter set extension RBSP semantics

seq_parameter_set_id identifies the sequence parameter set associated with the sequence parameter set extension. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

aux_format_idc equal to 0 indicates that there are no auxiliary coded pictures in the coded video sequence. aux_format_idc equal to 1 indicates that exactly one auxiliary coded picture is present in each access unit of the coded video sequence, and that for alpha blending purposes the decoded samples of the associated primary coded picture in

each access unit should be multiplied by the interpretation sample values of the auxiliary coded picture in the access unit in the display process after output from the decoding process. aux_format_idc equal to 2 indicates that exactly one auxiliary coded picture exists in each access unit of the coded video sequence, and that for alpha blending purposes the decoded samples of the associated primary coded picture in each access unit should not be multiplied by the interpretation sample values of the auxiliary coded picture in the access unit in the display process after output from the decoding process. aux_format_idc equal to 3 indicates that exactly one auxiliary coded picture exists in each access unit of the coded video sequence, and that the usage of the auxiliary coded pictures is unspecified. The value of aux_format_idc shall be in the range of 0 to 3, inclusive. Values greater than 3 for aux_format_idc are reserved to indicate the presence of exactly one auxiliary coded picture in each access unit of the coded video sequence for purposes to be specified in the future by ITU-T | ISO/IEC. When aux_format_idc is not present, it shall be inferred to be equal to 0.

NOTE 1 – Decoders conforming to this Recommendation | International Standard are not required to decode auxiliary coded pictures.

bit_depth_aux_minus8 specifies the bit depth of the samples of the sample array of the auxiliary coded picture. bit_depth_aux_minus8 shall be in the range of 0 to 4, inclusive.

alpha_incr_flag equal to 0 indicates that the interpretation sample value for each decoded auxiliary coded picture sample value is equal to the decoded auxiliary coded picture sample value for purposes of alpha blending. alpha_incr_flag equal to 1 indicates that, for purposes of alpha blending, after decoding the auxiliary coded picture samples, any auxiliary coded picture sample value that is greater than Min(alpha_opaque_value, alpha_transparent_value) should be increased by one to obtain the interpretation sample value for the auxiliary coded picture sample, and any auxiliary coded picture sample value that is less than or equal to Min(alpha_opaque_value, alpha_transparent_value) should be used without alteration as the interpretation sample value for the decoded auxiliary coded picture sample value.

alpha_opaque_value specifies the interpretation sample value of an auxiliary coded picture sample for which the associated luma and chroma samples of the same access unit are considered opaque for purposes of alpha blending. The number of bits used for the representation of the alpha_opaque_value syntax element is bit_depth_aux_minus8 + 9 bits.

alpha_transparent_value specifies the interpretation sample value of an auxiliary coded picture sample for which the associated luma and chroma samples of the same access unit are considered transparent for purposes of alpha blending. The number of bits used for the representation of the alpha_transparent_value syntax element is bit_depth_aux_minus8 + 9 bits.

When alpha_incr_flag is equal to 1, alpha_transparent_value shall not be equal to alpha_opaque_value and Log2(Abs(alpha_opaque_value – alpha_transparent_value)) shall have an integer value. A value of alpha_transparent_value that is equal to alpha_opaque_value indicates that the auxiliary coded picture is not intended for alpha blending purposes.

NOTE 2 – For alpha blending purposes, alpha_opaque_value may be greater than alpha_transparent_value, or it may be less than alpha_transparent_value. Interpretation sample values should be clipped to the range of alpha_opaque_value to alpha_transparent_value, inclusive.

The decoding of the sequence parameter set extension and the decoding of auxiliary coded pictures is not required for conformance with this Recommendation | International Standard.

The syntax of each coded slice of an auxiliary coded picture shall obey the same constraints as a coded slice of a redundant picture, with the following differences of constraints.

– The following applies in regard to whether the primary coded picture is an IDR picture:
  – If the primary coded picture is an IDR picture, the auxiliary coded slice syntax shall correspond to that of a slice having nal_unit_type equal to 5 (a slice of an IDR picture);
  – Otherwise (the primary coded picture is not an IDR picture), the auxiliary coded slice syntax shall correspond to that of a slice having nal_unit_type equal to 1 (a slice of a non-IDR picture).
– The slices of an auxiliary coded picture (when present) shall contain all macroblocks corresponding to those of the primary coded picture.
– redundant_pic_cnt shall be equal to 0 in all auxiliary coded slices.

The (optional) decoding process for the decoding of auxiliary coded pictures is the same as if the auxiliary coded pictures were primary coded pictures in a separate coded video stream that differs from the primary coded pictures in the current coded video stream in the following ways.

– The IDR or non-IDR status of each auxiliary coded picture shall be inferred to be the same as the IDR or non-IDR status of the primary picture in the same access unit, rather than being inferred from the value of nal_ref_idc.

– The value of chroma_format_idc and the value of ChromaArrayType shall be inferred to be equal to 0 for the decoding of the auxiliary coded pictures.

– The value of bit_depth_luma_minus8 shall be inferred to be equal to bit_depth_aux_minus8 for the decoding of the auxiliary coded pictures.

NOTE 3 – Alpha blending composition is normally performed with a background picture B, a foreground picture F, and a decoded auxiliary coded picture A, all of the same size. Assume for purposes of example illustration that the chroma resolution of B and F have been upsampled to the same resolution as the luma. Denote corresponding samples of B, F and A by b, f and a, respectively. Denote luma and chroma samples by subscripts Y, Cb and Cr.

Define the variables alphaRange, alphaFwt and alphaBwt as follows:

alphaRange = Abs(alpha_opaque_value - alpha_transparent_value)

alphaFwt = Abs(a - alpha_transparent_value)

alphaBwt = Abs(a - alpha_opaque_value)

Then, in alpha blending composition, samples d of the displayed picture D may be calculated as

$d_Y = (alphaFwt*f_Y + alphaBwt*b_Y + alphaRange/2) / alphaRange$

$d_{CB} = (alphaFwt*f_{CB} + alphaBwt*b_{CB} + alphaRange/2) / alphaRange$

$d_{CR} = (alphaFwt*f_{CR} + alphaBwt*b_{CR} + alphaRange/2) / alphaRange$

The samples of pictures D, F and B could also represent red, green, and blue component values (see subclause E.2.1). Here we have assumed Y, Cb and Cr component values. Each component, e.g., Y, is assumed for purposes of example illustration above to have the same bit depth in each of the pictures D, F and B. However, different components, e.g., Y and Cb, need not have the same bit depth in this example.

When aux_format_idc is equal to 1, F would be the decoded picture obtained from the decoded luma and chroma, and A would be the decoded picture obtained from the decoded auxiliary coded picture. In this case, the indicated example alpha blending composition involves multiplying the samples of F by factors obtained from the samples of A.

A picture format that is useful for editing or direct viewing, and that is commonly used, is called pre-multiplied-black video. If the foreground picture was F, then the pre-multiplied-black video S is given by

$s_Y = (alphaFwt*f_Y) / alphaRange$

$s_{CB} = (alphaFwt*f_{CB}) / alphaRange$

$s_{CR} = (alphaFwt*f_{CR}) / alphaRange$

Pre-multiplied-black video has the characteristic that the picture S will appear correct if displayed against a black background. For a non-black background B, the composition of the displayed picture D may be calculated as

$d_Y = s_Y + (alphaBwt*b_Y + alphaRange/2) / alphaRange$

$d_{CB} = s_{CB} + (alphaBwt*b_{CB} + alphaRange/2) / alphaRange$

$d_{CR} = s_{CR} + (alphaBwt*b_{CR} + alphaRange/2) / alphaRange$

When aux_format_idc is equal to 2, S would be the decoded picture obtained from the decoded luma and chroma, and A would again be the decoded picture obtained from the decoded auxiliary coded picture. In this case, alpha blending composition does not involve multiplication of the samples of S by factors obtained from the samples of A.

additional_extension_flag equal to 0 indicates that no additional data follows within the sequence parameter set extension syntax structure prior to the RBSP trailing bits. The value of additional_extension_flag shall be equal to 0. The value of 1 for additional_extension_flag is reserved for future use by ITU-T | ISO/IEC. Decoders that conform to this Recommendation | International Standard shall ignore all data that follows the value of 1 for additional_extension_flag in a sequence parameter set extension NAL unit.

7.4.2.2 Picture parameter set RBSP semantics

pic_parameter_set_id identifies the picture parameter set that is referred to in the slice header. The value of pic_parameter_set_id shall be in the range of 0 to 255, inclusive.

seq_parameter_set_id refers to the active sequence parameter set. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

entropy_coding_mode_flag selects the entropy decoding method to be applied for the syntax elements for which two descriptors appear in the syntax tables as follows.

– If entropy_coding_mode_flag is equal to 0, the method specified by the left descriptor in the syntax table is applied (Exp-Golomb coded, see subclause 9.1 or CAVLC, see subclause 9.2).

– Otherwise (entropy_coding_mode_flag is equal to 1), the method specified by the right descriptor in the syntax table is applied (CABAC, see subclause 9.3).

pic_order_present_flag equal to 1 specifies that the picture order count related syntax elements are present in the slice headers as specified in subclause 7.3.3. pic_order_present_flag equal to 0 specifies that the picture order count related syntax elements are not present in the slice headers.

num_slice_groups_minus1 plus 1 specifies the number of slice groups for a picture. When num_slice_groups_minus1 is equal to 0, all slices of the picture belong to the same slice group. The allowed range of num_slice_groups_minus1 is specified in Annex A.

slice_group_map_type specifies how the mapping of slice group map units to slice groups is coded. The value of slice_group_map_type shall be in the range of 0 to 6, inclusive.

slice_group_map_type equal to 0 specifies interleaved slice groups.

slice_group_map_type equal to 1 specifies a dispersed slice group mapping.

slice_group_map_type equal to 2 specifies one or more "foreground" slice groups and a "leftover" slice group.

slice_group_map_type values equal to 3, 4, and 5 specify changing slice groups. When num_slice_groups_minus1 is not equal to 1, slice_group_map_type shall not be equal to 3, 4, or 5.

slice_group_map_type equal to 6 specifies an explicit assignment of a slice group to each slice group map unit.

Slice group map units are specified as follows.

– If frame_mbs_only_flag is equal to 0 and mb_adaptive_frame_field_flag is equal to 1 and the coded picture is a frame, the slice group map units are macroblock pair units.

– Otherwise, if frame_mbs_only_flag is equal to 1 or a coded picture is a field, the slice group map units are units of macroblocks.

– Otherwise (frame_mbs_only_flag is equal to 0 and mb_adaptive_frame_field_flag is equal to 0 and the coded picture is a frame), the slice group map units are units of two macroblocks that are vertically contiguous as in a frame macroblock pair of an MBAFF frame.

run_length_minus1[i **]** is used to specify the number of consecutive slice group map units to be assigned to the i-th slice group in raster scan order of slice group map units. The value of run_length_minus1[i] shall be in the range of 0 to PicSizeInMapUnits - 1, inclusive.

top_left[i **]** and **bottom_right[** i **]** specify the top-left and bottom-right corners of a rectangle, respectively. top_left[i] and bottom_right[i] are slice group map unit positions in a raster scan of the picture for the slice group map units. For each rectangle i, all of the following constraints shall be obeyed by the values of the syntax elements top_left[i] and bottom_right[i]

– top_left[i] shall be less than or equal to bottom_right[i] and bottom_right[i] shall be less than PicSizeInMapUnits.

– (top_left[i] % PicWidthInMbs) shall be less than or equal to the value of (bottom_right[i] % PicWidthInMbs).

slice_group_change_direction_flag is used with slice_group_map_type to specify the refined map type when slice_group_map_type is 3, 4, or 5.

slice_group_change_rate_minus1 is used to specify the variable SliceGroupChangeRate. SliceGroupChangeRate specifies the multiple in number of slice group map units by which the size of a slice group can change from one picture to the next. The value of slice_group_change_rate_minus1 shall be in the range of 0 to PicSizeInMapUnits – 1, inclusive. The SliceGroupChangeRate variable is specified as follows:

$$SliceGroupChangeRate = slice\_group\_change\_rate\_minus1 + 1 \quad (7\text{-}21)$$

pic_size_in_map_units_minus1 is used to specify the number of slice group map units in the picture. pic_size_in_map_units_minus1 shall be equal to PicSizeInMapUnits - 1.

slice_group_id[i **]** identifies a slice group of the i-th slice group map unit in raster scan order. The size of the slice_group_id[i] syntax element is Ceil(Log2(num_slice_groups_minus1 + 1)) bits. The value of slice_group_id[i] shall be in the range of 0 to num_slice_groups_minus1, inclusive.

num_ref_idx_l0_active_minus1 specifies the maximum reference index for reference picture list 0 that shall be used to decode each slice of the picture in which list 0 prediction is used when num_ref_idx_active_override_flag is equal to 0 for the slice. When MbaffFrameFlag is equal to 1, num_ref_idx_l0_active_minus1 is the maximum index value for the decoding of frame macroblocks and 2 * num_ref_idx_l0_active_minus1 + 1 is the maximum index value for the decoding of field macroblocks. The value of num_ref_idx_l0_active_minus1 shall be in the range of 0 to 31, inclusive.

num_ref_idx_l1_active_minus1 has the same semantics as num_ref_idx_l0_active_minus1 with l0 and list 0 replaced by l1 and list 1, respectively.

weighted_pred_flag equal to 0 specifies that weighted prediction shall not be applied to P and SP slices. weighted_pred_flag equal to 1 specifies that weighted prediction shall be applied to P and SP slices.

weighted_bipred_idc equal to 0 specifies that the default weighted prediction shall be applied to B slices. weighted_bipred_idc equal to 1 specifies that explicit weighted prediction shall be applied to B slices. weighted_bipred_idc equal to 2 specifies that implicit weighted prediction shall be applied to B slices. The value of weighted_bipred_idc shall be in the range of 0 to 2, inclusive.

pic_init_qp_minus26 specifies the initial value minus 26 of $SliceQP_Y$ for each slice. The initial value is modified at the slice layer when a non-zero value of slice_qp_delta is decoded, and is modified further when a non-zero value of mb_qp_delta is decoded at the macroblock layer. The value of pic_init_qp_minus26 shall be in the range of $-(26 + QpBdOffset_Y)$ to +25, inclusive.

pic_init_qs_minus26 specifies the initial value minus 26 of $SliceQS_Y$ for all macroblocks in SP or SI slices. The initial value is modified at the slice layer when a non-zero value of slice_qs_delta is decoded. The value of pic_init_qs_minus26 shall be in the range of -26 to +25, inclusive.

chroma_qp_index_offset specifies the offset that shall be added to QP_Y and QS_Y for addressing the table of QP_C values for the Cb chroma component. The value of chroma_qp_index_offset shall be in the range of -12 to +12, inclusive.

deblocking_filter_control_present_flag equal to 1 specifies that a set of syntax elements controlling the characteristics of the deblocking filter is present in the slice header. deblocking_filter_control_present_flag equal to 0 specifies that the set of syntax elements controlling the characteristics of the deblocking filter is not present in the slice headers and their inferred values are in effect.

constrained_intra_pred_flag equal to 0 specifies that intra prediction allows usage of residual data and decoded samples of neighbouring macroblocks coded using Inter macroblock prediction modes for the prediction of macroblocks coded using Intra macroblock prediction modes. constrained_intra_pred_flag equal to 1 specifies constrained intra prediction, in which case prediction of macroblocks coded using Intra macroblock prediction modes only uses residual data and decoded samples from I or SI macroblock types.

redundant_pic_cnt_present_flag equal to 0 specifies that the redundant_pic_cnt syntax element is not present in slice headers, data partitions B, and data partitions C that refer (either directly or by association with a corresponding data partition A) to the picture parameter set. redundant_pic_cnt_present_flag equal to 1 specifies that the redundant_pic_cnt syntax element is present in all slice headers, data partitions B, and data partitions C that refer (either directly or by association with a corresponding data partition A) to the picture parameter set.

transform_8x8_mode_flag equal to 1 specifies that the 8x8 transform decoding process may be in use (see subclause 8.5). transform_8x8_mode_flag equal to 0 specifies that the 8x8 transform decoding process is not in use. When transform_8x8_mode_flag is not present, it shall be inferred to be 0.

pic_scaling_matrix_present_flag equal to 1 specifies that parameters are present to modify the scaling lists specified in the sequence parameter set. pic_scaling_matrix_present_flag equal to 0 specifies that the scaling lists used for the picture shall be inferred to be equal to those specified by the sequence parameter set. When pic_scaling_matrix_present_flag is not present, it shall be inferred to be equal to 0.

pic_scaling_list_present_flag[i **]** equal to 1 specifies that the scaling list syntax structure is present to specify the scaling list for index i. pic_scaling_list_present_flag[i] equal to 0 specifies that the syntax structure for scaling list i is not present in the picture parameter set and that depending on the value of seq_scaling_matrix_present_flag, the following applies.

– If seq_scaling_matrix_present_flag is equal to 0, the scaling list fall-back rule set A as specified in Table 7-2 shall be used to derive the picture-level scaling list for index i.

– Otherwise (seq_scaling_matrix_present_flag is equal to 1), the scaling list fall-back rule set B as specified in Table 7-2 shall be used to derive the picture-level scaling list for index i.

second_chroma_qp_index_offset specifies the offset that shall be added to QP_Y and QS_Y for addressing the table of QP_C values for the Cr chroma component. The value of second_chroma_qp_index_offset shall be in the range of -12 to +12, inclusive.

When second_chroma_qp_index_offset is not present, it shall be inferred to be equal to chroma_qp_index_offset.

NOTE – When ChromaArrayType is equal to 0, the values of bit_depth_chroma_minus8, chroma_qp_index_offset and second_chroma_qp_index_offset are not used in the decoding process. In particular, when separate_colour_plane_flag is equal to 1, each colour plane is decoded as a distinct monochrome picture using the luma component decoding process (except for the selection of scaling matrices), including the application of the luma quantisation parameter derivation process without application of an offset for the decoding of the pictures having colour_plane_id not equal to 0.

7.4.2.3 Supplemental enhancement information RBSP semantics

Supplemental Enhancement Information (SEI) contains information that is not necessary to decode the samples of coded pictures from VCL NAL units.

7.4.2.3.1 Supplemental enhancement information message semantics

An SEI NAL unit contains one or more SEI messages. Each SEI message consists of the variables specifying the type payloadType and size payloadSize of the SEI payload. SEI payloads are specified in Annex D. The derived SEI payload size payloadSize is specified in bytes and shall be equal to the number of bytes in the SEI payload.

ff_byte is a byte equal to 0xFF identifying a need for a longer representation of the syntax structure that it is used within.

last_payload_type_byte is the last byte of the payload type of an SEI message.

last_payload_size_byte is the last byte of the size of an SEI message.

7.4.2.4 Access unit delimiter RBSP semantics

The access unit delimiter may be used to indicate the type of slices present in a primary coded picture and to simplify the detection of the boundary between access units. There is no normative decoding process associated with the access unit delimiter.

primary_pic_type indicates that the slice_type values for all slices of the primary coded picture are members of the set listed in Table 7-5 for the given value of primary_pic_type.

Table 7-5 – Meaning of primary_pic_type

primary_pic_type	slice_type values that may be present in the primary coded picture
0	2, 7
1	0, 2, 5, 7
2	0, 1, 2, 5, 6, 7
3	4, 9
4	3, 4, 8, 9
5	2, 4, 7, 9
6	0, 2, 3, 4, 5, 7, 8, 9
7	0, 1, 2, 3, 4, 5, 6, 7, 8, 9

7.4.2.5 End of sequence RBSP semantics

The end of sequence RBSP specifies that the next subsequent access unit in the bitstream in decoding order (if any) shall be an IDR access unit. The syntax content of the SODB and RBSP for the end of sequence RBSP are empty. No normative decoding process is specified for an end of sequence RBSP.

7.4.2.6 End of stream RBSP semantics

The end of stream RBSP indicates that no additional NAL units shall be present in the bitstream that are subsequent to the end of stream RBSP in decoding order. The syntax content of the SODB and RBSP for the end of stream RBSP are empty. No normative decoding process is specified for an end of stream RBSP.

7.4.2.7 Filler data RBSP semantics

The filler data RBSP contains bytes whose value shall be equal to 0xFF. No normative decoding process is specified for a filler data RBSP.

ff_byte is a byte equal to 0xFF.

7.4.2.8 Slice layer without partitioning RBSP semantics

The slice layer without partitioning RBSP consists of a slice header and slice data.

7.4.2.9 Slice data partition RBSP semantics

7.4.2.9.1 Slice data partition A RBSP semantics

When slice data partitioning is in use, the coded data for a single slice is divided into three separate partitions. Partition A contains all syntax elements of category 2.

Category 2 syntax elements include all syntax elements in the slice header and slice data syntax structures other than the syntax elements in the residual( ) syntax structure.

slice_id identifies the slice associated with the data partition. The value of slice_id is constrained as follows.

– If separate_colour_plane_flag is equal to 0, the following applies.

  – If arbitrary slice order is not allowed as specified in Annex A, the first slice of a coded picture, in decoding order, shall have slice_id equal to 0 and the value of slice_id shall be incremented by one for each subsequent slice of the coded picture in decoding order.

  – Otherwise (arbitrary slice order is allowed), each slice shall have a unique slice_id value within the set of slices of the coded picture.

– Otherwise (separate_colour_plane_flag is equal to 1), the following applies.

  – If arbitrary slice order is not allowed as specified in Annex A, the first slice of a coded picture having each value of colour_plane_id, in decoding order, shall have slice_id equal to 0 and the value of slice_id shall be incremented by one for each subsequent slice of the coded picture having the same value of colour_plane_id, in decoding order.

  – Otherwise (arbitrary slice order is allowed) each slice shall have a unique slice_id value within each set of slices of the coded picture that have the same value of colour_plane_id.

The range of slice_id is specified as follows.

– If MbaffFrameFlag is equal to 0, slice_id shall be in the range of 0 to PicSizeInMbs - 1, inclusive.

– Otherwise (MbaffFrameFlag is equal to 1), slice_id shall be in the range of 0 to PicSizeInMbs / 2 - 1, inclusive.

7.4.2.9.2 Slice data partition B RBSP semantics

When slice data partitioning is in use, the coded data for a single slice is divided into one to three separate partitions. Slice data partition B contains all syntax elements of category 3.

Category 3 syntax elements include all syntax elements in the residual( ) syntax structure and in syntax structures used within that syntax structure for collective macroblock types I and SI as specified in Table 7-10.

slice_id has the same semantics as specified in subclause 7.4.2.9.1.

colour_plane_id specifies the colour plane associated with the current slice RBSP when separate_colour_plane_flag is equal to 1. The value of colour_plane_id shall be in the range of 0 to 2, inclusive. colour_plane_id equal to 0, 1, and 2 correspond to the Y, Cb, and Cr planes, respectively.

NOTE – There is no dependency between the decoding processes of pictures having different values of colour_plane_id.

redundant_pic_cnt shall be equal to 0 for slices and slice data partitions belonging to the primary coded picture. The redundant_pic_cnt shall be greater than 0 for coded slices and coded slice data partitions in redundant coded pictures. When redundant_pic_cnt is not present, its value shall be inferred to be equal to 0. The value of redundant_pic_cnt shall be in the range of 0 to 127, inclusive.

The presence of a slice data partition B RBSP is specified as follows.

– If the syntax elements of a slice data partition A RBSP indicate the presence of any syntax elements of category 3 in the slice data for a slice, a slice data partition B RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

– Otherwise (the syntax elements of a slice data partition A RBSP do not indicate the presence of any syntax elements of category 3 in the slice data for a slice), no slice data partition B RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

7.4.2.9.3 Slice data partition C RBSP semantics

When slice data partitioning is in use, the coded data for a single slice is divided into three separate partitions. Slice data partition C contains all syntax elements of category 4.

Category 4 syntax elements include all syntax elements in the residual( ) syntax structure and in syntax structures used within that syntax structure for collective macroblock types P and B as specified in Table 7-10.

slice_id has the same semantics as specified in subclause 7.4.2.9.1.

colour_plane_id has the same semantics as specified in subclause 7.4.2.9.2.

redundant_pic_cnt has the same semantics as specified in subclause 7.4.2.9.2.

The presence of a slice data partition C RBSP is specified as follows.

– If the syntax elements of a slice data partition A RBSP indicate the presence of any syntax elements of category 4 in the slice data for a slice, a slice data partition C RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

– Otherwise (the syntax elements of a slice data partition A RBSP do not indicate the presence of any syntax elements of category 4 in the slice data for a slice), no slice data partition C RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

7.4.2.10 RBSP slice trailing bits semantics

cabac_zero_word is a byte-aligned sequence of two bytes equal to 0x0000.

Let NumBytesInVclNALunits be the sum of the values of NumBytesInNALunit for all VCL NAL units of a coded picture.

Let BinCountsInNALunits be the number of times that the parsing process function DecodeBin( ), specified in subclause 9.3.3.2, is invoked to decode the contents of all VCL NAL units of a coded picture. When entropy_coding_mode_flag is equal to 1, BinCountsInNALunits shall not exceed (32 ÷ 3) * NumBytesInVclNALunits + (RawMbBits * PicSizeInMbs) ÷ 32.

NOTE – The constraint on the maximum number of bins resulting from decoding the contents of the slice layer NAL units can be met by inserting a number of cabac_zero_word syntax elements to increase the value of NumBytesInVclNALunits. Each cabac_zero_word is represented in a NAL unit by the three-byte sequence 0x000003 (as a result of the constraints on NAL unit contents that result in requiring inclusion of an emulation_prevention_three_byte for each cabac_zero_word).

7.4.2.11 RBSP trailing bits semantics

rbsp_stop_one_bit shall be equal to 1.

rbsp_alignment_zero_bit shall be equal to 0.

7.4.3 Slice header semantics

When present, the value of the slice header syntax elements pic_parameter_set_id, frame_num, field_pic_flag, bottom_field_flag, idr_pic_id, pic_order_cnt_lsb, delta_pic_order_cnt_bottom, delta_pic_order_cnt[0], delta_pic_order_cnt[1], sp_for_switch_flag, and slice_group_change_cycle shall be the same in all slice headers of a coded picture.

first_mb_in_slice specifies the address of the first macroblock in the slice. When arbitrary slice order is not allowed as specified in Annex A, the value of first_mb_in_slice is constrained as follows.

– If separate_colour_plane_flag is equal to 0, the value of first_mb_in_slice shall not be less than the value of first_mb_in_slice for any other slice of the current picture that precedes the current slice in decoding order.

– Otherwise (separate_colour_plane_flag is equal to 1), the value of first_mb_in_slice shall not be less than the value of first_mb_in_slice for any other slice of the current picture that precedes the current slice in decoding order and has the same value of colour_plane_id.

The first macroblock address of the slice is derived as follows.

– If MbaffFrameFlag is equal to 0, first_mb_in_slice is the macroblock address of the first macroblock in the slice, and first_mb_in_slice shall be in the range of 0 to PicSizeInMbs – 1, inclusive.

– Otherwise (MbaffFrameFlag is equal to 1), first_mb_in_slice * 2 is the macroblock address of the first macroblock in the slice, which is the top macroblock of the first macroblock pair in the slice, and first_mb_in_slice shall be in the range of 0 to PicSizeInMbs / 2 – 1, inclusive.

slice_type specifies the coding type of the slice according to Table 7-6.

Table 7-6 – Name association to slice_type

slice_type	Name of slice_type
0	P (P slice)
1	B (B slice)
2	I (I slice)
3	SP (SP slice)
4	SI (SI slice)
5	P (P slice)
6	B (B slice)
7	I (I slice)
8	SP (SP slice)
9	SI (SI slice)

slice_type values in the range 5..9 specify, in addition to the coding type of the current slice, that all other slices of the current coded picture shall have a value of slice_type equal to the current value of slice_type or equal to the current value of slice_type – 5.

When nal_unit_type is equal to 5 (IDR picture), slice_type shall be equal to 2, 4, 7, or 9.

When num_ref_frames is equal to 0, slice_type shall be equal to 2, 4, 7, or 9.

pic_parameter_set_id specifies the picture parameter set in use. The value of pic_parameter_set_id shall be in the range of 0 to 255, inclusive.

colour_plane_id specifies the colour plane associated with the current slice RBSP when separate_colour_plane_flag is equal to 1. The value of colour_plane_id shall be in the range of 0 to 2, inclusive. colour_plane_id equal to 0, 1, and 2 correspond to the Y, Cb, and Cr planes, respectively.

NOTE 1 – There is no dependency between the decoding processes of pictures having different values of colour_plane_id.

frame_num is used as an identifier for pictures and shall be represented by log2_max_frame_num_minus4 + 4 bits in the bitstream. frame_num is constrained as follows:

The variable PrevRefFrameNum is derived as follows.

– If the current picture is an IDR picture, PrevRefFrameNum is set equal to 0.

– Otherwise (the current picture is not an IDR picture), PrevRefFrameNum is set as follows.

  – If the decoding process for gaps in frame_num specified in subclause 8.2.5.2 was invoked by the decoding process for an access unit that contained a non-reference picture that followed the previous access unit in decoding order that contained a reference picture, PrevRefFrameNum is set equal to the value of frame_num for the last of the "non-existing" reference frames inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2.

  – Otherwise, PrevRefFrameNum is set equal to the value of frame_num for the previous access unit in decoding order that contained a reference picture.

The value of frame_num is constrained as follows.

– If the current picture is an IDR picture, frame_num shall be equal to 0.

– Otherwise (the current picture is not an IDR picture), referring to the primary coded picture in the previous access unit in decoding order that contains a reference picture as the preceding reference picture, the value of frame_num for the current picture shall not be equal to PrevRefFrameNum unless all of the following three conditions are true.

  – the current picture and the preceding reference picture belong to consecutive access units in decoding order

  – the current picture and the preceding reference picture are reference fields having opposite parity

  – one or more of the following conditions is true

    – the preceding reference picture is an IDR picture

    – the preceding reference picture includes a memory_management_control_operation syntax element equal to 5

NOTE 2 – When the preceding reference picture includes a memory_management_control_operation syntax element equal to 5, PrevRefFrameNum is equal to 0.

- there is a primary coded picture that precedes the preceding reference picture and the primary coded picture that precedes the preceding reference picture does not have frame_num equal to PrevRefFrameNum
- there is a primary coded picture that precedes the preceding reference picture and the primary coded picture that precedes the preceding reference picture is not a reference picture

When the value of frame_num is not equal to PrevRefFrameNum, the following applies.

- There shall not be any previous field or frame in decoding order that is currently marked as "used for short-term reference" that has a value of frame_num equal to any value taken on by the variable UnusedShortTermFrameNum in the following:

```
UnusedShortTermFrameNum = ( PrevRefFrameNum + 1 ) % MaxFrameNum
while( UnusedShortTermFrameNum  !=  frame_num )                    (7-22)
    UnusedShortTermFrameNum = ( UnusedShortTermFrameNum + 1 ) % MaxFrameNum
```

- The value of frame_num is constrained as follows.
  - If gaps_in_frame_num_value_allowed_flag is equal to 0, the value of frame_num for the current picture shall be equal to (PrevRefFrameNum + 1) % MaxFrameNum.
  - Otherwise (gaps_in_frame_num_value_allowed_flag is equal to 1), the following applies.
    - If frame_num is greater than PrevRefFrameNum, there shall not be any non-reference pictures in the bitstream that follow the previous reference picture and precede the current picture in decoding order in which either of the following conditions is true.
      - The value of frame_num for the non-reference picture is less than PrevRefFrameNum.
      - The value of frame_num for the non-reference picture is greater than the value of frame_num for the current picture.
    - Otherwise (frame_num is less than PrevRefFrameNum), there shall not be any non-reference pictures in the bitstream that follow the previous reference picture and precede the current picture in decoding order in which both of the following conditions are true.
      - The value of frame_num for the non-reference picture is less than PrevRefFrameNum.
      - The value of frame_num for the non-reference picture is greater than the value of frame_num for the current picture.

A picture including a memory_management_control_operation equal to 5 shall have frame_num constraints as described above and, after the decoding of the current picture and the processing of the memory management control operations, the picture shall be inferred to have had frame_num equal to 0 for all subsequent use in the decoding process, except as specified in subclause 7.4.1.2.4.

NOTE 3 – When the primary coded picture is not an IDR picture and does not contain memory_management_control_operation syntax element equal to 5, the value of frame_num of a corresponding redundant coded picture is the same as the value of frame_num in the primary coded picture. Alternatively, the redundant coded picture includes a memory_management_control_operation syntax element equal to 5 and the corresponding primary coded picture is an IDR picture.

field_pic_flag equal to 1 specifies that the slice is a slice of a coded field. field_pic_flag equal to 0 specifies that the slice is a slice of a coded frame. When field_pic_flag is not present it shall be inferred to be equal to 0.

The variable MbaffFrameFlag is derived as follows

```
MbaffFrameFlag = ( mb_adaptive_frame_field_flag  &&  !field_pic_flag )    (7-23)
```

The variable for the picture height in units of macroblocks is derived as follows

```
PicHeightInMbs = FrameHeightInMbs / ( 1 + field_pic_flag )                (7-24)
```

The variable for picture height for the luma component is derived as follows

$$PicHeightInSamples_L = PicHeightInMbs * 16 \quad (7\text{-}25)$$

The variable for picture height for the chroma component is derived as follows

$$PicHeightInSamples_C = PicHeightInMbs * MbHeightC \quad (7\text{-}26)$$

The variable PicSizeInMbs for the current picture is derived according to:

$$PicSizeInMbs = PicWidthInMbs * PicHeightInMbs \quad (7\text{-}27)$$

The variable MaxPicNum is derived as follows.

– If field_pic_flag is equal to 0, MaxPicNum is set equal to MaxFrameNum.

– Otherwise (field_pic_flag is equal to 1), MaxPicNum is set equal to 2*MaxFrameNum.

The variable CurrPicNum is derived as follows.

– If field_pic_flag is equal to 0, CurrPicNum is set equal to frame_num.

– Otherwise (field_pic_flag is equal to 1), CurrPicNum is set equal to 2 * frame_num + 1.

bottom_field_flag equal to 1 specifies that the slice is part of a coded bottom field. bottom_field_flag equal to 0 specifies that the picture is a coded top field. When this syntax element is not present for the current slice, it shall be inferred to be equal to 0.

idr_pic_id identifies an IDR picture. The values of idr_pic_id in all the slices of an IDR picture shall remain unchanged. When two consecutive access units in decoding order are both IDR access units, the value of idr_pic_id in the slices of the first such IDR access unit shall differ from the idr_pic_id in the second such IDR access unit. The value of idr_pic_id shall be in the range of 0 to 65535, inclusive.

pic_order_cnt_lsb specifies the picture order count modulo MaxPicOrderCntLsb for the top field of a coded frame or for a coded field. The size of the pic_order_cnt_lsb syntax element is log2_max_pic_order_cnt_lsb_minus4 + 4 bits. The value of the pic_order_cnt_lsb shall be in the range of 0 to MaxPicOrderCntLsb – 1, inclusive.

delta_pic_order_cnt_bottom specifies the picture order count difference between the bottom field and the top field of a coded frame as follows.

– If the current picture includes a memory_management_control_operation equal to 5, the value of delta_pic_order_cnt_bottom shall be in the range of (1 – MaxPicOrderCntLsb) to 2^{31} - 1, inclusive.

– Otherwise (the current picture does not include a memory_management_control_operation equal to 5), the value of delta_pic_order_cnt_bottom shall be in the range of $–2^{31}$ to 2^{31} - 1, inclusive.

When this syntax element is not present in the bitstream for the current slice, it shall be inferred to be equal to 0.

delta_pic_order_cnt[0 **]** specifies the picture order count difference from the expected picture order count for the top field of a coded frame or for a coded field as specified in subclause 8.2.1. The value of delta_pic_order_cnt[0] shall be in the range of -2^{31} to 2^{31} - 1, inclusive. When this syntax element is not present in the bitstream for the current slice, it shall be inferred to be equal to 0.

delta_pic_order_cnt[1 **]** specifies the picture order count difference from the expected picture order count for the bottom field of a coded frame specified in subclause 8.2.1. The value of delta_pic_order_cnt[1] shall be in the range of -2^{31} to 2^{31} - 1, inclusive. When this syntax element is not present in the bitstream for the current slice, it shall be inferred to be equal to 0.

redundant_pic_cnt shall be equal to 0 for slices and slice data partitions belonging to the primary coded picture. The value of redundant_pic_cnt shall be greater than 0 for coded slices or coded slice data partitions of a redundant coded picture. When redundant_pic_cnt is not present in the bitstream, its value shall be inferred to be equal to 0. The value of redundant_pic_cnt shall be in the range of 0 to 127, inclusive.

NOTE 4 – Any area of the decoded primary picture and the corresponding area that would result from application of the decoding process specified in clause 8 for any redundant picture in the same access unit should be visually similar in appearance.

The value of pic_parameter_set_id in a coded slice or coded slice data partition of a redundant coded picture shall be such that the value of pic_order_present_flag in the picture parameter set in use in a redundant coded picture is equal to the value of pic_order_present_flag in the picture parameter set in use in the corresponding primary coded picture.

When present in the primary coded picture and any redundant coded picture, the following syntax elements shall have the same value: field_pic_flag, bottom_field_flag, and idr_pic_id.

When the value of nal_ref_idc in one VCL NAL unit of an access unit is equal to 0, the value of nal_ref_idc in all other VCL NAL units of the same access unit shall be equal to 0.

NOTE 5 – The above constraint also has the following implications. If the value of nal_ref_idc for the VCL NAL units of the primary coded picture is equal to 0, the value of nal_ref_idc for the VCL NAL units of any corresponding redundant coded picture are equal to 0; otherwise (the value of nal_ref_idc for the VCL NAL units of the primary coded picture is greater than 0), the value of nal_ref_idc for the VCL NAL units of any corresponding redundant coded picture are also greater than 0.

The marking status of reference pictures and the value of frame_num after the decoded reference picture marking process as specified in subclause 8.2.5 is invoked for the primary coded picture or any redundant coded picture of the same access unit shall be identical regardless whether the primary coded picture or any redundant coded picture (instead of the primary coded picture) of the access unit would be decoded.

NOTE 6 – The above constraint also has the following implications.

If a primary coded picture is not an IDR picture, the contents of the dec_ref_pic_marking( ) syntax structure must be identical in all slice headers of the primary coded picture and all redundant coded pictures corresponding to the primary coded picture.

Otherwise (a primary coded picture is an IDR picture), the following applies.

If a redundant coded picture corresponding to the primary coded picture is an IDR picture, the contents of the dec_ref_pic_marking( ) syntax structure must be identical in all slice headers of the primary coded picture and the redundant coded picture corresponding to the primary coded picture.

Otherwise (a redundant picture corresponding to the primary coded picture is not an IDR picture), all slice headers of the redundant picture must contain a dec_ref_pic_marking syntax( ) structure including a memory_management_control_operation syntax element equal to 5, and the following applies.

If the value of long_term_reference_flag in the primary coded picture is equal to 0, the dec_ref_pic_marking syntax structure of the redundant coded picture must not include a memory_management_control_operation syntax element equal to 6.

Otherwise (the value of long_term_reference_flag in the primary coded picture is equal to 1), the dec_ref_pic_marking syntax structure of the redundant coded picture must include memory_management_control_operation syntax elements equal to 5, 4, and 6 in decoding order, and the value of max_long_term_frame_idx_plus1 must be equal to 1, and the value of long_term_frame_idx must be equal to 0.

The values of TopFieldOrderCnt and BottomFieldOrderCnt (if applicable) that result after completion of the decoding process for any redundant coded picture or the primary coded picture of the same access unit shall be identical regardless whether the primary coded picture or any redundant coded picture (instead of the primary coded picture) of the access unit would be decoded.

There is no required decoding process for a coded slice or coded slice data partition of a redundant coded picture. When the redundant_pic_cnt in the slice header of a coded slice is greater than 0, the decoder may discard the coded slice. However, a coded slice or coded slice data partition of any redundant coded picture shall obey the same constraints as a coded slice or coded slice data partition of a primary picture.

NOTE 7 – When some of the samples in the decoded primary picture cannot be correctly decoded due to errors or losses in transmission of the sequence and a coded redundant slice can be correctly decoded, the decoder should replace the samples of the decoded primary picture with the corresponding samples of the decoded redundant slice. When more than one redundant slice covers the relevant region of the primary picture, the redundant slice having the lowest value of redundant_pic_cnt should be used.

Redundant slices and slice data partitions having the same value of redundant_pic_cnt belong to the same redundant picture. Decoded slices within the same redundant picture need not cover the entire picture area and shall not overlap.

direct_spatial_mv_pred_flag specifies the method used in the decoding process to derive motion vectors and reference indices for inter prediction as follows.

– If direct_spatial_mv_pred_flag is equal to 1, the derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8 in subclause 8.4.1.2 shall use spatial direct mode prediction as specified in subclause 8.4.1.2.2.

– Otherwise (direct_spatial_mv_pred_flag is equal to 0), the derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8 in subclause 8.4.1.2 shall use temporal direct mode prediction as specified in subclause 8.4.1.2.3.

num_ref_idx_active_override_flag equal to 0 specifies that the values of the syntax elements num_ref_idx_l0_active_minus1 and num_ref_idx_l1_active_minus1 specified in the referred picture parameter set are in effect. num_ref_idx_active_override_flag equal to 1 specifies that the num_ref_idx_l0_active_minus1 and num_ref_idx_l1_active_minus1 specified in the referred picture parameter set are overridden for the current slice (and only for the current slice) by the following values in the slice header.

When the current slice is a P, SP, or B slice and field_pic_flag is equal to 0 and the value of num_ref_idx_l0_active_minus1 in the picture parameter set exceeds 15, num_ref_idx_active_override_flag shall be equal to 1.

When the current slice is a B slice and field_pic_flag is equal to 0 and the value of num_ref_idx_l1_active_minus1 in the picture parameter set exceeds 15, num_ref_idx_active_override_flag shall be equal to 1.

num_ref_idx_l0_active_minus1 specifies the maximum reference index for reference picture list 0 that shall be used to decode the slice.

The range of num_ref_idx_l0_active_minus1 is specified as follows.

– If field_pic_flag is equal to 0, num_ref_idx_l0_active_minus1 shall be in the range of 0 to 15, inclusive. When MbaffFrameFlag is equal to 1, num_ref_idx_l0_active_minus1 is the maximum index value for the decoding of frame macroblocks and 2 * num_ref_idx_l0_active_minus1 + 1 is the maximum index value for the decoding of field macroblocks.

– Otherwise (field_pic_flag is equal to 1), num_ref_idx_l0_active_minus1 shall be in the range of 0 to 31, inclusive.

num_ref_idx_l1_active_minus1 has the same semantics as num_ref_idx_l0_active_minus1 with l0 and list 0 replaced by l1 and list 1, respectively.

cabac_init_idc specifies the index for determining the initialisation table used in the initialisation process for context variables. The value of cabac_init_idc shall be in the range of 0 to 2, inclusive.

slice_qp_delta specifies the initial value of QP_Y to be used for all the macroblocks in the slice until modified by the value of mb_qp_delta in the macroblock layer. The initial QP_Y quantisation parameter for the slice is computed as:

$$SliceQP_Y = 26 + pic\_init\_qp\_minus26 + slice\_qp\_delta \quad (7\text{-}28)$$

The value of slice_qp_delta shall be limited such that $SliceQP_Y$ is in the range of $-QpBdOffset_Y$ to +51, inclusive.

sp_for_switch_flag specifies the decoding process to be used to decode P macroblocks in an SP slice as follows.

– If sp_for_switch_flag is equal to 0, the P macroblocks in the SP slice shall be decoded using the SP decoding process for non-switching pictures as specified in subclause 8.6.1.

– Otherwise (sp_for_switch_flag is equal to 1), the P macroblocks in the SP slice shall be decoded using the SP and SI decoding process for switching pictures as specified in subclause 8.6.2.

slice_qs_delta specifies the value of QS_Y for all the macroblocks in SP and SI slices. The QS_Y quantisation parameter for the slice is computed as:

$$QS_Y = 26 + pic\_init\_qs\_minus26 + slice\_qs\_delta \quad (7\text{-}29)$$

The value of slice_qs_delta shall be limited such that QS_Y is in the range of 0 to 51, inclusive. This value of QS_Y is used for the decoding of all macroblocks in SI slices with mb_type equal to SI and all macroblocks in SP slices with prediction mode equal to inter.

disable_deblocking_filter_idc specifies whether the operation of the deblocking filter shall be disabled across some block edges of the slice and specifies for which edges the filtering is disabled. When disable_deblocking_filter_idc is not present in the slice header, the value of disable_deblocking_filter_idc shall be inferred to be equal to 0.

The value of disable_deblocking_filter_idc shall be in the range of 0 to 2, inclusive.

slice_alpha_c0_offset_div2 specifies the offset used in accessing the α and t_{C0} deblocking filter tables for filtering operations controlled by the macroblocks within the slice. From this value, the offset that shall be applied when addressing these tables shall be computed as:

$$FilterOffsetA = slice\_alpha\_c0\_offset\_div2 << 1 \quad (7\text{-}30)$$

The value of slice_alpha_c0_offset_div2 shall be in the range of -6 to +6, inclusive. When slice_alpha_c0_offset_div2 is not present in the slice header, the value of slice_alpha_c0_offset_div2 shall be inferred to be equal to 0.

slice_beta_offset_div2 specifies the offset used in accessing the β deblocking filter table for filtering operations controlled by the macroblocks within the slice. From this value, the offset that is applied when addressing the β table of the deblocking filter shall be computed as:

$$FilterOffsetB = slice\_beta\_offset\_div2 << 1 \quad (7\text{-}31)$$

The value of slice_beta_offset_div2 shall be in the range of -6 to +6, inclusive. When slice_beta_offset_div2 is not present in the slice header the value of slice_beta_offset_div2 shall be inferred to be equal to 0.

slice_group_change_cycle is used to derive the number of slice group map units in slice group 0 when slice_group_map_type is equal to 3, 4, or 5, as specified by

MapUnitsInSliceGroup0 = Min(slice_group_change_cycle * SliceGroupChangeRate, PicSizeInMapUnits) (7-32)

The value of slice_group_change_cycle is represented in the bitstream by the following number of bits

Ceil(Log2(PicSizeInMapUnits ÷ SliceGroupChangeRate + 1)) (7-33)

The value of slice_group_change_cycle shall be in the range of 0 to Ceil(PicSizeInMapUnits÷SliceGroupChangeRate), inclusive.

7.4.3.1 Reference picture list reordering semantics

The syntax elements reordering_of_pic_nums_idc, abs_diff_pic_num_minus1, and long_term_pic_num specify the change from the initial reference picture lists to the reference picture lists to be used for decoding the slice.

ref_pic_list_reordering_flag_l0 equal to 1 specifies that the syntax element reordering_of_pic_nums_idc is present for specifying reference picture list 0. ref_pic_list_reordering_flag_l0 equal to 0 specifies that this syntax element is not present.

When ref_pic_list_reordering_flag_l0 is equal to 1, the number of times that reordering_of_pic_nums_idc is not equal to 3 following ref_pic_list_reordering_flag_l0 shall not exceed num_ref_idx_l0_active_minus1 + 1.

When RefPicList0[num_ref_idx_l0_active_minus1] in the initial reference picture list produced as specified in subclause 8.2.4.2 is equal to "no reference picture", ref_pic_list_reordering_flag_l0 shall be equal to 1 and reordering_of_pic_nums_idc shall not be equal to 3 until RefPicList0[num_ref_idx_l0_active_minus1] in the reordered list produced as specified in subclause 8.2.4.3 is not equal to "no reference picture".

ref_pic_list_reordering_flag_l1 equal to 1 specifies that the syntax element reordering_of_pic_nums_idc is present for specifying reference picture list 1. ref_pic_list_reordering_flag_l1 equal to 0 specifies that this syntax element is not present.

When ref_pic_list_reordering_flag_l1 is equal to 1, the number of times that reordering_of_pic_nums_idc is not equal to 3 following ref_pic_list_reordering_flag_l1 shall not exceed num_ref_idx_l1_active_minus1 + 1.

When decoding a slice with slice_type equal to 1 or 6 and RefPicList1[num_ref_idx_l1_active_minus1] in the initial reference picture list produced as specified in subclause 8.2.4.2 is equal to "no reference picture", ref_pic_list_reordering_flag_l1 shall be equal to 1 and reordering_of_pic_nums_idc shall not be equal to 3 until RefPicList1[num_ref_idx_l1_active_minus1] in the reordered list produced as specified in subclause 8.2.4.3 is not equal to "no reference picture".

reordering_of_pic_nums_idc together with abs_diff_pic_num_minus1 or long_term_pic_num specifies which of the reference pictures are re-mapped. The values of reordering_of_pic_nums_idc are specified in Table 7-7. The value of the first reordering_of_pic_nums_idc that follows immediately after ref_pic_list_reordering_flag_l0 or ref_pic_list_reordering_flag_l1 shall not be equal to 3.

Table 7-7 – reordering_of_pic_nums_idc operations for reordering of reference picture lists

reordering_of_pic_nums_idc	Reordering specified
0	abs_diff_pic_num_minus1 is present and corresponds to a difference to subtract from a picture number prediction value
1	abs_diff_pic_num_minus1 is present and corresponds to a difference to add to a picture number prediction value
2	long_term_pic_num is present and specifies the long-term picture number for a reference picture
3	End loop for reordering of the initial reference picture list

abs_diff_pic_num_minus1 plus 1 specifies the absolute difference between the picture number of the picture being moved to the current index in the list and the picture number prediction value. abs_diff_pic_num_minus1 shall be in the range of 0 to MaxPicNum – 1. The allowed values of abs_diff_pic_num_minus1 are further restricted as specified in subclause 8.2.4.3.1.

long_term_pic_num specifies the long-term picture number of the picture being moved to the current index in the list. When decoding a coded frame, long_term_pic_num shall be equal to a LongTermPicNum assigned to one of the reference frames or complementary reference field pairs marked as "used for long-term reference". When decoding a coded field, long_term_pic_num shall be equal to a LongTermPicNum assigned to one of the reference fields marked as "used for long-term reference".

7.4.3.2 Prediction weight table semantics

luma_log2_weight_denom is the base 2 logarithm of the denominator for all luma weighting factors. The value of luma_log2_weight_denom shall be in the range of 0 to 7, inclusive.

chroma_log2_weight_denom is the base 2 logarithm of the denominator for all chroma weighting factors. The value of chroma_log2_weight_denom shall be in the range of 0 to 7, inclusive.

luma_weight_l0_flag equal to 1 specifies that weighting factors for the luma component of list 0 prediction are present. luma_weight_l0_flag equal to 0 specifies that these weighting factors are not present.

luma_weight_l0[i **]** is the weighting factor applied to the luma prediction value for list 0 prediction using RefPicList0[i]. When luma_weight_l0_flag is equal to 1, the value of luma_weight_l0[i] shall be in the range of –128 to 127, inclusive. When luma_weight_l0_flag is equal to 0, luma_weight_l0[i] shall be inferred to be equal to $2^{\text{luma\_log2\_weight\_denom}}$ for RefPicList0[i].

luma_offset_l0[i **]** is the additive offset applied to the luma prediction value for list 0 prediction using RefPicList0[i]. The value of luma_offset_l0[i] shall be in the range of –128 to 127, inclusive. When luma_weight_l0_flag is equal to 0, luma_offset_l0[i] shall be inferred as equal to 0 for RefPicList0[i].

chroma_weight_l0_flag equal to 1 specifies that weighting factors for the chroma prediction values of list 0 prediction are present. chroma_weight_l0_flag equal to 0 specifies that these weighting factors are not present.

chroma_weight_l0[i **][** j **]** is the weighting factor applied to the chroma prediction values for list 0 prediction using RefPicList0[i] with j equal to 0 for Cb and j equal to 1 for Cr. When chroma_weight_l0_flag is equal to 1, the value of chroma_weight_l0[i][j] shall be in the range of –128 to 127, inclusive. When chroma_weight_l0_flag is equal to 0**,** chroma_weight_l0[i][j] shall be inferred to be equal to $2^{\text{chroma\_log2\_weight\_denom}}$ for RefPicList0[i].

chroma_offset_l0[i **][** j **]** is the additive offset applied to the chroma prediction values for list 0 prediction using RefPicList0[i] with j equal to 0 for Cb and j equal to 1 for Cr. The value of chroma_offset_l0[i][j] shall be in the range of -128 to 127, inclusive. When chroma_weight_l0_flag is equal to 0**,** chroma_offset_l0[i][j] shall be inferred to be equal to 0 for RefPicList0[i].

luma_weight_l1_flag, luma_weight_l1, **luma_offset_l1**, **chroma_weight_l1_flag**, **chroma_weight_l1**, **chroma_offset_l1** have the same semantics as luma_weight_l0_flag, luma_weight_l0, luma_offset_l0, chroma_weight_l0_flag, chroma_weight_l0, chroma_offset_l0, respectively, with l0, list 0, and List0 replaced by l1, list 1, and List1, respectively.

7.4.3.3 Decoded reference picture marking semantics

The syntax elements no_output_of_prior_pics_flag, long_term_reference_flag, adaptive_ref_pic_marking_mode_flag, memory_management_control_operation, difference_of_pic_nums_minus1, long_term_frame_idx, long_term_pic_num, and max_long_term_frame_idx_plus1 specify marking of the reference pictures.

The marking of a reference picture can be "unused for reference", "used for short-term reference", or "used for long-term reference", but only one among these three. When a reference picture is referred to as being marked as "used for reference", this collectively refers to the picture being marked as "used for short-term reference" or "used for long-term reference" (but not both). A reference picture that is marked as "used for short-term reference" is referred to as a short-term reference picture. A reference picture that is marked as "used for long-term reference" is referred to as a long-term reference picture.

The syntax element adaptive_ref_pic_marking_mode_flag and the content of the decoded reference picture marking syntax structure shall be identical for all coded slices of a coded picture.

The syntax category of the decoded reference picture marking syntax structure shall be inferred as follows.

– If the decoded reference picture marking syntax structure is in a slice header, the syntax category of the decoded reference picture marking syntax structure shall be inferred to be equal to 2.

– Otherwise (the decoded reference picture marking syntax structure is in a decoded reference picture marking repetition SEI message as specified in Annex D), the syntax category of the decoded reference picture marking syntax structure shall be inferred to be equal to 5.

no_output_of_prior_pics_flag specifies how the previously-decoded pictures in the decoded picture buffer are treated after decoding of an IDR picture. See Annex C. When the IDR picture is the first IDR picture in the bitstream, the value of no_output_of_prior_pics_flag has no effect on the decoding process. When the IDR picture is not the first IDR picture in the bitstream and the value of PicWidthInMbs, FrameHeightInMbs, or max_dec_frame_buffering derived from the active sequence parameter set is different from the value of PicWidthInMbs, FrameHeightInMbs, or max_dec_frame_buffering derived from the sequence parameter set active for the preceding picture, no_output_of_prior_pics_flag equal to 1 may be inferred by the decoder, regardless of the actual value of no_output_of_prior_pics_flag.

long_term_reference_flag equal to 0 specifies that the MaxLongTermFrameIdx variable is set equal to “no long-term frame indices” and that the IDR picture is marked as “used for short-term reference”. long_term_reference_flag equal to 1 specifies that the MaxLongTermFrameIdx variable is set equal to 0 and that the current IDR picture is marked “used for long-term reference” and is assigned LongTermFrameIdx equal to 0. When num_ref_frames is equal to 0, long_term_reference_flag shall be equal to 0.

adaptive_ref_pic_marking_mode_flag selects the reference picture marking mode of the currently decoded picture as specified in Table 7-8. adaptive_ref_pic_marking_mode_flag shall be equal to 1 when the number of frames, complementary field pairs, and non-paired fields that are currently marked as "used for long-term reference" is equal to Max(num_ref_frames, 1).

Table 7-8 – Interpretation of adaptive_ref_pic_marking_mode_flag

adaptive_ref_pic_marking_mode_flag	Reference picture marking mode specified
0	Sliding window reference picture marking mode: A marking mode providing a first-in first-out mechanism for short-term reference pictures.
1	Adaptive reference picture marking mode: A reference picture marking mode providing syntax elements to specify marking of reference pictures as “unused for reference” and to assign long-term frame indices.

memory_management_control_operation specifies a control operation to be applied to affect the reference picture marking. The memory_management_control_operation syntax element is followed by data necessary for the operation specified by the value of memory_management_control_operation. The values and control operations associated with memory_management_control_operation are specified in Table 7-9. The memory_management_control_operation syntax elements are processed by the decoding process in the order in which they appear in the slice header, and the semantics constraints expressed for each memory_management_control_operation apply at the specific position in that order at which that individual memory_management_control_operation is processed.

For interpretation of memory_management_control_operation, the term reference picture is interpreted as follows.

– If the current picture is a frame, the term reference picture refers either to a reference frame or a complementary reference field pair.

– Otherwise (the current picture is a field), the term reference picture refers either to a reference field or a field of a reference frame.

memory_management_control_operation shall not be equal to 1 in a slice header unless the specified reference picture is marked as "used for short-term reference" when the memory_management_control_operation is processed by the decoding process.

memory_management_control_operation shall not be equal to 2 in a slice header unless the specified long-term picture number refers to a reference picture that is marked as "used for long-term reference" when the memory_management_control_operation is processed by the decoding process.

memory_management_control_operation shall not be equal to 3 in a slice header unless the specified reference picture is marked as "used for short-term reference" when the memory_management_control_operation is processed by the decoding process.

memory_management_control_operation shall not be equal to 3 or 6 if the value of the variable MaxLongTermFrameIdx is equal to "no long-term frame indices" when the memory_management_control_operation is processed by the decoding process.

Not more than one memory_management_control_operation equal to 4 shall be present in a slice header.

Not more than one memory_management_control_operation equal to 5 shall be present in a slice header.

Not more than one memory_management_control_operation equal to 6 shall be present in a slice header.

memory_management_control_operation shall not be equal to 5 in a slice header unless no memory_management_control_operation in the range of 1 to 3 is present in the same decoded reference picture marking syntax structure.

A memory_management_control_operation equal to 5 shall not follow a memory_management_control_operation equal to 6 in the same slice header.

When a memory_management_control_operation equal to 6 is present, any memory_management_control_operation equal to 2, 3, or 4 that follows the memory_management_control_operation equal to 6 within the same slice header shall not specify the current picture to be marked as "unused for reference".

NOTE 1 – These constraints prohibit any combination of multiple memory_management_control_operation syntax elements that would specify the current picture to be marked as "unused for reference". However, some other combinations of memory_management_control_operation syntax elements are permitted that may affect the marking status of other reference pictures more than once in the same slice header. In particular, it is permitted for a memory_management_control_operation equal to 3 that specifies a long-term frame index to be assigned to a particular short-term reference picture to be followed in the same slice header by a memory_management_control_operation equal to 2, 3, 4 or 6 that specifies the same reference picture to subsequently be marked as "unused for reference".

Table 7-9 – Memory management control operation (memory_management_control_operation) values

memory_management_control_operation	Memory Management Control Operation
0	End memory_management_control_operation syntax element loop
1	Mark a short-term reference picture as “unused for reference”
2	Mark a long-term reference picture as “unused for reference”
3	Mark a short-term reference picture as "used for long-term reference" and assign a long-term frame index to it
4	Specify the maximum long-term frame index and mark all long-term reference pictures having long-term frame indices greater than the maximum value as "unused for reference"
5	Mark all reference pictures as "unused for reference" and set the MaxLongTermFrameIdx variable to "no long-term frame indices"
6	Mark the current picture as "used for long-term reference" and assign a long-term frame index to it

When decoding a field and a memory_management_control_operation command equal to 3 is present that assigns a long-term frame index to a field that is part of a short-term reference frame or part of a short-term complementary reference field pair, another memory_management_control_operation command to assign the same long-term frame index to the other field of the same frame or complementary reference field pair shall be present in the same decoded reference picture marking syntax structure.

NOTE 2 – The above requirement must be fulfilled even when the field referred to by the memory_management_control_operation equal to 3 is subsequently marked as "unused for reference" (for example when a memory_management_control_operation equal to 2 is present in the same slice header that causes the field to be marked as "unused for reference").

When the first field (in decoding order) of a complementary reference field pair includes a long_term_reference_flag equal to 1 or a memory_management_control_operation command equal to 6, the decoded reference picture marking syntax structure for the other field of the complementary reference field pair shall contain a memory_management_control_operation command equal to 6 that assigns the same long-term frame index to the other field.

NOTE 3 – The above requirement must be fulfilled even when the first field of the complementary reference field pair is subsequently marked as "unused for reference" (for example, when a memory_management_control_operation equal to 2 is present in the slice header of the second field that causes the first field to be marked as "unused for reference").

difference_of_pic_nums_minus1 is used (with memory_management_control_operation equal to 3 or 1) to assign a long-term frame index to a short-term reference picture or to mark a short-term reference picture as "unused for reference". When the associated memory_management_control_operation is processed by the decoding process, the resulting picture number derived from difference_of_pic_nums_minus1 shall be a picture number assigned to one of the reference pictures marked as "used for reference" and not previously assigned to a long-term frame index.

The resulting picture number is constrained as follows.

– If field_pic_flag is equal to 0, the resulting picture number shall be one of the set of picture numbers assigned to reference frames or complementary reference field pairs.

  NOTE 4 – When field_pic_flag is equal to 0, the resulting picture number must be a picture number assigned to a complementary reference field pair in which both fields are marked as "used for reference" or a frame in which both fields are marked as "used for reference". In particular, when field_pic_flag is equal to 0, the marking of a non-paired field or a frame in which a single field is marked as "used for reference" cannot be affected by a memory_management_control_operation equal to 1.

– Otherwise (field_pic_flag is equal to 1), the resulting picture number shall be one of the set of picture numbers assigned to reference fields.

long_term_pic_num is used (with memory_management_control_operation equal to 2) to mark a long-term reference picture as "unused for reference". When the associated memory_management_control_operation is processed by the decoding process, long_term_pic_num shall be equal to a long-term picture number assigned to one of the reference pictures that is currently marked as "used for long-term reference".

The resulting long-term picture number is constrained as follows.

– If field_pic_flag is equal to 0, the resulting long-term picture number shall be one of the set of long-term picture numbers assigned to reference frames or complementary reference field pairs.

  NOTE 5 – When field_pic_flag is equal to 0, the resulting long-term picture number must be a long-term picture number assigned to a complementary reference field pair in which both fields are marked as "used for reference" or a frame in which both fields are marked as "used for reference". In particular, when field_pic_flag is equal to 0, the marking of a non-paired field or a frame in which a single field is marked as "used for reference" cannot be affected by a memory_management_control_operation equal to 2.

– Otherwise (field_pic_flag is equal to 1), the resulting long-term picture number shall be one of the set of long-term picture numbers assigned to reference fields.

long_term_frame_idx is used (with memory_management_control_operation equal to 3 or 6) to assign a long-term frame index to a picture. When the associated memory_management_control_operation is processed by the decoding process, the value of long_term_frame_idx shall be in the range of 0 to MaxLongTermFrameIdx, inclusive.

max_long_term_frame_idx_plus1 minus 1 specifies the maximum value of long-term frame index allowed for long-term reference pictures (until receipt of another value of max_long_term_frame_idx_plus1). The value of max_long_term_frame_idx_plus1 shall be in the range of 0 to num_ref_frames, inclusive.

7.4.4 Slice data semantics

cabac_alignment_one_bit is a bit equal to 1.

mb_skip_run specifies the number of consecutive skipped macroblocks for which, when decoding a P or SP slice, mb_type shall be inferred to be P_Skip and the macroblock type is collectively referred to as a P macroblock type, or for which, when decoding a B slice, mb_type shall be inferred to be B_Skip and the macroblock type is collectively referred to as a B macroblock type. The value of mb_skip_run shall be in the range of 0 to PicSizeInMbs – CurrMbAddr, inclusive.

mb_skip_flag equal to 1 specifies that for the current macroblock, when decoding a P or SP slice, mb_type shall be inferred to be P_Skip and the macroblock type is collectively referred to as P macroblock type, or for which, when decoding a B slice, mb_type shall be inferred to be B_Skip and the macroblock type is collectively referred to as B macroblock type. mb_skip_flag equal to 0 specifies that the current macroblock is not skipped.

mb_field_decoding_flag equal to 0 specifies that the current macroblock pair is a frame macroblock pair. mb_field_decoding_flag equal to 1 specifies that the macroblock pair is a field macroblock pair. Both macroblocks of a frame macroblock pair are referred to in the text as frame macroblocks, whereas both macroblocks of a field macroblock pair are referred to in the text as field macroblocks.

When mb_field_decoding_flag is not present for either macroblock of a macroblock pair, the value of mb_field_decoding_flag is derived as follows.

– If there is a neighbouring macroblock pair immediately to the left of the current macroblock pair in the same slice, the value of mb_field_decoding_flag shall be inferred to be equal to the value of mb_field_decoding_flag for the neighbouring macroblock pair immediately to the left of the current macroblock pair,

– Otherwise, if there is no neighbouring macroblock pair immediately to the left of the current macroblock pair in the same slice and there is a neighbouring macroblock pair immediately above the current macroblock pair in the same slice, the value of mb_field_decoding_flag shall be inferred to be equal to the value of mb_field_decoding_flag for the neighbouring macroblock pair immediately above the current macroblock pair,

– Otherwise (there is no neighbouring macroblock pair either immediately to the left or immediately above the current macroblock pair in the same slice), the value of mb_field_decoding_flag shall be inferred to be equal to 0.

end_of_slice_flag equal to 0 specifies that another macroblock is following in the slice. end_of_slice_flag equal to 1 specifies the end of the slice and that no further macroblock follows.

The function NextMbAddress( ) used in the slice data syntax table is specified in subclause 8.2.2.

7.4.5 Macroblock layer semantics

mb_type specifies the macroblock type. The semantics of mb_type depend on the slice type.

Tables and semantics are specified for the various macroblock types for I, SI, P, SP, and B slices. Each table presents the value of mb_type, the name of mb_type, the number of macroblock partitions used (given by the NumMbPart(mb_type) function), the prediction mode of the macroblock (when it is not partitioned) or the first partition (given by the MbPartPredMode(mb_type, 0) function) and the prediction mode of the second partition (given by the MbPartPredMode(mb_type, 1) function). When a value is not applicable it is designated by “na”. In the text, the value of mb_type may be referred to as the macroblock type and a value X of MbPartPredMode( ) may be referred to in the text by "X macroblock (partition) prediction mode" or as “X prediction macroblocks”.

Table 7-10 shows the allowed collective macroblock types for each slice_type.

NOTE 1 – There are some macroblock types with Pred_L0 prediction mode that are classified as B macroblock types.

Table 7-10 – Allowed collective macroblock types for slice_type

slice_type	Allowed collective macroblock types
I (slice)	I (see Table 7-11) (macroblock types)
P (slice)	P (see Table 7-13) and I (see Table 7-11) (macroblock types)
B (slice)	B (see Table 7-14) and I (see Table 7-11) (macroblock types)
SI (slice)	SI (see Table 7-12) and I (see Table 7-11) (macroblock types)
SP (slice)	P (see Table 7-13) and I (see Table 7-11) (macroblock types)

transform_size_8x8_flag equal to 1 specifies that for the current macroblock the transform coefficient decoding process and picture construction process prior to deblocking filter process for residual 8x8 blocks shall be invoked for luma samples, and when ChromaArrayType = = 3 also for Cb and Cr samples. transform_size_8x8_flag equal to 0 specifies that for the current macroblock the transform coefficient decoding process and picture construction process prior to deblocking filter process for residual 4x4 blocks shall be invoked for luma samples, and when ChromaArrayType = = 3 also for Cb and Cr samples. When transform_size_8x8_flag is not present in the bitstream, it shall be inferred to be equal to 0.

NOTE 2 – When the current macroblock prediction mode MbPartPredMode(mb_type, 0) is equal to Intra_16x16, transform_size_8x8_flag is not present in the bitstream and then inferred to be equal to 0.

When sub_mb_type[mbPartIdx] (see subclause 7.4.5.2) is present in the bitstream for all 8x8 blocks indexed by mbPartIdx = 0..3, the variable noSubMbPartSizeLessThan8x8Flag indicates whether for each of the four 8x8 blocks the corresponding SubMbPartWidth(sub_mb_type[mbPartIdx]) and SubMbPartHeight(sub_mb_type[mbPartIdx]) are both equal to 8.

NOTE 3 – When noSubMbPartSizeLessThan8x8Flag is equal to 0 and the current macroblock type is not equal to I_NxN, transform_size_8x8_flag is not present in the bitstream and then inferred to be equal to 0.

Macroblock types that may be collectively referred to as I macroblock types are specified in Table 7-11.

The macroblock types for I slices are all I macroblock types.

Table 7-11 – Macroblock types for I slices

mb_type	Name of mb_type	transform_size_8x8_flag	MbPartPredMode (mb_type, 0)	Intra16x16 PredMode	CodedBlock PatternChroma	CodedBlock PatternLuma
0	I_NxN	0	Intra_4x4	na	Equation 7-34	Equation 7-34
0	I_NxN	1	Intra_8x8	na	Equation 7-34	Equation 7-34
1	I_16x16_0_0_0	na	Intra_16x16	0	0	0
2	I_16x16_1_0_0	na	Intra_16x16	1	0	0
3	I_16x16_2_0_0	na	Intra_16x16	2	0	0
4	I_16x16_3_0_0	na	Intra_16x16	3	0	0
5	I_16x16_0_1_0	na	Intra_16x16	0	1	0
6	I_16x16_1_1_0	na	Intra_16x16	1	1	0
7	I_16x16_2_1_0	na	Intra_16x16	2	1	0
8	I_16x16_3_1_0	na	Intra_16x16	3	1	0
9	I_16x16_0_2_0	na	Intra_16x16	0	2	0
10	I_16x16_1_2_0	na	Intra_16x16	1	2	0
11	I_16x16_2_2_0	na	Intra_16x16	2	2	0
12	I_16x16_3_2_0	na	Intra_16x16	3	2	0
13	I_16x16_0_0_1	na	Intra_16x16	0	0	15
14	I_16x16_1_0_1	na	Intra_16x16	1	0	15
15	I_16x16_2_0_1	na	Intra_16x16	2	0	15
16	I_16x16_3_0_1	na	Intra_16x16	3	0	15
17	I_16x16_0_1_1	na	Intra_16x16	0	1	15
18	I_16x16_1_1_1	na	Intra_16x16	1	1	15
19	I_16x16_2_1_1	na	Intra_16x16	2	1	15
20	I_16x16_3_1_1	na	Intra_16x16	3	1	15
21	I_16x16_0_2_1	na	Intra_16x16	0	2	15
22	I_16x16_1_2_1	na	Intra_16x16	1	2	15
23	I_16x16_2_2_1	na	Intra_16x16	2	2	15
24	I_16x16_3_2_1	na	Intra_16x16	3	2	15
25	I_PCM	na	na	na	na	na

The following semantics are assigned to the macroblock types in Table 7-11.

I_NxN: A mnemonic name for mb_type equal to 0 with MbPartPredMode(mb_type, 0) equal to Intra_4x4 or Intra_8x8.

I_16x16_0_0_0, I_16x16_1_0_0, I_16x16_2_0_0, I_16x16_3_0_0, I_16x16_0_1_0, I_16x16_1_1_0, I_16x16_2_1_0, I_16x16_3_1_0, I_16x16_0_2_0, I_16x16_1_2_0, I_16x16_2_2_0, I_16x16_3_2_0, I_16x16_0_0_1, I_16x16_1_0_1, I_16x16_2_0_1, I_16x16_3_0_1, I_16x16_0_1_1, I_16x16_1_1_1, I_16x16_2_1_1, I_16x16_3_1_1, I_16x16_0_2_1, I_16x16_1_2_1, I_16x16_2_2_1, I_16x16_3_2_1: the macroblock is coded as an Intra_16x16 prediction mode macroblock.

To each Intra_16x16 prediction macroblock, an Intra16x16PredMode is assigned, which specifies the Intra_16x16 prediction mode, and values of CodedBlockPatternLuma and CodedBlockPatternChroma are assigned as specified in Table 7-11.

Intra_4x4 specifies the macroblock prediction mode and specifies that the Intra_4x4 prediction process is invoked as specified in subclause 8.3.1. Intra_4x4 is an Intra macroblock prediction mode.

Intra_8x8 specifies the macroblock prediction mode and specifies that the Intra_8x8 prediction process is invoked as specified in subclause 8.3.2. Intra_8x8 is an Intra macroblock prediction mode.

Intra_16x16 specifies the macroblock prediction mode and specifies that the Intra_16x16 prediction process is invoked as specified in subclause 8.3.3. Intra_16x16 is an Intra macroblock prediction mode.

For a macroblock coded with mb_type equal to I_PCM, the Intra macroblock prediction mode shall be inferred.

A macroblock type that may be referred to as SI macroblock type is specified in Table 7-12.

The macroblock types for SI slices are specified in Table 7-12 and 7-11. The mb_type value 0 is specified in Table 7-12 and the mb_type values 1 to 26 are specified in Table 7-11, indexed by subtracting 1 from the value of mb_type.

Table 7-12 – Macroblock type with value 0 for SI slices

mb_type	Name of mb_type	MbPartPredMode (mb_type, 0)	Intra16x16PredMode	CodedBlockPatternChroma	CodedBlockPatternLuma
0	SI	Intra_4x4	na	Equation 7-34	Equation 7-34

The following semantics are assigned to the macroblock type in Table 7-12. The SI macroblock is coded as Intra_4x4 prediction macroblock.

Macroblock types that may be collectively referred to as P macroblock types are specified in Table 7-13.

The macroblock types for P and SP slices are specified in Table 7-13 and 7-11. mb_type values 0 to 4 are specified in Table 7-13 and mb_type values 5 to 30 are specified in Table 7-11, indexed by subtracting 5 from the value of mb_type.

Table 7-13 – Macroblock type values 0 to 4 for P and SP slices

mb_type	Name of mb_type	NumMbPart (mb_type)	MbPartPredMode (mb_type, 0)	MbPartPredMode (mb_type, 1)	MbPartWidth (mb_type)	MbPartHeight (mb_type)
0	P_L0_16x16	1	Pred_L0	na	16	16
1	P_L0_L0_16x8	2	Pred_L0	Pred_L0	16	8
2	P_L0_L0_8x16	2	Pred_L0	Pred_L0	8	16
3	P_8x8	4	na	na	8	8
4	P_8x8ref0	4	na	na	8	8
inferred	P_Skip	1	Pred_L0	na	16	16

The following semantics are assigned to the macroblock types in Table 7-13.

– P_L0_16x16: the samples of the macroblock are predicted with one luma macroblock partition of size 16x16 luma samples and associated chroma samples.

– P_L0_L0_MxN, with MxN being replaced by 16x8 or 8x16: the samples of the macroblock are predicted using two luma partitions of size MxN equal to 16x8, or two luma partitions of size MxN equal to 8x16, and associated chroma samples, respectively.

– P_8x8: for each sub-macroblock an additional syntax element (sub_mb_type) is present in the bitstream that specifies the type of the corresponding sub-macroblock (see subclause 7.4.5.2).

– P_8x8ref0: has the same semantics as P_8x8 but no syntax element for the reference index (ref_idx_l0) is present in the bitstream and ref_idx_l0[mbPartIdx] shall be inferred to be equal to 0 for all sub-macroblocks of the macroblock (with indices mbPartIdx equal to 0..3).

– P_Skip: no further data is present for the macroblock in the bitstream.

The following semantics are assigned to the macroblock prediction modes (MbPartPredMode( )) in Table 7-13.

– Pred_L0: specifies that the inter prediction process is invoked using list 0 prediction. Pred_L0 is an Inter macroblock prediction mode.

Macroblock types that may be collectively referred to as B macroblock types are specified in Table 7-14.

The macroblock types for B slices are specified in Table 7-14 and 7-11. The mb_type values 0 to 22 are specified in Table 7-14 and the mb_type values 23 to 48 are specified in Table 7-11, indexed by subtracting 23 from the value of mb_type.

Table 7-14 – Macroblock type values 0 to 22 for B slices

mb_type	Name of mb_type	NumMbPart (mb_type)	MbPartPredMode (mb_type, 0)	MbPartPredMode (mb_type, 1)	MbPartWidth (mb_type)	MbPartHeight (mb_type)
0	B_Direct_16x16	na	Direct	na	8	8
1	B_L0_16x16	1	Pred_L0	na	16	16
2	B_L1_16x16	1	Pred_L1	na	16	16
3	B_Bi_16x16	1	BiPred	na	16	16
4	B_L0_L0_16x8	2	Pred_L0	Pred_L0	16	8
5	B_L0_L0_8x16	2	Pred_L0	Pred_L0	8	16
6	B_L1_L1_16x8	2	Pred_L1	Pred_L1	16	8
7	B_L1_L1_8x16	2	Pred_L1	Pred_L1	8	16
8	B_L0_L1_16x8	2	Pred_L0	Pred_L1	16	8
9	B_L0_L1_8x16	2	Pred_L0	Pred_L1	8	16
10	B_L1_L0_16x8	2	Pred_L1	Pred_L0	16	8
11	B_L1_L0_8x16	2	Pred_L1	Pred_L0	8	16
12	B_L0_Bi_16x8	2	Pred_L0	BiPred	16	8
13	B_L0_Bi_8x16	2	Pred_L0	BiPred	8	16
14	B_L1_Bi_16x8	2	Pred_L1	BiPred	16	8
15	B_L1_Bi_8x16	2	Pred_L1	BiPred	8	16
16	B_Bi_L0_16x8	2	BiPred	Pred_L0	16	8
17	B_Bi_L0_8x16	2	BiPred	Pred_L0	8	16
18	B_Bi_L1_16x8	2	BiPred	Pred_L1	16	8
19	B_Bi_L1_8x16	2	BiPred	Pred_L1	8	16
20	B_Bi_Bi_16x8	2	BiPred	BiPred	16	8
21	B_Bi_Bi_8x16	2	BiPred	BiPred	8	16
22	B_8x8	4	na	na	8	8
inferred	B_Skip	na	Direct	na	8	8

The following semantics are assigned to the macroblock types in Table 7-14:

– B_Direct_16x16: no motion vector differences or reference indices are present for the macroblock in the bitstream. The functions MbPartWidth(B_Direct_16x16), and MbPartHeight(B_Direct_16x16) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.

– B_X_16x16 with X being replaced by L0, L1, or Bi: the samples of the macroblock are predicted with one luma macroblock partition of size 16x16 luma samples and associated chroma samples. For a macroblock with type B_X_16x16 with X being replaced by either L0 or L1, one motion vector difference and one reference index is present in the bitstream for the macroblock. For a macroblock with type B_X_16x16 with X being replaced by Bi, two motion vector differences and two reference indices are present in the bitstream for the macroblock.

– B_X0_X1_MxN, with X0, X1 referring to the first and second macroblock partition and being replaced by L0, L1, or Bi, and MxN being replaced by 16x8 or 8x16: the samples of the macroblock are predicted using two luma partitions of size MxN equal to 16x8, or two luma partitions of size MxN equal to 8x16, and associated chroma samples, respectively. For a macroblock partition X0 or X1 with X0 or X1 being replaced by either L0 or L1, one motion vector difference and one reference index is present in the bitstream. For a macroblock partition X0 or X1 with X0 or X1 being replaced by Bi, two motion vector differences and two reference indices are present in the bitstream for the macroblock partition.

– B_8x8: for each sub-macroblock an additional syntax element (sub_mb_type) is present in the bitstream that specifies the type of the corresponding sub-macroblock (see subclause 7.4.5.2).

– B_Skip: no further data is present for the macroblock in the bitstream. The functions MbPartWidth(B_Skip), and MbPartHeight(B_Skip) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.

The following semantics are assigned to the macroblock prediction modes (MbPartPredMode( )) in Table 7-14.

– Direct: no motion vector differences or reference indices are present for the macroblock (in case of B_Skip or B_Direct_16x16) in the bitstream. Direct is an Inter macroblock prediction mode.

– Pred_L0: see semantics for Table 7-13.

– Pred_L1: specifies that the Inter prediction process is invoked using list 1 prediction. Pred_L1 is an Inter macroblock prediction mode.

– BiPred: specifies that the Inter prediction process is invoked using list 0 and list 1 prediction. BiPred is an Inter macroblock prediction mode.

pcm_alignment_zero_bit is a bit equal to 0.

pcm_sample_luma[i] is a sample value. The first pcm_sample_luma[i] values represent luma sample values in the raster scan within the macroblock. The number of bits used to represent each of these samples is $BitDepth_Y$. When profile_idc is not equal to 44, 100, 110, 122, or 244, pcm_sample_luma[i] shall not be equal to 0.

pcm_sample_chroma[i] is a sample value. The first MbWidthC * MbHeightC pcm_sample_chroma[i] values represent Cb sample values in the raster scan within the macroblock and the remaining MbWidthC * MbHeightC pcm_sample_chroma[i] values represent Cr sample values in the raster scan within the macroblock. The number of bits used to represent each of these samples is $BitDepth_C$. When profile_idc is not equal to 44, 100, 110, 122, or 244, pcm_sample_chroma[i] shall not be equal to 0.

coded_block_pattern specifies which of the four 8x8 luma blocks and associated chroma blocks of a macroblock may contain non-zero transform coefficient levels. When coded_block_pattern is present in the bitstream, the variables CodedBlockPatternLuma and CodedBlockPatternChroma are derived as follows.

```
CodedBlockPatternLuma = coded_block_pattern % 16
CodedBlockPatternChroma = coded_block_pattern / 16                    (7-34)
```

When the macroblock type is not equal to I_PCM, the following applies.

– If the macroblock prediction mode is equal Intra_16x16, the following applies.
  – If ChromaArrayType is not equal to 3, the value of CodedBlockPatternLuma distinguishes between the following cases.
    – If CodedBlockPatternLuma is equal to 0, all AC transform coefficient levels of the luma component of the macroblock are equal to 0 for all 16 of the 4x4 blocks in the 16x16 luma block.
    – Otherwise (CodedBlockPatternLuma is not equal to 0), CodedBlockPatternLuma is equal to 15, at least one of the AC transform coefficient levels of the luma component of the macroblock shall be non-zero, and the AC transform coefficient levels are scanned for all 16 of the 4x4 blocks in the 16x16 block.

  - Otherwise (ChromaArrayType is equal to 3), the value of CodedBlockPatternLuma distinguishes between the following cases.
    - If CodedBlockPatternLuma is equal to 0, all AC transform coefficient levels of the luma, Cb, and Cr components of the macroblock are equal to 0 for all 16 of the 4x4 blocks in the luma, Cb, and Cr components of the macroblock.
    - Otherwise (CodedBlockPatternLuma is not equal to 0), CodedBlockPatternLuma is equal to 15, at least one of the AC transform coefficient levels of the luma, Cb, or Cr components of the macroblock shall be non-zero, and the AC transform coefficient levels are scanned for all 16 of the 4x4 blocks in the luma Cb, and Cr components of the macroblock.

- Otherwise (the macroblock prediction mode is not equal to Intra_16x16), coded_block_pattern is present in the bitstream, and the following applies.
  - If ChromaArrayType is not equal to 3, each of the four LSBs of CodedBlockPatternLuma distinguishes, for one of the four 8x8 luma blocks of the macroblock, between the following cases.
    - If the corresponding bit of CodedBlockPatternLuma is equal to 0, all transform coefficient levels of the luma transform blocks in the 8x8 luma block are equal to zero.
    - Otherwise (the corresponding bit of CodedBlockPatternLuma is equal to 1), one or more transform coefficient levels of one or more of the luma transform blocks in the 8x8 luma block shall be non-zero valued and the transform coefficient levels of the corresponding transform blocks are scanned.
  - Otherwise (ChromaArrayType is equal to 3), each of the four LSBs of CodedBlockPatternLuma distinguishes, for one of the four 8x8 luma blocks of the macroblock, between the following cases.
    - If the corresponding bit of CodedBlockPatternLuma is equal to 0, all transform coefficient levels of the luma, Cb, and Cr transform blocks in the 8x8 luma block are equal to zero.
    - Otherwise (the corresponding bit of CodedBlockPatternLuma is equal to 1), one or more transform coefficient levels of one or more of the luma, Cb, or Cr transform blocks in the 8x8 luma block shall be non-zero valued and the transform coefficient levels of the corresponding transform blocks are scanned.

When the macroblock type is not equal to I_PCM, CodedBlockPatternChroma is interpreted as follows.

- If ChromaArrayType is not equal to 0 or 3, CodedBlockPatternChroma is specified in Table 7-15.
- Otherwise (ChromaArrayType is equal to 0 or 3), the bitstream shall not contain data that results in a derived value of CodedBlockPatternChroma that is not equal to 0.

Table 7-15 – Specification of CodedBlockPatternChroma values

CodedBlockPatternChroma	Description
0	All chroma transform coefficient levels are equal to 0.
1	One or more chroma DC transform coefficient levels shall be non-zero valued. All chroma AC transform coefficient levels are equal to 0.
2	Zero or more chroma DC transform coefficient levels are non-zero valued. One or more chroma AC transform coefficient levels shall be non-zero valued.

mb_qp_delta can change the value of QP_Y in the macroblock layer. The decoded value of mb_qp_delta shall be in the range of $-(26 + QpBdOffset_Y / 2)$ to $+(25 + QpBdOffset_Y / 2)$, inclusive. mb_qp_delta shall be inferred to be equal to 0 when it is not present for any macroblock (including P_Skip and B_Skip macroblock types).

The value of QP_Y is derived as

$$QP_Y = ((QP_{Y,PREV} + mb\_qp\_delta + 52 + 2 * QpBdOffset_Y) \% (52 + QpBdOffset_Y)) - QpBdOffset_Y \quad (7\text{-}35)$$

where $QP_{Y,PREV}$ is the luma quantisation parameter, QP_Y, of the previous macroblock in decoding order in the current slice. For the first macroblock in the slice $QP_{Y,PREV}$ is initially set equal to $SliceQP_Y$ derived in Equation 7-28 at the start of each slice.

The value of QP'_Y is derived as

$$QP'_Y = QP_Y + QpBdOffset_Y \quad (7\text{-}36)$$

7.4.5.1 Macroblock prediction semantics

All samples of the macroblock are predicted. The prediction modes are derived using the following syntax elements.

prev_intra4x4_pred_mode_flag[luma4x4BlkIdx **]** and **rem_intra4x4_pred_mode[** luma4x4BlkIdx **]** specify the Intra_4x4 prediction of the 4x4 luma block with index luma4x4BlkIdx = 0..15. When ChromaArrayType is equal to 3, prev_intra4x4_pred_mode_flag[luma4x4BlkIdx] and rem_intra4x4_pred_mode[luma4x4BlkIdx] also specify the Intra_4x4 prediction of the 4x4 Cb block with luma4x4BlkIdx equal to cb4x4BlkIdx for cb4x4BlkIdx = 0..15 and the Intra_4x4 prediction of the 4x4 Cr block with luma4x4BlkIdx equal to cr4x4BlkIdx for cr4x4BlkIdx = 0..15.

prev_intra8x8_pred_mode_flag[luma8x8BlkIdx] and **rem_intra8x8_pred_mode**[luma8x8BlkIdx] specify the Intra_8x8 prediction of the 8x8 luma block with index luma8x8BlkIdx = 0..3. When ChromaArrayType is equal to 3, prev_intra8x8_pred_mode_flag[luma8x8BlkIdx] and rem_intra8x8_pred_mode[luma8x8BlkIdx] also specify the Intra_8x8 prediction of the 8x8 Cb block with luma8x8BlkIdx equal to cb8x8BlkIdx for cb8x8BlkIdx = 0..3 and the Intra_8x8 prediction of the 8x8 Cr block with index luma8x8BlkIdx equal to cr8x8BlkIdx for cr8x8BlkIdx = 0..3.

intra_chroma_pred_mode specifies the type of spatial prediction used for chroma in macroblocks using Intra_4x4 or Intra_16x16 prediction, as shown in Table 7-16. The value of intra_chroma_pred_mode shall be in the range of 0 to 3, inclusive.

Table 7-16 – Relationship between intra_chroma_pred_mode and spatial prediction modes

intra_chroma_pred_mode	Intra Chroma Prediction Mode
0	DC
1	Horizontal
2	Vertical
3	Plane

ref_idx_l0[mbPartIdx **]** when present, specifies the index in reference picture list 0 of the reference picture to be used for prediction.

The range of ref_idx_l0[mbPartIdx], the index in list 0 of the reference picture, and, if applicable, the parity of the field within the reference picture used for prediction are specified as follows.

– If MbaffFrameFlag is equal to 0 or mb_field_decoding_flag is equal to 0, the value of ref_idx_l0[mbPartIdx] shall be in the range of 0 to num_ref_idx_l0_active_minus1, inclusive.

– Otherwise (MbaffFrameFlag is equal to 1 and mb_field_decoding_flag is equal to 1), the value of ref_idx_l0[mbPartIdx] shall be in the range of 0 to 2 * num_ref_idx_l0_active_minus1 + 1, inclusive.

When only one reference picture is used for inter prediction, the values of ref_idx_l0[mbPartIdx] shall be inferred to be equal to 0.

ref_idx_l1[mbPartIdx **]** has the same semantics as ref_idx_l0, with l0 and list 0 replaced by l1 and list 1, respectively.

mvd_l0[mbPartIdx **][** 0 **][** compIdx **]** specifies the difference between a vector component to be used and its prediction. The index mbPartIdx specifies to which macroblock partition mvd_l0 is assigned. The partitioning of the macroblock is specified by mb_type. The horizontal motion vector component difference is decoded first in decoding order and is assigned CompIdx = 0. The vertical motion vector component is decoded second in decoding order and is assigned CompIdx = 1. The range of the components of mvd_l0[mbPartIdx][0][compIdx] is specified by constraints on the motion vector variable values derived from it as specified in Annex A.

mvd_l1[mbPartIdx **][** 0 **][** compIdx **]** has the same semantics as mvd_l0, with l0 and L0 replaced by l1 and L1, respectively.

7.4.5.2 Sub-macroblock prediction semantics

sub_mb_type[mbPartIdx **]** specifies the sub-macroblock types.

Tables and semantics are specified for the various sub-macroblock types for P, and B macroblock types. Each table presents the value of sub_mb_type, the name of sub_mb_type, the number of sub-macroblock partitions used (given by the NumSubMbPart(sub_mb_type) function), and the prediction mode of the sub-macroblock (given by the SubMbPredMode(sub_mb_type) function). In the text, the value of sub_mb_type may be referred to by

“sub-macroblock type”. In the text, the value of SubMbPredMode( ) may be referred to by “sub-macroblock prediction mode”.

The interpretation of sub_mb_type[mbPartIdx] for P macroblock types is specified in Table 7-17, where the row for "inferred" specifies values inferred when sub_mb_type[mbPartIdx] is not present.

Table 7-17 – Sub-macroblock types in P macroblocks

sub_mb_type[mbPartIdx]	Name of sub_mb_type[mbPartIdx]	NumSubMbPart (sub_mb_type[mbPartIdx])	SubMbPredMode (sub_mb_type[mbPartIdx])	SubMbPartWidth (sub_mb_type[mbPartIdx])	SubMbPartHeight (sub_mb_type[mbPartIdx])
inferred	na	na	na	na	na
0	P_L0_8x8	1	Pred_L0	8	8
1	P_L0_8x4	2	Pred_L0	8	4
2	P_L0_4x8	2	Pred_L0	4	8
3	P_L0_4x4	4	Pred_L0	4	4

The following semantics are assigned to the sub-macroblock types in Table 7-17.

– P_L0_MxN, with MxN being replaced by 8x8, 8x4, 4x8, or 4x4: the samples of the sub-macroblock are predicted using one luma partition of size MxN equal to 8x8, two luma partitions of size MxN equal to 8x4, or two luma partitions of size MxN equal to 4x8, or four luma partitions of size MxN equal to 4x4, and associated chroma samples, respectively.

The following semantics are assigned to the sub-macroblock prediction modes (SubMbPredMode( )) in Table 7-17.

– Pred_L0: see semantics for Table 7-13.

The interpretation of sub_mb_type[mbPartIdx] for B macroblock types is specified in Table 7-18, where the row for "inferred" specifies values inferred when sub_mb_type[mbPartIdx] is not present, and the inferred value "mb_type" specifies that the name of sub_mb_type[mbPartIdx] is the same as the name of mb_type for this case.

Table 7-18 – Sub-macroblock types in B macroblocks

sub_mb_type[mbPartIdx]	Name of sub_mb_type[mbPartIdx]	NumSubMbPart (sub_mb_type[mbPartIdx])	SubMbPredMode (sub_mb_type[mbPartIdx])	SubMbPartWidth (sub_mb_type[mbPartIdx])	SubMbPartHeight (sub_mb_type[mbPartIdx])
inferred	mb_type	4	Direct	4	4
0	B_Direct_8x8	4	Direct	4	4
1	B_L0_8x8	1	Pred_L0	8	8
2	B_L1_8x8	1	Pred_L1	8	8
3	B_Bi_8x8	1	BiPred	8	8
4	B_L0_8x4	2	Pred_L0	8	4
5	B_L0_4x8	2	Pred_L0	4	8
6	B_L1_8x4	2	Pred_L1	8	4
7	B_L1_4x8	2	Pred_L1	4	8
8	B_Bi_8x4	2	BiPred	8	4
9	B_Bi_4x8	2	BiPred	4	8
10	B_L0_4x4	4	Pred_L0	4	4
11	B_L1_4x4	4	Pred_L1	4	4
12	B_Bi_4x4	4	BiPred	4	4

The following semantics are assigned to the sub-macroblock types in Table 7-18:

– B_Skip and B_Direct_16x16: no motion vector differences or reference indices are present for the sub-macroblock in the bitstream. The functions SubMbPartWidth( ) and SubMbPartHeight( ) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.

– B_Direct_8x8: no motion vector differences or reference indices are present for the sub-macroblock in the bitstream. The functions SubMbPartWidth(B_Direct_8x8) and SubMbPartHeight(B_Direct_8x8) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.

– B_X_MxN, with X being replaced by L0, L1, or Bi, and MxN being replaced by 8x8, 8x4, 4x8 or 4x4: the samples of the sub-macroblock are predicted using one luma partition of size MxN equal to 8x8, or the samples of the sub-macroblock are predicted using two luma partitions of size MxN equal to 8x4, or the samples of the sub-macroblock are predicted using two luma partitions of size MxN equal to 4x8, or the samples of the sub-macroblock are predicted using four luma partitions of size MxN equal to 4x4, and associated chroma samples, respectively. All sub-macroblock partitions share the same reference index. For an MxN sub-macroblock partition in a sub-macroblock with sub_mb_type being B_X_MxN with X being replaced by either L0 or L1, one motion vector difference is present in the bitstream. For an MxN sub-macroblock partition in a sub-macroblock with sub_mb_type being B_Bi_MxN, two motion vector difference are present in the bitstream.

The following semantics are assigned to the sub-macroblock prediction modes (SubMbPredMode( )) in Table 7-18.

– Direct: see semantics for Table 7-14.

– Pred_L0: see semantics for Table 7-13.

– Pred_L1: see semantics for Table 7-14.

– BiPred: see semantics for Table 7-14.

ref_idx_l0[mbPartIdx **]** has the same semantics as ref_idx_l0 in subclause 7.4.5.1.

ref_idx_l1[mbPartIdx **]** has the same semantics as ref_idx_l1 in subclause 7.4.5.1.

mvd_l0[mbPartIdx **][** subMbPartIdx **][** compIdx **]** has the same semantics as mvd_l0 in subclause 7.4.5.1, except that it is applied to the sub-macroblock partition index with subMbPartIdx. The indices mbPartIdx and subMbPartIdx specify to which macroblock partition and sub-macroblock partition mvd_l0 is assigned.

mvd_l1[mbPartIdx **][** subMbPartIdx **][** compIdx **]** has the same semantics as mvd_l1 in subclause 7.4.5.1.

7.4.5.3 Residual data semantics

The syntax structure residual_block( ), which is used for parsing the transform coefficient levels, is assigned as follows.

– If entropy_coding_mode_flag is equal to 0, residual_block is set equal to residual_block_cavlc, which is used for parsing the syntax elements for transform coefficient levels.

– Otherwise (entropy_coding_mode_flag is equal to 1), residual_block is set equal to residual_block_cabac, which is used for parsing the syntax elements for transform coefficient levels.

The syntax structure residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8) is used with the variables in brackets being its output and being assigned as follows.

Intra16x16DCLevel is set equal to i16x16DClevel, Intra16x16ACLevel is set equal to i16x16AClevel, LumaLevel is set equal to level, and LumaLevel8x8 is set equal to level8x8.

When ChromaArrayType is equal to 1 or 2, the following applies.

– For each chroma component, indexed by iCbCr = 0..1, the DC transform coefficient levels of the 4 * NumC8x8 4x4 chroma blocks are parsed into the iCbCr-th list ChromaDCLevel[iCbCr].

– For each of the 4x4 chroma blocks, indexed by i4x4 = 0..3 and i8x8 = 0..NumC8x8 – 1, of each chroma component, indexed by iCbCr = 0..1, the 15 AC transform coefficient levels are parsed into the (i8x8*4 + i4x4)-th list of the iCbCr-th chroma component ChromaACLevel[iCbCr][i8x8*4 + i4x4].

When ChromaArrayType is equal to 3, the following applies.

– The syntax structure residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8) is used for the Cb component with the variables in brackets being its output and being assigned as follows. CbIntra16x16DCLevel is set equal to i16x16DClevel, CbIntra16x16ACLevel is set equal to i16x16AClevel, CbLevel is set equal to level, and CbLevel8x8 is set equal to level8x8.

– The syntax structure residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8) is used for the Cr component with the variables in brackets being its output and being assigned as follows. CrIntra16x16DCLevel is set equal to i16x16DClevel, CrIntra16x16ACLevel is set equal to i16x16AClevel, CrLevel is set equal to level, and CrLevel8x8 is set equal to level8x8.

7.4.5.3.1 Residual luma data semantics

Output of this syntax structure are the variables i16x16DClevel, i16x16AClevel, level, and level8x8.

The syntax structure residual_block( ), which is used for parsing the transform coefficient levels, is assigned as follows.

– If entropy_coding_mode_flag is equal to 0, residual_block is set equal to residual_block_cavlc, which is used for parsing the syntax elements for transform coefficient levels.

– Otherwise (entropy_coding_mode_flag is equal to 1), residual_block is set equal to residual_block_cabac, which is used for parsing the syntax elements for transform coefficient levels.

Depending on mb_type, the syntax structure residual_block(coeffLevel, maxNumCoeff) is used with the arguments coeffLevel, which is a list containing the maxNumCoeff transform coefficient levels that are parsed in residual_block( ) and maxNumCoeff as follows.

Depending on MbPartPredMode(mb_type, 0), the following applies.

– If MbPartPredMode(mb_type, 0) is equal to Intra_16x16, the transform coefficient levels are parsed into the list i16x16DClevel and into the 16 lists i16x16AClevel[i]. i16x16DClevel contains the 16 transform coefficient levels

of the DC transform coefficient levels for each 4x4 luma block. For each of the 16 4x4 luma blocks indexed by i = 0..15, the 15 AC transform coefficients levels of the i-th block are parsed into the i-th list i16x16AClevel[i].

– Otherwise (MbPartPredMode(mb_type, 0) is not equal to Intra_16x16), the following applies.
  – If transform_size_8x8_flag is equal to 0, for each of the 16 4x4 luma blocks indexed by i = 0..15, the 16 transform coefficient levels of the i-th block are parsed into the i-th list level[i].
  – Otherwise (transform_size_8x8_flag is equal to 1), for each of the 4 8x8 luma blocks indexed by i8x8 = 0..3, the following applies.
    – If entropy_coding_mode_flag is equal to 0, first for each of the 4 4x4 luma blocks indexed by i4x4 = 0..3, the 16 transform coefficient levels of the i4x4-th block are parsed into the (i8x8 * 4 + i4x4)-th list level[i8x8 * 4 + i4x4]. Then, the 64 transform coefficient levels of the i8x8-th 8x8 luma block which are indexed by 4 * i + i4x4, where i = 0..15 and i4x4 = 0..3, are derived as level8x8[i8x8][4 * i + i4x4] = level[i8x8 * 4 + i4x4][i].

      NOTE – The 4x4 luma blocks with luma4x4BlkIdx = i8x8 * 4 + i4x4 containing every fourth transform coefficient level of the corresponding i8x8-th 8x8 luma block with offset i4x4 are assumed to represent spatial locations given by the inverse 4x4 luma block scanning process in subclause 6.4.3.

    – Otherwise (entropy_coding_mode_flag is equal to 1), the 64 transform coefficient levels of the i8x8-th block are parsed into the i8x8-th list level8x8[i8x8].

7.4.5.3.2 Residual block CAVLC semantics

The function TotalCoeff(coeff_token) that is used in subclause 7.3.5.3.2 returns the number of non-zero transform coefficient levels derived from coeff_token.

The function TrailingOnes(coeff_token) that is used in subclause 7.3.5.3.2 returns the trailing ones derived from coeff_token.

coeff_token specifies the total number of non-zero transform coefficient levels and the number of trailing one transform coefficient levels in a transform coefficient level scan. A trailing one transform coefficient level is one of up to three consecutive non-zero transform coefficient levels having an absolute value equal to 1 at the end of a scan of non-zero transform coefficient levels. The range of coeff_token is specified in subclause 9.2.1.

trailing_ones_sign_flag specifies the sign of a trailing one transform coefficient level as follows.

– If trailing_ones_sign_flag is equal to 0, the corresponding transform coefficient level is decoded as +1.

– Otherwise (trailing_ones_sign_flag equal to 1), the corresponding transform coefficient level is decoded as -1.

level_prefix and **level_suffix** specify the value of a non-zero transform coefficient level. The range of level_prefix and level_suffix is specified in subclause 9.2.2.

total_zeros specifies the total number of zero-valued transform coefficient levels that are located before the position of the last non-zero transform coefficient level in a scan of transform coefficient levels. The range of total_zeros is specified in subclause 9.2.3.

run_before specifies the number of consecutive transform coefficient levels in the scan with zero value before a non-zero valued transform coefficient level. The range of run_before is specified in subclause 9.2.3.

coeffLevel contains maxNumCoeff transform coefficient levels for the current list of transform coefficient levels.

7.4.5.3.3 Residual block CABAC semantics

coded_block_flag specifies whether the block contains non-zero transform coefficient levels as follows.

– If coded_block_flag is equal to 0, the block contains no non-zero transform coefficient levels.

– Otherwise (coded_block_flag is equal to 1), the block contains at least one non-zero transform coefficient level.

When coded_block_flag is not present, it is inferred to be equal to 1.

significant_coeff_flag[i **]** specifies whether the transform coefficient level at scanning position i is non-zero as follows.

– If significant_coeff_flag[i] is equal to 0, the transform coefficient level at scanning position i is set equal to 0;

– Otherwise (significant_coeff_flag[i] is equal to 1), the transform coefficient level at scanning position i has a non-zero value.

last_significant_coeff_flag[i **]** specifies for the scanning position i whether there are non-zero transform coefficient levels for subsequent scanning positions i + 1 to maxNumCoeff – 1 as follows.

– If last_significant_coeff_flag[i] is equal to 1, all following transform coefficient levels (in scanning order) of the block have value equal to 0.

– Otherwise (last_significant_coeff_flag[i] is equal to 0), there are further non-zero transform coefficient levels along the scanning path.

coeff_abs_level_minus1[i **]** is the absolute value of a transform coefficient level minus 1. The value of coeff_abs_level_minus1 is constrained by the limits in subclause 8.5.

coeff_sign_flag[i **]** specifies the sign of a transform coefficient level as follows.

– If coeff_sign_flag is equal to 0, the corresponding transform coefficient level has a positive value.

– Otherwise (coeff_sign_flag is equal to 1), the corresponding transform coefficient level has a negative value.

coeffLevel contains maxNumCoeff transform coefficient levels for the current list of transform coefficient levels.

8 Decoding process

Outputs of this process are decoded samples of the current picture (sometimes referred to by the variable CurrPic).

Depending on the value of chroma_format_idc, the number of sample arrays of the current picture is as follows.

– If chroma_format_idc is equal to 0, the current picture consists of 1 sample array S_L.

– Otherwise (chroma_format_idc is not equal to 0), the current picture consists of 3 sample arrays S_L, S_{Cb}, S_{Cr}.

This clause describes the decoding process, given syntax elements and upper-case variables from clause 7.

The decoding process is specified such that all decoders shall produce numerically identical results. Any decoding process that produces identical results to the process described here conforms to the decoding process requirements of this Recommendation | International Standard.

Each picture referred to in this clause is a complete or part of a primary coded picture. Each slice referred to in this clause is a slice of a primary coded picture. Each slice data partition referred to in this clause is a slice data partition of a primary coded picture.

Depending on the value of separate_colour_plane_flag, the decoding process is structured as follows.

– If separate_colour_plane_flag is equal to 0, the decoding process is invoked a single time with the current picture being the output.

– Otherwise (separate_colour_plane_flag is equal to 1), the decoding process is invoked three times. Inputs to the decoding process are all NAL units of the primary coded picture with identical value of colour_plane_id. The decoding process of NAL units with a particular value of colour_plane_id is specified as if only a coded video sequence with monochrome colour format with that particular value of colour_plane_id would be present in the bitstream. The output of each of the three decoding processes is assigned to the 3 sample arrays of the current picture with the NAL units with colour_plane_id equal to 0 being assigned to S_L, the NAL units with colour_plane_id equal to 1 being assigned to S_{Cb}, and the NAL units with colour_plane_id equal to 2 being assigned to S_{Cr}.

NOTE - The variable ChromaArrayType is derived as 0 when separate_colour_plane_flag is equal to 1 and chroma_format_idc is equal to 3. In the decoding process, the value of this variable is evaluated resulting in operations identical to that of monochrome pictures with chroma_format_idc being equal to 0.

An overview of the decoding process is given as follows.

– The decoding of NAL units is specified in subclause 8.1.

– The processes in subclause 8.2 specify decoding processes using syntax elements in the slice layer and above.

  – Variables and functions relating to picture order count are derived in subclause 8.2.1. (only needed to be invoked for one slice of a picture).

  – Variables and functions relating to the macroblock to slice group map are derived in subclause 8.2.2. (only needed to be invoked for one slice of a picture).

  – The method of combining the various partitions when slice data partitioning is used is described in subclause 8.2.3.

  - When the frame_num of the current picture is not equal to PrevRefFrameNum and is not equal to (PrevRefFrameNum + 1) % MaxFrameNum, the decoding process for gaps in frame_num is performed according to subclause 8.2.5.2 prior to the decoding of any slices of the current picture.
  - At the beginning of the decoding process for each P, SP, or B slice, the decoding process for reference picture lists construction specified in subclause 8.2.4 performed for derivation of reference picture list 0 (RefPicList0), and when decoding a B slice, reference picture list 1 (RefPicList1).
  - When the current picture is a reference picture and after all slices of the current picture have been decoded, the decoded reference picture marking process in subclause 8.2.5 specifies how the current picture is used in the decoding process of inter prediction in later decoded pictures.
- The processes in subclauses 8.3, 8.4, 8.5, 8.6, and 8.7 specify decoding processes using syntax elements in the macroblock layer and above.
  - The intra prediction process for I and SI macroblocks, except for I_PCM macroblocks as specified in subclause 8.3, has intra prediction samples as its output. For I_PCM macroblocks subclause 8.3 directly specifies a picture construction process. The output are the constructed samples prior to the deblocking filter process.
  - The inter prediction process for P and B macroblocks is specified in subclause 8.4 with inter prediction samples being the output.
  - The transform coefficient decoding process and picture construction process prior to deblocking filter process are specified in subclause 8.5. That process derives samples for I and B macroblocks and for P macroblocks in P slices. The output are constructed samples prior to the deblocking filter process.
  - The decoding process for P macroblocks in SP slices or SI macroblocks is specified in subclause 8.6. That process derives samples for P macroblocks in SP slices and for SI macroblocks. The output are constructed samples prior to the deblocking filter process.
  - The constructed samples prior to the deblocking filter process that are next to the edges of blocks and macroblocks are processed by a deblocking filter as specified in subclause 8.7 with the output being the decoded samples.

8.1 NAL unit decoding process

Inputs to this process are NAL units.

Outputs of this process are the RBSP syntax structures encapsulated within the NAL units.

The decoding process for each NAL unit extracts the RBSP syntax structure from the NAL unit and then operates the decoding processes specified for the RBSP syntax structure in the NAL unit as follows.

Subclause 8.2 describes the decoding process for NAL units with nal_unit_type equal to 1 through 5.

Subclauses 8.3 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1, 2, and 5.

Subclause 8.4 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 and 2.

Subclause 8.5 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 and 3 to 5.

Subclause 8.6 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 and 3 to 5.

Subclause 8.7 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 to 5.

NAL units with nal_unit_type equal to 7 and 8 contain sequence parameter sets and picture parameter sets, respectively. Picture parameter sets are used in the decoding processes of other NAL units as determined by reference to a picture parameter set within the slice headers of each picture. Sequence parameter sets are used in the decoding processes of other NAL units as determined by reference to a sequence parameter set within the picture parameter sets of each sequence.

No normative decoding process is specified for NAL units with nal_unit_type equal to 6, 9, 10, 11, and 12.

8.2 Slice decoding process

8.2.1 Decoding process for picture order count

Outputs of this process are TopFieldOrderCnt (if applicable) and BottomFieldOrderCnt (if applicable).

Picture order counts are used to determine initial picture orderings for reference pictures in the decoding of B slices (see subclauses 8.2.4.2.3 and 8.2.4.2.4), to represent picture order differences between frames or fields for motion vector derivation in temporal direct mode (see subclause 8.4.1.2.3), for implicit mode weighted prediction in B slices (see subclause 8.4.2.3.2), and for decoder conformance checking (see subclause C.4).

Picture order count information is derived for every frame, field (whether decoded from a coded field or as a part of a decoded frame), or complementary field pair as follows:

– Each coded frame is associated with two picture order counts, called TopFieldOrderCnt and BottomFieldOrderCnt for its top field and bottom field, respectively.

– Each coded field is associated with a picture order count, called TopFieldOrderCnt for a coded top field and BottomFieldOrderCnt for a bottom field.

– Each complementary field pair is associated with two picture order counts, which are the TopFieldOrderCnt for its coded top field and the BottomFieldOrderCnt for its coded bottom field, respectively.

TopFieldOrderCnt and BottomFieldOrderCnt indicate the picture order of the corresponding top field or bottom field relative to the first output field of the previous IDR picture or the previous reference picture including a memory_management_control_operation equal to 5 in decoding order.

TopFieldOrderCnt and BottomFieldOrderCnt are derived by invoking one of the decoding processes for picture order count type 0, 1, and 2 in subclauses 8.2.1.1, 8.2.1.2, and 8.2.1.3, respectively. When the current picture includes a memory management control operation equal to 5, after the decoding of the current picture, tempPicOrderCnt is set equal to PicOrderCnt(CurrPic), TopFieldOrderCnt of the current picture (if any) is set equal to TopFieldOrderCnt - tempPicOrderCnt, and BottomFieldOrderCnt of the current picture (if any) is set equal to BottomFieldOrderCnt - tempPicOrderCnt.

The bitstream shall not contain data that results in Min(TopFieldOrderCnt, BottomFieldOrderCnt) not equal to 0 for a coded IDR frame, TopFieldOrderCnt not equal to 0 for a coded IDR top field, or BottomFieldOrderCnt not equal to 0 for a coded IDR bottom field. Thus, at least one of TopFieldOrderCnt and BottomFieldOrderCnt shall be equal to 0 for the fields of a coded IDR frame.

When the current picture is not an IDR picture, the following applies.

– Consider the list variable listD containing as elements the TopFieldOrderCnt and BottomFieldOrderCnt values associated with the list of pictures including all of the following
  – the first picture in the list is the previous picture of any of the following types
    – an IDR picture
    – a picture containing a memory_management_control_operation equal to 5
  – the following additional pictures.
    – If pic_order_cnt_type is equal to 0, all other pictures that follow in decoding order after the first picture in the list and are not "non-existing" frames inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2 and either precede the current picture in decoding order or are the current picture. When pic_order_cnt_type is equal to 0 and the current picture is not a "non-existing" frame inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2, the current picture is included in listD prior to the invoking of the decoded reference picture marking process.

      Otherwise (pic_order_cnt_type is not equal to 0), all other pictures that follow in decoding order after the first picture in the list and either precede the current picture in decoding order or are the current picture. When pic_order_cnt_type is not equal to 0, the current picture is included in listD prior to the invoking of the decoded reference picture marking process.

– Consider the list variable listO which contains the elements of listD sorted in ascending order. listO shall not contain any of the following.
  – a pair of TopFieldOrderCnt and BottomFieldOrderCnt for a frame or complementary field pair that are not at consecutive positions in listO.
  – a TopFieldOrderCnt that has a value equal to another TopFieldOrderCnt.
  – a BottomFieldOrderCnt that has a value equal to another BottomFieldOrderCnt.

– a BottomFieldOrderCnt that has a value equal to a TopFieldOrderCnt unless the BottomFieldOrderCnt and TopFieldOrderCnt belong to the same coded frame or complementary field pair.

The bitstream shall not contain data that results in values of TopFieldOrderCnt, BottomFieldOrderCnt, PicOrderCntMsb, or FrameNumOffset used in the decoding process as specified in subclauses 8.2.1.1 to 8.2.1.3 that exceed the range of values from -2^{31} to $2^{31}-1$, inclusive.

The function PicOrderCnt(picX) is specified as follows:

```
if( picX is a frame or a complementary field pair )
    PicOrderCnt( picX ) = Min( TopFieldOrderCnt, BottomFieldOrderCnt ) of the frame or complementary field
pair picX
else if( picX is a top field )
    PicOrderCnt( picX ) = TopFieldOrderCnt of field picX                                    (8-1)
else if( picX is a bottom field )
    PicOrderCnt( picX ) = BottomFieldOrderCnt of field picX
```

Then DiffPicOrderCnt(picA, picB) is specified as follows:

```
DiffPicOrderCnt( picA, picB ) = PicOrderCnt( picA ) - PicOrderCnt( picB )                   (8-2)
```

The bitstream shall not contain data that results in values of DiffPicOrderCnt(picA, picB) used in the decoding process that exceed the range of -2^{15} to $2^{15} - 1$, inclusive.

NOTE 1 – Let X be the current picture and Y and Z be two other pictures in the same sequence, Y and Z are considered to be in the same output order direction from X when both DiffPicOrderCnt(X, Y) and DiffPicOrderCnt(X, Z) are positive or both are negative.

NOTE 2 – Many applications assign PicOrderCnt(X) proportional to the sampling time of the picture X relative to the sampling time of an IDR picture.

When the current picture includes a memory_management_control_operation equal to 5, PicOrderCnt(CurrPic) shall be greater than PicOrderCnt(any other picture in listD).

8.2.1.1 Decoding process for picture order count type 0

This process is invoked when pic_order_cnt_type is equal to 0.

Input to this process is PicOrderCntMsb of the previous reference picture in decoding order as specified in this subclause.

Outputs of this process are either or both TopFieldOrderCnt or BottomFieldOrderCnt.

The variables prevPicOrderCntMsb and prevPicOrderCntLsb are derived as follows.

– If the current picture is an IDR picture, prevPicOrderCntMsb is set equal to 0 and prevPicOrderCntLsb is set equal to 0.

– Otherwise (the current picture is not an IDR picture), the following applies.

  – If the previous reference picture in decoding order included a memory_management_control_operation equal to 5, the following applies.

    – If the previous reference picture in decoding order is not a bottom field, prevPicOrderCntMsb is set equal to 0 and prevPicOrderCntLsb is set equal to the value of TopFieldOrderCnt for the previous reference picture in decoding order.

    – Otherwise (the previous reference picture in decoding order is a bottom field), prevPicOrderCntMsb is set equal to 0 and prevPicOrderCntLsb is set equal to 0.

  – Otherwise (the previous reference picture in decoding order did not include a memory_management_control_operation equal to 5), prevPicOrderCntMsb is set equal to PicOrderCntMsb of the previous reference picture in decoding order and prevPicOrderCntLsb is set equal to the value of pic_order_cnt_lsb of the previous reference picture in decoding order.

PicOrderCntMsb of the current picture is derived as follows:

```
if( ( pic_order_cnt_lsb  <  prevPicOrderCntLsb )  &&
    ( ( prevPicOrderCntLsb – pic_order_cnt_lsb )  >=  ( MaxPicOrderCntLsb / 2 ) ) )
    PicOrderCntMsb = prevPicOrderCntMsb + MaxPicOrderCntLsb                          (8-3)
else if( ( pic_order_cnt_lsb  >  prevPicOrderCntLsb )  &&
         ( ( pic_order_cnt_lsb – prevPicOrderCntLsb )  >  ( MaxPicOrderCntLsb / 2 ) ) )
    PicOrderCntMsb = prevPicOrderCntMsb – MaxPicOrderCntLsb
else
    PicOrderCntMsb = prevPicOrderCntMsb
```

When the current picture is not a bottom field, TopFieldOrderCnt is derived as follows:

```
if( !field_pic_flag  ||  !bottom_field_flag )
    TopFieldOrderCnt = PicOrderCntMsb + pic_order_cnt_lsb                            (8-4)
```

When the current picture is not a top field, BottomFieldOrderCnt is derived as follows:

```
if( !field_pic_flag )
    BottomFieldOrderCnt = TopFieldOrderCnt + delta_pic_order_cnt_bottom
else if( bottom_field_flag )                                                         (8-5)
    BottomFieldOrderCnt = PicOrderCntMsb + pic_order_cnt_lsb
```

8.2.1.2 Decoding process for picture order count type 1

This process is invoked when pic_order_cnt_type is equal to 1.

Input to this process is FrameNumOffset of the previous picture in decoding order as specified in this subclause.

Outputs of this process are either or both TopFieldOrderCnt or BottomFieldOrderCnt.

The values of TopFieldOrderCnt and BottomFieldOrderCnt are derived as specified in this subclause. Let prevFrameNum be equal to the frame_num of the previous picture in decoding order.

When the current picture is not an IDR picture, the variable prevFrameNumOffset is derived as follows.

– If the previous picture in decoding order included a memory_management_control_operation equal to 5, prevFrameNumOffset is set equal to 0.

– Otherwise (the previous picture in decoding order did not include a memory_management_control_operation equal to 5), prevFrameNumOffset is set equal to the value of FrameNumOffset of the previous picture in decoding order.

NOTE – When gaps_in_frame_num_value_allowed_flag is equal to 1, the previous picture in decoding order may be a "non-existing" frame inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2.

The derivation proceeds in the following ordered steps.

1. The variable FrameNumOffset is derived as follows:

```
if( IdrPicFlag  = =  1 )
    FrameNumOffset = 0
else if( prevFrameNum > frame_num )                                                  (8-6)
    FrameNumOffset = prevFrameNumOffset + MaxFrameNum
else
    FrameNumOffset = prevFrameNumOffset
```

2. The variable absFrameNum is derived as follows:

```
if( num_ref_frames_in_pic_order_cnt_cycle  !=  0 )
    absFrameNum = FrameNumOffset + frame_num
else                                                                                 (8-7)
    absFrameNum = 0
if( nal_ref_idc  = =  0  &&  absFrameNum  >  0 )
    absFrameNum = absFrameNum – 1
```

3. When absFrameNum > 0, picOrderCntCycleCnt and frameNumInPicOrderCntCycle are derived as follows:

```
if( absFrameNum  >  0 ) {
    picOrderCntCycleCnt = ( absFrameNum – 1 ) / num_ref_frames_in_pic_order_cnt_cycle
    frameNumInPicOrderCntCycle = ( absFrameNum – 1 ) % num_ref_frames_in_pic_order_cnt_cycle        (8-8)
}
```

4. The variable expectedDeltaPerPicOrderCntCycle is derived as follows:

```
expectedDeltaPerPicOrderCntCycle = 0
for( i = 0;  i < num_ref_frames_in_pic_order_cnt_cycle;  i++ )
    expectedDeltaPerPicOrderCntCycle += offset_for_ref_frame[ i ]                                   (8-9)
```

5. The variable expectedPicOrderCnt is derived as follows:

```
if( absFrameNum > 0 ){
    expectedPicOrderCnt = picOrderCntCycleCnt * expectedDeltaPerPicOrderCntCycle
    for( i = 0; i <= frameNumInPicOrderCntCycle; i++ )
        expectedPicOrderCnt = expectedPicOrderCnt + offset_for_ref_frame[ i ]
} else
    expectedPicOrderCnt = 0
if( nal_ref_idc  = =  0 )                                                                           (8-10)
    expectedPicOrderCnt = expectedPicOrderCnt + offset_for_non_ref_pic
```

6. The variables TopFieldOrderCnt or BottomFieldOrderCnt are derived as follows:

```
if( !field_pic_flag ) {
    TopFieldOrderCnt = expectedPicOrderCnt + delta_pic_order_cnt[ 0 ]
    BottomFieldOrderCnt = TopFieldOrderCnt +
            offset_for_top_to_bottom_field + delta_pic_order_cnt[ 1 ]                               (8-11)
} else if( !bottom_field_flag )
    TopFieldOrderCnt = expectedPicOrderCnt + delta_pic_order_cnt[ 0 ]
else
    BottomFieldOrderCnt = expectedPicOrderCnt + offset_for_top_to_bottom_field + delta_pic_order_cnt[ 0 ]
```

8.2.1.3 Decoding process for picture order count type 2

This process is invoked when pic_order_cnt_type is equal to 2.

Outputs of this process are either or both TopFieldOrderCnt or BottomFieldOrderCnt.

Let prevFrameNum be equal to the frame_num of the previous picture in decoding order.

When the current picture is not an IDR picture, the variable prevFrameNumOffset is derived as follows.

– If the previous picture in decoding order included a memory_management_control_operation equal to 5, prevFrameNumOffset is set equal to 0.

– Otherwise (the previous picture in decoding order did not include a memory_management_control_operation equal to 5), prevFrameNumOffset is set equal to the value of FrameNumOffset of the previous picture in decoding order.

NOTE 1 – When gaps_in_frame_num_value_allowed_flag is equal to 1, the previous picture in decoding order may be a "non-existing" frame inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2.

The variable FrameNumOffset is derived as follows.

```
if( IdrPicFlag  = =  1 )
    FrameNumOffset = 0
else if( prevFrameNum  >  frame_num )                                                               (8-12)
    FrameNumOffset = prevFrameNumOffset + MaxFrameNum
else
    FrameNumOffset = prevFrameNumOffset
```

The variable tempPicOrderCnt is derived as follows:

```
if( IdrPicFlag  = =  1 )
    tempPicOrderCnt = 0
else if( nal_ref_idc  = =  0 )                                          (8-13)
    tempPicOrderCnt = 2 * ( FrameNumOffset + frame_num ) – 1
else
    tempPicOrderCnt = 2 * ( FrameNumOffset + frame_num )
```

The variables TopFieldOrderCnt or BottomFieldOrderCnt are derived as follows:

```
if( !field_pic_flag ) {
    TopFieldOrderCnt = tempPicOrderCnt
    BottomFieldOrderCnt = tempPicOrderCnt                               (8-14)
} else if( bottom_field_flag )
    BottomFieldOrderCnt = tempPicOrderCnt
else
    TopFieldOrderCnt = tempPicOrderCnt
```

NOTE 2 – Picture order count type 2 cannot be used in a coded video sequence that contains consecutive non-reference pictures that would result in more than one of these pictures having the same value of TopFieldOrderCnt or more than one of these pictures having the same value of BottomFieldOrderCnt.

NOTE 3 – Picture order count type 2 results in an output order that is the same as the decoding order.

8.2.2 Decoding process for macroblock to slice group map

Inputs to this process are the active picture parameter set and the slice header of the slice to be decoded.

Output of this process is a macroblock to slice group map MbToSliceGroupMap.

This process is invoked at the start of every slice.

NOTE – The output of this process is equal for all slices of a picture.

When num_slice_groups_minus1 is equal to 1 and slice_group_map_type is equal to 3, 4, or 5, slice groups 0 and 1 have a size and shape determined by slice_group_change_direction_flag as shown in Table 8-1 and specified in subclauses 8.2.2.4 to 8.2.2.6.

Table 8-1 – Refined slice group map type

slice_group_map_type	slice_group_change_direction_flag	refined slice group map type
3	0	Box-out clockwise
3	1	Box-out counter-clockwise
4	0	Raster scan
4	1	Reverse raster scan
5	0	Wipe right
5	1	Wipe left

In such a case, MapUnitsInSliceGroup0 slice group map units in the specified growth order are allocated for slice group 0 and the remaining PicSizeInMapUnits – MapUnitsInSliceGroup0 slice group map units of the picture are allocated for slice group 1.

When num_slice_groups_minus1 is equal to 1 and slice_group_map_type is equal to 4 or 5, the variable sizeOfUpperLeftGroup is defined as follows:

```
sizeOfUpperLeftGroup = ( slice_group_change_direction_flag ?
                         ( PicSizeInMapUnits – MapUnitsInSliceGroup0 ) : MapUnitsInSliceGroup0 )   (8-15)
```

The variable mapUnitToSliceGroupMap is derived as follows.

– If num_slice_groups_minus1 is equal to 0, the map unit to slice group map is generated for all i ranging from 0 to PicSizeInMapUnits – 1, inclusive, as specified by:

```
mapUnitToSliceGroupMap[ i ] = 0                                    (8-16)
```

– Otherwise (num_slice_groups_minus1 is not equal to 0), mapUnitToSliceGroupMap is derived as follows.
  – If slice_group_map_type is equal to 0, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.1 applies.
  – Otherwise, if slice_group_map_type is equal to 1, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.2 applies.
  – Otherwise, if slice_group_map_type is equal to 2, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.3 applies.
  – Otherwise, if slice_group_map_type is equal to 3, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.4 applies.
  – Otherwise, if slice_group_map_type is equal to 4, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.5 applies.
  – Otherwise, if slice_group_map_type is equal to 5, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.6 applies.
  – Otherwise (slice_group_map_type is equal to 6), the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.7 applies.

After derivation of the mapUnitToSliceGroupMap, the process specified in subclause 8.2.2.8 is invoked to convert the map unit to slice group map mapUnitToSliceGroupMap to the macroblock to slice group map MbToSliceGroupMap. After derivation of the macroblock to slice group map as specified in subclause 8.2.2.8, the function NextMbAddress(n) is defined as the value of the variable nextMbAddress derived as specified by:

```
i = n + 1
while( i < PicSizeInMbs  &&  MbToSliceGroupMap[ i ]  !=  MbToSliceGroupMap[ n ] )
    i++;
nextMbAddress = i                                                  (8-17)
```

8.2.2.1 Specification for interleaved slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 0.

The map unit to slice group map is generated as specified by:

```
i = 0
do
    for( iGroup = 0; iGroup <= num_slice_groups_minus1 && i < PicSizeInMapUnits;
          i += run_length_minus1[ iGroup++ ] + 1 )
        for( j = 0; j <= run_length_minus1[ iGroup ] && i + j < PicSizeInMapUnits; j++ )
            mapUnitToSliceGroupMap[ i + j ] = iGroup                (8-18)
while( i < PicSizeInMapUnits )
```

8.2.2.2 Specification for dispersed slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 1.

The map unit to slice group map is generated as specified by:

```
for( i = 0; i < PicSizeInMapUnits; i++ )
    mapUnitToSliceGroupMap[ i ] = ( ( i % PicWidthInMbs ) +
                                    ( ( ( i / PicWidthInMbs ) * ( num_slice_groups_minus1 + 1 ) ) / 2 ) )
                                  % ( num_slice_groups_minus1 + 1 )    (8-19)
```

8.2.2.3 Specification for foreground with left-over slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 2.

The map unit to slice group map is generated as specified by:

```
for( i = 0; i < PicSizeInMapUnits; i++ )
    mapUnitToSliceGroupMap[ i ] = num_slice_groups_minus1
for( iGroup = num_slice_groups_minus1 – 1; iGroup >= 0; iGroup-- ) {
    yTopLeft = top_left[ iGroup ] / PicWidthInMbs
    xTopLeft = top_left[ iGroup ] % PicWidthInMbs
    yBottomRight = bottom_right[ iGroup ] / PicWidthInMbs
    xBottomRight = bottom_right[ iGroup ] % PicWidthInMbs
    for( y = yTopLeft; y <= yBottomRight; y++ )
        for( x = xTopLeft; x <= xBottomRight; x++ )
            mapUnitToSliceGroupMap[ y * PicWidthInMbs + x ] = iGroup                    (8-20)
}
```

NOTE – The rectangles may overlap. Slice group 0 contains the macroblocks that are within the rectangle specified by top_left[0] and bottom_right[0]. A slice group having slice group ID greater than 0 and less than num_slice_groups_minus1 contains the macroblocks that are within the specified rectangle for that slice group that are not within the rectangle specified for any slice group having a smaller slice group ID. The slice group with slice group ID equal to num_slice_groups_minus1 contains the macroblocks that are not in the other slice groups.

8.2.2.4 Specification for box-out slice group map types

The specifications in this subclause apply when slice_group_map_type is equal to 3.

The map unit to slice group map is generated as specified by:

```
for( i = 0; i < PicSizeInMapUnits; i++ )
    mapUnitToSliceGroupMap[ i ] = 1
x = ( PicWidthInMbs – slice_group_change_direction_flag ) / 2
y = ( PicHeightInMapUnits – slice_group_change_direction_flag ) / 2
( leftBound, topBound ) = ( x, y )
( rightBound, bottomBound ) = ( x, y )
( xDir, yDir ) = ( slice_group_change_direction_flag – 1, slice_group_change_direction_flag )
for( k = 0; k < MapUnitsInSliceGroup0; k += mapUnitVacant ) {
    mapUnitVacant = ( mapUnitToSliceGroupMap[ y * PicWidthInMbs + x ]  = =  1 )
    if( mapUnitVacant )
        mapUnitToSliceGroupMap[ y * PicWidthInMbs + x ] = 0                             (8-21)
    if( xDir  = =  –1  &&  x  = =  leftBound ) {
        leftBound = Max( leftBound – 1, 0 )
        x = leftBound
        ( xDir, yDir ) = ( 0, 2 * slice_group_change_direction_flag – 1 )
    } else if( xDir  = =  1  &&  x  = =  rightBound ) {
        rightBound = Min( rightBound + 1, PicWidthInMbs – 1 )
        x = rightBound
        ( xDir, yDir ) = ( 0, 1 – 2 * slice_group_change_direction_flag )
    } else if( yDir  = =  –1  &&  y  = =  topBound ) {
        topBound = Max( topBound – 1, 0 )
        y = topBound
        ( xDir, yDir ) = ( 1 – 2 * slice_group_change_direction_flag, 0 )
    } else if( yDir  = =  1  &&  y  = =  bottomBound ) {
        bottomBound  =  Min( bottomBound + 1, PicHeightInMapUnits – 1 )
        y = bottomBound
        ( xDir, yDir ) = ( 2 * slice_group_change_direction_flag – 1, 0 )
    } else
        ( x, y ) = ( x + xDir, y + yDir )
}
```

8.2.2.5 Specification for raster scan slice group map types

The specifications in this subclause apply when slice_group_map_type is equal to 4.

The map unit to slice group map is generated as specified by:

```
for( i = 0; i < PicSizeInMapUnits; i++ )
    if( i < sizeOfUpperLeftGroup )
        mapUnitToSliceGroupMap[ i ] = slice_group_change_direction_flag
    else                                                                    (8-22)
        mapUnitToSliceGroupMap[ i ] = 1 – slice_group_change_direction_flag
```

8.2.2.6 Specification for wipe slice group map types

The specifications in this subclause apply when slice_group_map_type is equal to 5.

The map unit to slice group map is generated as specified by:

```
k = 0;
for( j = 0; j < PicWidthInMbs; j++ )
    for( i = 0; i < PicHeightInMapUnits; i++ )
        if( k++ < sizeOfUpperLeftGroup )
            mapUnitToSliceGroupMap[ i * PicWidthInMbs + j ] = slice_group_change_direction_flag
        else                                                                (8-23)
            mapUnitToSliceGroupMap[ i * PicWidthInMbs + j ] = 1 – slice_group_change_direction_flag
```

8.2.2.7 Specification for explicit slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 6.

The map unit to slice group map is generated as specified by:

```
mapUnitToSliceGroupMap[ i ] = slice_group_id[ i ]                           (8-24)
```

for all i ranging from 0 to PicSizeInMapUnits – 1, inclusive.

8.2.2.8 Specification for conversion of map unit to slice group map to macroblock to slice group map

For each value of i ranging from 0 to PicSizeInMbs – 1, inclusive, the macroblock to slice group map is specified as follows.

— If frame_mbs_only_flag is equal to 1 or field_pic_flag is equal to 1, the macroblock to slice group map is specified by:

```
MbToSliceGroupMap[ i ] = mapUnitToSliceGroupMap[ i ]                        (8-25)
```

– Otherwise, if MbaffFrameFlag is equal to 1, the macroblock to slice group map is specified by:

```
MbToSliceGroupMap[ i ] = mapUnitToSliceGroupMap[ i / 2 ]                    (8-26)
```

– Otherwise (frame_mbs_only_flag is equal to 0 and mb_adaptive_frame_field_flag is equal to 0 and field_pic_flag is equal to 0), the macroblock to slice group map is specified by:

```
MbToSliceGroupMap[ i ] = mapUnitToSliceGroupMap[ ( i / ( 2 * PicWidthInMbs ) ) * PicWidthInMbs
                                                 + ( i % PicWidthInMbs ) ]  (8-27)
```

8.2.3 Decoding process for slice data partitioning

Inputs to this process are

– a slice data partition A layer RBSP,

– when syntax elements of category 3 are present in the slice data, a slice data partition B layer RBSP having the same slice_id as in the slice data partition A layer RBSP, and

– when syntax elements of category 4 are present in the slice data, a slice data partition C layer RBSP having the same slice_id as in the slice data partition A layer RBSP.

NOTE 1 – The slice data partition B layer RBSP and slice data partition C layer RBSP need not be present.

Output of this process is a coded slice.

When slice data partitioning is not used, coded slices are represented by a slice layer without partitioning RBSP that contains a slice header followed by a slice data syntax structure that contains all the syntax elements of categories 2, 3, and 4 (see category column in subclause 7.3) of the macroblock data for the macroblocks of the slice.

When slice data partitioning is used, the macroblock data of a slice is partitioned into one to three partitions contained in separate NAL units. Partition A contains a slice data partition A header, and all syntax elements of category 2. Partition B, when present, contains a slice data partition B header and all syntax elements of category 3. Partition C, when present, contains a slice data partition C header and all syntax elements of category 4.

When slice data partitioning is used, the syntax elements of each category are parsed from a separate NAL unit, which need not be present when no symbols of the respective category exist. The decoding process shall process the slice data partitions of a coded slice in a manner equivalent to processing a corresponding slice layer without partitioning RBSP by extracting each syntax element from the slice data partition in which the syntax element appears depending on the slice data partition assignment in the syntax tables in subclause 7.3.

NOTE 2 – Syntax elements of category 3 are relevant to the decoding of residual data of I and SI macroblock types. Syntax elements of category 4 are relevant to the decoding of residual data of P and B macroblock types. Category 2 encompasses all other syntax elements related to the decoding of macroblocks, and their information is often denoted as header information. The slice data partition A header contains all the syntax elements of the slice header, and additionally a slice_id that are used to associate the slice data partitions B and C with the slice data partition A. The slice data partition B and C headers contain the slice_id syntax element that establishes their association with the slice data partition A of the slice.

8.2.4 Decoding process for reference picture lists construction

This process is invoked at the beginning of decoding of each P, SP, or B slice.

Decoded reference pictures are marked as "used for short-term reference" or "used for long-term reference" as specified by the bitstream and specified in subclause 8.2.5. Short-term reference pictures are identified by the value of frame_num. Long-term reference pictures are assigned a long-term frame index as specified by the bitstream and specified in subclause 8.2.5.

Subclause 8.2.4.1 is invoked to specify

– the assignment of variables FrameNum, FrameNumWrap, and PicNum to each of the short-term reference pictures, and

– the assignment of variable LongTermPicNum to each of the long-term reference pictures.

Reference pictures are addressed through reference indices as specified in subclause 8.4.2.1. A reference index is an index into a reference picture list. When decoding a P or SP slice, there is a single reference picture list RefPicList0. When decoding a B slice, there is a second independent reference picture list RefPicList1 in addition to RefPicList0.

At the beginning of decoding of each slice, reference picture list RefPicList0, and for B slices RefPicList1, are derived as follows.

– An initial reference picture list RefPicList0 and for B slices RefPicList1 are derived as specified in subclause 8.2.4.2.

– The initial reference picture list RefPicList0 and for B slices RefPicList1 are modified as specified in subclause 8.2.4.3.

NOTE – The reordering process for reference picture lists specified in subclause 8.2.4.3 allows the contents of RefPicList0 and for B slices RefPicList1 to be modified in a flexible fashion. In particular, it is possible for a picture that is currently marked "used for reference" to be inserted into RefPicList0 and for B slices RefPicList1 even when the picture is not in the initial reference picture list derived as specified in subclause 8.2.4.2.

The number of entries in the modified reference picture list RefPicList0 is num_ref_idx_l0_active_minus1 + 1, and for B slices the number of entries in the modified reference picture list RefPicList1 is num_ref_idx_l1_active_minus1 + 1. A reference picture may appear at more than one index in the modified reference picture lists RefPicList0 or RefPicList1.

8.2.4.1 Decoding process for picture numbers

This process is invoked when the decoding process for reference picture lists construction specified in subclause 8.2.4 or the decoded reference picture marking process specified in subclause 8.2.5 is invoked.

The variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum are used for the initialisation process for reference picture lists in subclause 8.2.4.2, the modification process for reference picture lists in subclause 8.2.4.3, and for the decoded reference picture marking process in subclause 8.2.5.

To each short-term reference picture the variables FrameNum and FrameNumWrap are assigned as follows. First, FrameNum is set equal to the syntax element frame_num that has been decoded in the slice header(s) of the corresponding short-term reference picture. Then the variable FrameNumWrap is derived as

```
if( FrameNum > frame_num )
    FrameNumWrap = FrameNum – MaxFrameNum                    (8-28)
else
    FrameNumWrap = FrameNum
```

where the value of frame_num used in Equation 8-28 is the frame_num in the slice header(s) for the current picture.

Each long-term reference picture has an associated value of LongTermFrameIdx (that was assigned to it as specified in subclause 8.2.5).

To each short-term reference picture a variable PicNum is assigned, and to each long-term reference picture a variable LongTermPicNum is assigned. The values of these variables depend on the value of field_pic_flag and bottom_field_flag for the current picture and they are set as follows.

– If field_pic_flag is equal to 0, the following applies.
  – For each short-term reference frame or complementary reference field pair:

    PicNum = FrameNumWrap (8-29)

  – For each long-term reference frame or long-term complementary reference field pair:

    LongTermPicNum = LongTermFrameIdx (8-30)

    NOTE – When decoding a frame the value of MbaffFrameFlag has no influence on the derivations in subclauses 8.2.4.2, 8.2.4.3, and 8.2.5.

– Otherwise (field_pic_flag is equal to 1), the following applies.
  – For each short-term reference field the following applies.
    – If the reference field has the same parity as the current field

    PicNum = 2 * FrameNumWrap + 1 (8-31)

    – Otherwise (the reference field has the opposite parity of the current field),

    PicNum = 2 * FrameNumWrap (8-32)

  – For each long-term reference field the following applies.
    – If the reference field has the same parity as the current field

    LongTermPicNum = 2 * LongTermFrameIdx + 1 (8-33)

    – Otherwise (the reference field has the opposite parity of the current field),

    LongTermPicNum = 2 * LongTermFrameIdx (8-34)

8.2.4.2 Initialisation process for reference picture lists

This initialisation process is invoked when decoding a P, SP, or B slice header.

RefPicList0 and RefPicList1 have initial entries as specified in subclauses 8.2.4.2.1 through 8.2.4.2.5.

When the number of entries in the initial RefPicList0 or RefPicList1 produced as specified in subclauses 8.2.4.2.1 through 8.2.4.2.5 is greater than num_ref_idx_l0_active_minus1 + 1 or num_ref_idx_l1_active_minus1 + 1, respectively, the extra entries past position num_ref_idx_l0_active_minus1 or num_ref_idx_l1_active_minus1 are discarded from the initial reference picture list.

When the number of entries in the initial RefPicList0 or RefPicList1 produced as specified in subclauses 8.2.4.2.1 through 8.2.4.2.5 is less than num_ref_idx_l0_active_minus1 + 1 or num_ref_idx_l1_active_minus1 + 1, respectively, the remaining entries in the initial reference picture list are set equal to "no reference picture".

8.2.4.2.1 Initialisation process for the reference picture list for P and SP slices in frames

This initialisation process is invoked when decoding a P or SP slice in a coded frame.

When this process is invoked, there shall be at least one reference frame or complementary reference field pair that is currently marked as "used for short-term reference" or "used for long-term reference".

The reference picture list RefPicList0 is ordered so that short-term reference frames and short-term complementary reference field pairs have lower indices than long-term reference frames and long-term complementary reference field pairs.

The short-term reference frames and complementary reference field pairs are ordered starting with the frame or complementary field pair with the highest PicNum value and proceeding through in descending order to the frame or complementary field pair with the lowest PicNum value.

The long-term reference frames and complementary reference field pairs are ordered starting with the frame or complementary field pair with the lowest LongTermPicNum value and proceeding through in ascending order to the frame or complementary field pair with the highest LongTermPicNum value.

NOTE – A non-paired reference field is not used for inter prediction for decoding a frame, regardless of the value of MbaffFrameFlag.

For example, when three reference frames are marked as "used for short-term reference" with PicNum equal to 300, 302, and 303 and two reference frames are marked as "used for long-term reference" with LongTermPicNum equal to 0 and 3, the initial index order is:

– RefPicList0[0] is set equal to the short-term reference picture with PicNum = 303,

– RefPicList0[1] is set equal to the short-term reference picture with PicNum = 302,

– RefPicList0[2] is set equal to the short-term reference picture with PicNum = 300,

– RefPicList0[3] is set equal to the long-term reference picture with LongTermPicNum = 0, and

– RefPicList0[4] is set equal to the long-term reference picture with LongTermPicNum = 3.

8.2.4.2.2 Initialisation process for the reference picture list for P and SP slices in fields

This initialisation process is invoked when decoding a P or SP slice in a coded field.

Each field included in the reference picture list RefPicList0 has a separate index in the reference picture list RefPicList0.

NOTE – When decoding a field, there are effectively at least twice as many pictures available for referencing as there would be when decoding a frame at the same position in decoding order.

Two ordered lists of reference frames, refFrameList0ShortTerm and refFrameList0LongTerm, are derived as follows. For purposes of the formation of this list of frames, decoded reference frames, complementary reference field pairs, non-paired reference fields and reference frames in which a single field is marked "used for short-term reference" or "used for long-term reference" are all considered reference frames.

– All frames having one or more fields marked "used for short-term reference" are included in the list of short-term reference frames refFrameList0ShortTerm. When the current field is the second field (in decoding order) of a complementary reference field pair and the first field is marked as "used for short-term reference", the first field is included in the list of short-term reference frames refFrameList0ShortTerm. refFrameList0ShortTerm is ordered starting with the reference frame with the highest FrameNumWrap value and proceeding through in descending order to the reference frame with the lowest FrameNumWrap value.

– All frames having one or more fields marked "used for long-term reference" are included in the list of long-term reference frames refFrameList0LongTerm. When the current field is the second field (in decoding order) of a complementary reference field pair and the first field is marked as "used for long-term reference, the first field is included in the list of long-term reference frames refFrameList0LongTerm. refFrameList0LongTerm is ordered starting with the reference frame with the lowest LongTermFrameIdx value and proceeding through in ascending order to the reference frame with the highest LongTermFrameIdx value.

The process specified in subclause 8.2.4.2.5 is invoked with refFrameList0ShortTerm and refFrameList0LongTerm given as input and the output is assigned to RefPicList0.

8.2.4.2.3 Initialisation process for reference picture lists for B slices in frames

This initialisation process is invoked when decoding a B slice in a coded frame.

For purposes of the formation of the reference picture lists RefPicList0 and RefPicList1 the term reference entry refers in the following to decoded reference frames or complementary reference field pairs.

When this process is invoked, there shall be at least one reference entry that is currently marked as "used for short-term reference" or "used for long-term reference".

For B slices, the order of short-term reference entries in the reference picture lists RefPicList0 and RefPicList1 depends on output order, as given by PicOrderCnt( ). When pic_order_cnt_type is equal to 0, reference pictures that are marked as "non-existing" as specified in subclause 8.2.5.2 are not included in either RefPicList0 or RefPicList1.

NOTE 1 – When gaps_in_frame_num_value_allowed_flag is equal to 1, encoders should use reference picture list reordering to ensure proper operation of the decoding process (particularly when pic_order_cnt_type is equal to 0, in which case PicOrderCnt( ) is not inferred for "non-existing" frames).

The reference picture list RefPicList0 is ordered such that short-term reference entries have lower indices than long-term reference entries. It is ordered as follows.

– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt(entryShortTerm) less than PicOrderCnt(CurrPic), these values of entryShortTerm are placed at the beginning of refPicList0 in descending order of PicOrderCnt(entryShortTerm). All of the remaining values of entryShortTerm (when present) are then appended to refPicList0 in ascending order of PicOrderCnt(entryShortTerm).

– The long-term reference entries are ordered starting with the long-term reference entry that has the lowest LongTermPicNum value and proceeding through in ascending order to the long-term reference entry that has the highest LongTermPicNum value.

The reference picture list RefPicList1 is ordered so that short-term reference entries have lower indices than long-term reference entries. It is ordered as follows.

– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt(entryShortTerm) greater than PicOrderCnt(CurrPic), these values of entryShortTerm are placed at the beginning of refPicList1 in ascending order of PicOrderCnt(entryShortTerm). All of the remaining values of entryShortTerm (when present) are then appended to refPicList1 in descending order of PicOrderCnt(entryShortTerm).

– Long-term reference entries are ordered starting with the long-term reference frame or complementary reference field pair that has the lowest LongTermPicNum value and proceeding through in ascending order to the long-term reference entry that has the highest LongTermPicNum value.

– When the reference picture list RefPicList1 has more than one entry and RefPicList1 is identical to the reference picture list RefPicList0, the first two entries RefPicList1[0] and RefPicList1[1] are switched.

NOTE 2 – A non-paired reference field is not used for inter prediction of frames (independent of the value of MbaffFrameFlag).

8.2.4.2.4 Initialisation process for reference picture lists for B slices in fields

This initialisation process is invoked when decoding a B slice in a coded field.

When decoding a field, each field of a stored reference frame is identified as a separate reference picture with a unique index. The order of short-term reference pictures in the reference picture lists RefPicList0 and RefPicList1 depend on output order, as given by PicOrderCnt( ). When pic_order_cnt_type is equal to 0, reference pictures that are marked as "non-existing" as specified in subclause 8.2.5.2 are not included in either RefPicList0 or RefPicList1.

NOTE 1 – When gaps_in_frame_num_value_allowed_flag is equal to 1, encoders should use reference picture list reordering to ensure proper operation of the decoding process (particularly when pic_order_cnt_type is equal to 0, in which case PicOrderCnt( ) is not inferred for "non-existing" frames).

NOTE 2 – When decoding a field, there are effectively at least twice as many pictures available for referencing as there would be when decoding a frame at the same position in decoding order.

Three ordered lists of reference frames, refFrameList0ShortTerm, refFrameList1ShortTerm and refFrameListLongTerm, are derived as follows. For purposes of the formation of these lists of frames the term reference entry refers in the following to decoded reference frames, complementary reference field pairs, or non-paired reference fields. When pic_order_cnt_type is equal to 0, the term reference entry does not refer to frames that are marked as "non-existing" as specified in subclause 8.2.5.2.

– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt(entryShortTerm) less than or equal to PicOrderCnt(CurrPic), these values of entryShortTerm are placed at the beginning of refFrameList0ShortTerm in descending order of PicOrderCnt(entryShortTerm). All of the remaining values of entryShortTerm (when present) are then appended to refFrameList0ShortTerm in ascending order of PicOrderCnt(entryShortTerm).

  NOTE 3 – When the current field follows in decoding order a coded field fldPrev with which together it forms a complementary reference field pair, fldPrev is included into the list refFrameList0ShortTerm using PicOrderCnt(fldPrev) and the ordering method described in the previous sentence is applied.

– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt(entryShortTerm) greater than PicOrderCnt(CurrPic), these values of entryShortTerm are placed at the beginning of refFrameList1ShortTerm in ascending order of PicOrderCnt(entryShortTerm). All of the remaining values of entryShortTerm (when present) are then appended to refFrameList1ShortTerm in descending order of PicOrderCnt(entryShortTerm).

  NOTE 4 – When the current field follows in decoding order a coded field fldPrev with which together it forms a complementary reference field pair, fldPrev is included into the list refFrameList1ShortTerm using PicOrderCnt(fldPrev) and the ordering method described in the previous sentence is applied.

– refFrameListLongTerm is ordered starting with the reference entry having the lowest LongTermFrameIdx value and proceeding through in ascending order to the reference entry having highest LongTermFrameIdx value.

  NOTE 5 – When the complementary field of the current picture is marked "used for long-term reference" it is included into the list refFrameListLongTerm. A reference entry in which only one field is marked as “used for long-term reference” is included into the list refFrameListLongTerm.

The process specified in subclause 8.2.4.2.5 is invoked with refFrameList0ShortTerm and refFrameListLongTerm given as input and the output is assigned to RefPicList0.

The process specified in subclause 8.2.4.2.5 is invoked with refFrameList1ShortTerm and refFrameListLongTerm given as input and the output is assigned to RefPicList1.

When the reference picture list RefPicList1 has more than one entry and RefPicList1 is identical to the reference picture list RefPicList0, the first two entries RefPicList1[0] and RefPicList1[1] are switched.

8.2.4.2.5 Initialisation process for reference picture lists in fields

Inputs of this process are the reference frame lists refFrameListXShortTerm (with X may be 0 or 1) and refFrameListLongTerm.

The reference picture list RefPicListX is a list ordered such that short-term reference fields have lower indices than long-term reference fields. Given the reference frame lists refFrameListXShortTerm and refFrameListLongTerm, it is derived as follows.

– Short-term reference fields are ordered by selecting reference fields from the ordered list of frames refFrameListXShortTerm by alternating between fields of differing parity, starting with a field that has the same parity as the current field (when present). When one field of a reference frame was not decoded or is not marked as “used for short-term reference”, the missing field is ignored and instead the next available stored reference field of the chosen parity from the ordered list of frames refFrameListXShortTerm is inserted into RefPicListX. When there are no more short-term reference fields of the alternate parity in the ordered list of frames refFrameListXShortTerm, the next not yet indexed fields of the available parity are inserted into RefPicListX in the order in which they occur in the ordered list of frames refFrameListXShortTerm.

– Long-term reference fields are ordered by selecting reference fields from the ordered list of frames refFrameListLongTerm by alternating between fields of differing parity, starting with a field that has the same parity as the current field (when present). When one field of a reference frame was not decoded or is not marked as “used for long-term reference”, the missing field is ignored and instead the next available stored reference field of the chosen parity from the ordered list of frames refFrameListLongTerm is inserted into RefPicListX. When there are no more long-term reference fields of the alternate parity in the ordered list of frames refFrameListLongTerm, the next not yet indexed fields of the available parity are inserted into RefPicListX in the order in which they occur in the ordered list of frames refFrameListLongTerm.

8.2.4.3 Reordering process for reference picture lists

When ref_pic_list_reordering_flag_l0 is equal to 1, the following applies.

– Let refIdxL0 be an index into the reference picture list RefPicList0. It is initially set equal to 0.

– The corresponding syntax elements reordering_of_pic_nums_idc are processed in the order they occur in the bitstream. For each of these syntax elements, the following applies.

– If reordering_of_pic_nums_idc is equal to 0 or equal to 1, the process specified in subclause 8.2.4.3.1 is invoked with refIdxL0 as input, and the output is assigned to refIdxL0.

– Otherwise, if reordering_of_pic_nums_idc is equal to 2, the process specified in subclause 8.2.4.3.2 is invoked with refIdxL0 as input, and the output is assigned to refIdxL0.

– Otherwise (reordering_of_pic_nums_idc is equal to 3), the reordering process for reference picture list RefPicList0 is finished.

When ref_pic_list_reordering_flag_l1 is equal to 1, the following applies.

– Let refIdxL1 be an index into the reference picture list RefPicList1. It is initially set equal to 0.

– The corresponding syntax elements reordering_of_pic_nums_idc are processed in the order they occur in the bitstream. For each of these syntax elements, the following applies.

  – If reordering_of_pic_nums_idc is equal to 0 or equal to 1, the process specified in subclause 8.2.4.3.1 is invoked with refIdxL1 as input, and the output is assigned to refIdxL1.

  – Otherwise, if reordering_of_pic_nums_idc is equal to 2, the process specified in subclause 8.2.4.3.2 is invoked with refIdxL1 as input, and the output is assigned to refIdxL1.

  – Otherwise (reordering_of_pic_nums_idc is equal to 3), the reordering process for reference picture list RefPicList1 is finished.

8.2.4.3.1 Reordering process of reference picture lists for short-term reference pictures

Input to this process is an index refIdxLX (with X being 0 or 1).

Output of this process is an incremented index refIdxLX.

The variable picNumLXNoWrap is derived as follows.

– If reordering_of_pic_nums_idc is equal to 0

```
if( picNumLXPred – ( abs_diff_pic_num_minus1 + 1 ) < 0 )
      picNumLXNoWrap = picNumLXPred – ( abs_diff_pic_num_minus1 + 1 ) + MaxPicNum        (8-35)
else
      picNumLXNoWrap = picNumLXPred – ( abs_diff_pic_num_minus1 + 1 )
```

– Otherwise (reordering_of_pic_nums_idc is equal to 1),

```
if( picNumLXPred + ( abs_diff_pic_num_minus1 + 1 )  >=  MaxPicNum )
      picNumLXNoWrap = picNumLXPred + ( abs_diff_pic_num_minus1 + 1 ) – MaxPicNum        (8-36)
else
      picNumLXNoWrap = picNumLXPred + ( abs_diff_pic_num_minus1 + 1 )
```

picNumLXPred is the prediction value for the variable picNumLXNoWrap. When the process specified in this subclause is invoked the first time for a slice (that is, for the first occurrence of reordering_of_pic_nums_idc equal to 0 or 1 in the ref_pic_list_reordering( ) syntax), picNumL0Pred and picNumL1Pred are initially set equal to CurrPicNum. After each assignment of picNumLXNoWrap, the value of picNumLXNoWrap is assigned to picNumLXPred.

The variable picNumLX is derived as follows

```
if( picNumLXNoWrap > CurrPicNum )
      picNumLX = picNumLXNoWrap – MaxPicNum                                             (8-37)
else
      picNumLX = picNumLXNoWrap
```

picNumLX shall be equal to the PicNum of a reference picture that is marked as “used for short-term reference” and shall not be equal to the PicNum of a short-term reference picture that is marked as "non-existing".

The following procedure is conducted to place the picture with short-term picture number picNumLX into the index position refIdxLX, shift the position of any other remaining pictures to later in the list, and increment the value of refIdxLX.

```
for( cIdx = num_ref_idx_lX_active_minus1 + 1; cIdx > refIdxLX; cIdx-- )
    RefPicListX[ cIdx ] = RefPicListX[ cIdx – 1]
RefPicListX[ refIdxLX++ ] = short-term reference picture with PicNum equal to picNumLX
nIdx = refIdxLX
for( cIdx = refIdxLX; cIdx <= num_ref_idx_lX_active_minus1 + 1; cIdx++ )                    (8-38)
    if( PicNumF( RefPicListX[ cIdx ] ) != picNumLX )
        RefPicListX[ nIdx++ ] = RefPicListX[ cIdx ]
```

where the function PicNumF(RefPicListX[cIdx]) is derived as follows:

– If the picture RefPicListX[cIdx] is marked as "used for short-term reference", PicNumF(RefPicListX[cIdx]) is the PicNum of the picture RefPicListX[cIdx].

– Otherwise (the picture RefPicListX[cIdx] is not marked as "used for short-term reference"), PicNumF(RefPicListX[cIdx]) is equal to MaxPicNum.

NOTE 1 – A value of MaxPicNum can never be equal to picNumLX.

NOTE 2 – Within this pseudo-code procedure, the length of the list RefPicListX is temporarily made one element longer than the length needed for the final list. After the execution of this procedure, only elements 0 through num_ref_idx_lX_active_minus1 of the list need to be retained.

8.2.4.3.2 Reordering process of reference picture lists for long-term reference pictures

Input to this process is an index refIdxLX (with X being 0 or 1).

Output of this process is an incremented index refIdxLX.

The following procedure is conducted to place the picture with long-term picture number long_term_pic_num into the index position refIdxLX, shift the position of any other remaining pictures to later in the list, and increment the value of refIdxLX.

```
for( cIdx = num_ref_idx_lX_active_minus1 + 1; cIdx > refIdxLX; cIdx-- )
    RefPicListX[ cIdx ] = RefPicListX[ cIdx – 1]
RefPicListX[ refIdxLX++ ] = long-term reference picture with LongTermPicNum equal to long_term_pic_num
nIdx = refIdxLX
for( cIdx = refIdxLX; cIdx <= num_ref_idx_lX_active_minus1 + 1; cIdx++ )                    (8-39)
    if( LongTermPicNumF( RefPicListX[ cIdx ] ) != long_term_pic_num )
        RefPicListX[ nIdx++ ] = RefPicListX[ cIdx ]
```

where the function LongTermPicNumF(RefPicListX[cIdx]) is derived as follows:

– If the picture RefPicListX[cIdx] is marked as "used for long-term reference", LongTermPicNumF(RefPicListX[cIdx]) is the LongTermPicNum of the picture RefPicListX[cIdx].

– Otherwise (the picture RefPicListX[cIdx] is not marked as "used for long-term reference"), LongTermPicNumF(RefPicListX[cIdx]) is equal to 2 * (MaxLongTermFrameIdx + 1).

NOTE 1 – A value of 2 * (MaxLongTermFrameIdx + 1) can never be equal to long_term_pic_num.

NOTE 2 – Within this pseudo-code procedure, the length of the list RefPicListX is temporarily made one element longer than the length needed for the final list. After the execution of this procedure, only elements 0 through num_ref_idx_lX_active_minus1 of the list need to be retained.

8.2.5 Decoded reference picture marking process

This process is invoked for decoded pictures when nal_ref_idc is not equal to 0.

NOTE – The decoding process for gaps in frame_num that is specified in subclause 8.2.5.2 may also be invoked when nal_ref_idc is equal to 0, as specified in clause 8.

A decoded picture with nal_ref_idc not equal to 0, referred to as a reference picture, is marked as “used for short-term reference” or "used for long-term reference". For a decoded reference frame, both of its fields are marked the same as the frame. For a complementary reference field pair, the pair is marked the same as both of its fields. A picture that is marked as "used for short-term reference" is identified by its FrameNum and, when it is a field, by its parity. A picture that is marked as "used for long-term reference" is identified by its LongTermFrameIdx and, when it is a field, by its parity.

Frames or complementary field pairs marked as “used for short-term reference” or as "used for long-term reference" can be used as a reference for inter prediction when decoding a frame until the frame, the complementary field pair, or one of its constituent fields is marked as “unused for reference”. A field marked as “used for short-term reference” or as

"used for long-term reference" can be used as a reference for inter prediction when decoding a field until marked as “unused for reference”.

A picture can be marked as "unused for reference" by the sliding window reference picture marking process, a first-in, first-out mechanism specified in subclause 8.2.5.3 or by the adaptive memory control reference picture marking process, a customised adaptive marking operation specified in subclause 8.2.5.4.

A short-term reference picture is identified for use in the decoding process by its variables FrameNum and FrameNumWrap and its picture number PicNum, and a long-term reference picture is identified for use in the decoding process by its long-term picture number LongTermPicNum. When the current picture is not an IDR picture, subclause 8.2.4.1 is invoked to specify the assignment of the variables FrameNum, FrameNumWrap, PicNum and LongTermPicNum.

8.2.5.1 Sequence of operations for decoded reference picture marking process

Decoded reference picture marking proceeds in the following ordered steps.

1. All slices of the current picture are decoded.
2. Depending on whether the current picture is an IDR picture, the following applies.
   - If the current picture is an IDR picture, the following applies.
     - All reference pictures are marked as "unused for reference".
     - Depending on long_term_reference_flag, the following applies.
       - If long_term_reference_flag is equal to 0, the IDR picture is marked as "used for short-term reference" and MaxLongTermFrameIdx is set equal to “no long-term frame indices”.
       - Otherwise (long_term_reference_flag is equal to 1), the IDR picture is marked as "used for long-term reference", the LongTermFrameIdx for the IDR picture is set equal to 0, and MaxLongTermFrameIdx is set equal to 0.
   - Otherwise (the current picture is not an IDR picture), the following applies.
     - If adaptive_ref_pic_marking_mode_flag is equal to 0, the process specified in subclause 8.2.5.3 is invoked.
     - Otherwise (adaptive_ref_pic_marking_mode_flag is equal to 1), the process specified in subclause 8.2.5.4 is invoked.
3. When the current picture is not an IDR picture and it was not marked as "used for long-term reference" by memory_management_control_operation equal to 6, it is marked as "used for short-term reference".

After marking the current decoded reference picture, the total number of frames with at least one field marked as “used for reference”, plus the number of complementary field pairs with at least one field marked as “used for reference”, plus the number of non-paired fields marked as “used for reference” shall not be greater than Max(num_ref_frames, 1).

8.2.5.2 Decoding process for gaps in frame_num

This process is invoked when frame_num is not equal to PrevRefFrameNum and is not equal to (PrevRefFrameNum + 1) % MaxFrameNum.

NOTE 1 – Although this process is specified as a subclause within subclause 8.2.5 (which defines a process that is invoked only when nal_ref_idc is not equal to 0), this process may also be invoked when nal_ref_idc is equal to 0 (as specified in clause 8). The reasons for the location of this subclause within the structure of this Recommendation | International Standard are historical.

NOTE 2 – This process can only be invoked for a conforming bitstream when gaps_in_frame_num_value_allowed_flag is equal to 1. When gaps_in_frame_num_value_allowed_flag is equal to 0 and frame_num is not equal to PrevRefFrameNum and is not equal to (PrevRefFrameNum + 1) % MaxFrameNum, the decoding process should infer an unintentional loss of pictures.

When this process is invoked, a set of values of frame_num pertaining to “non-existing” pictures is derived as all values taken on by UnusedShortTermFrameNum in Equation 7-22 except the value of frame_num for the current picture.

The decoding process generates and marks a frame for each of the values of frame_num pertaining to “non-existing” pictures, in the order in which the values of UnusedShortTermFrameNum are generated by Equation 7-22, using the “sliding window” picture marking process as specified in subclause 8.2.5.3. The generated frames are also marked as “non-existing” and “used for short-term reference”. The sample values of the generated frames may be set to any value. The bitstream shall not contain data that results in a reference to these generated frames which are marked as “non-existing” in the inter prediction process, a reference to these frames in the reordering commands for reference picture lists for short-term reference pictures (subclause 8.2.4.3.1), or a reference to these frames in the assignment process of a LongTermFrameIdx to a short-term reference picture (subclause 8.2.5.4.3).

When pic_order_cnt_type is not equal to 0, TopFieldOrderCnt and BottomFieldOrderCnt are derived for each of the "non-existing" frames by invoking the decoding process for picture order count in subclause 8.2.1. When invoking the process in subclause 8.2.1 for a particular "non-existing" frame, the current picture is considered to be a picture considered having frame_num inferred to be equal to UnusedShortTermFrameNum, nal_ref_idc inferred to be not equal to 0, nal_unit_type inferred to be not equal to 5, IdrPicFlag inferred to be equal to 0, field_pic_flag inferred to be equal to 0, adaptive_ref_pic_marking_mode_flag inferred to be equal to 0, delta_pic_order_cnt[0] (if needed) inferred to be equal to 0, and delta_pic_order_cnt[1] (if needed) inferred to be equal to 0.

NOTE 3 – The decoding process should infer an unintentional picture loss when any of these values of frame_num pertaining to "non-existing" pictures is referred to in the inter prediction process, is referred to in the reordering commands for reference picture lists for short-term reference pictures (subclause 8.2.4.3.1), or is referred to in the assignment process of a LongTermFrameIdx to a short-term reference picture (subclause 8.2.5.4.3). The decoding process should not infer an unintentional picture loss when a memory management control operation not equal to 3 is applied to a frame marked as "non-existing".

8.2.5.3 Sliding window decoded reference picture marking process

This process is invoked when adaptive_ref_pic_marking_mode_flag is equal to 0.

Depending on the properties of the current picture as specified below, the following applies.

– If the current picture is a coded field that is the second field in decoding order of a complementary reference field pair, and the first field has been marked as "used for short-term reference", the current picture is also marked as "used for short-term reference".

– Otherwise, the following applies.

  – Let numShortTerm be the total number of reference frames, complementary reference field pairs and non-paired reference fields for which at least one field is marked as "used for short-term reference". Let numLongTerm be the total number of reference frames, complementary reference field pairs and non-paired reference fields for which at least one field is marked as "used for long-term reference".

  – When numShortTerm + numLongTerm is equal to Max(num_ref_frames, 1), the condition that numShortTerm is greater than 0 shall be fulfilled, and the short-term reference frame, complementary reference field pair or non-paired reference field that has the smallest value of FrameNumWrap is marked as "unused for reference". When it is a frame or a complementary field pair, both of its fields are also marked as "unused for reference".

8.2.5.4 Adaptive memory control decoded reference picture marking process

This process is invoked when adaptive_ref_pic_marking_mode_flag is equal to 1.

The memory_management_control_operation commands with values of 1 to 6 are processed in the order they occur in the bitstream after the current picture has been decoded. For each of these memory_management_control_operation commands, one of the processes specified in subclauses 8.2.5.4.1 to 8.2.5.4.5 is invoked depending on the value of memory_management_control_operation. The memory_management_control_operation command with value of 0 specifies the end of memory_management_control_operation commands.

Memory management control operations are applied to pictures as follows.

– If field_pic_flag is equal to 0, memory_management_control_operation commands are applied to the frames or complementary reference field pairs specified.

– Otherwise (field_pic_flag is equal to 1), memory_management_control_operation commands are applied to the individual reference fields specified.

8.2.5.4.1 Marking process of a short-term reference picture as "unused for reference"

This process is invoked when memory_management_control_operation is equal to 1.

Let picNumX be specified by

$$picNumX = CurrPicNum - (difference\_of\_pic\_nums\_minus1 + 1). \quad (8\text{-}40)$$

Depending on field_pic_flag the value of picNumX is used to mark a short-term reference picture as "unused for reference" as follows.

– If field_pic_flag is equal to 0, the short-term reference frame or short-term complementary reference field pair specified by picNumX and both of its fields are marked as "unused for reference".

– Otherwise (field_pic_flag is equal to 1), the short-term reference field specified by picNumX is marked as "unused for reference". When that reference field is part of a reference frame or a complementary reference field pair, the

frame or complementary field pair is also marked as "unused for reference", but the marking of the other field is not changed.

8.2.5.4.2 Marking process of a long-term reference picture as “unused for reference”

This process is invoked when memory_management_control_operation is equal to 2.

Depending on field_pic_flag the value of LongTermPicNum is used to mark a long-term reference picture as “unused for reference” as follows.

– If field_pic_flag is equal to 0, the long-term reference frame or long-term complementary reference field pair having LongTermPicNum equal to long_term_pic_num and both of its fields are marked as “unused for reference”.

– Otherwise (field_pic_flag is equal to 1), the long-term reference field specified by LongTermPicNum equal to long_term_pic_num is marked as “unused for reference”. When that reference field is part of a reference frame or a complementary reference field pair, the frame or complementary field pair is also marked as "unused for reference", but the marking of the other field is not changed.

8.2.5.4.3 Assignment process of a LongTermFrameIdx to a short-term reference picture

This process is invoked when memory_management_control_operation is equal to 3.

Given the syntax element difference_of_pic_nums_minus1, the variable picNumX is obtained as specified in subclause 8.2.5.4.1. picNumX shall refer to a frame or complementary reference field pair or non-paired reference field marked as "used for short-term reference" and not marked as "non-existing".

When LongTermFrameIdx equal to long_term_frame_idx is already assigned to a long-term reference frame or a long-term complementary reference field pair, that frame or complementary field pair and both of its fields are marked as "unused for reference". When LongTermFrameIdx is already assigned to a non-paired reference field, and the field is not the complementary field of the picture specified by picNumX, that field is marked as “unused for reference”.

Depending on field_pic_flag the value of LongTermFrameIdx is used to mark a picture from "used for short-term reference" to "used for long-term reference" as follows.

– If field_pic_flag is equal to 0, the marking of the short-term reference frame or short-term complementary reference field pair specified by picNumX and both of its fields are changed from "used for short-term reference" to "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

– Otherwise (field_pic_flag is equal to 1), the marking of the short-term reference field specified by picNumX is changed from "used for short-term reference" to "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx. When the field is part of a reference frame or a complementary reference field pair, and the other field of the same reference frame or complementary reference field pair is also marked as "used for long-term reference", the reference frame or complementary reference field pair is also marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

8.2.5.4.4 Decoding process for MaxLongTermFrameIdx

This process is invoked when memory_management_control_operation is equal to 4.

All pictures for which LongTermFrameIdx is greater than max_long_term_frame_idx_plus1 – 1 and that are marked as "used for long-term reference" are marked as “unused for reference”.

The variable MaxLongTermFrameIdx is derived as follows.

– If max_long_term_frame_idx_plus1 is equal to 0, MaxLongTermFrameIdx is set equal to “no long-term frame indices”.

– Otherwise (max_long_term_frame_idx_plus1 is greater than 0), MaxLongTermFrameIdx is set equal to max_long_term_frame_idx_plus1 – 1.

NOTE – The memory_management_control_operation command equal to 4 can be used to mark long-term reference pictures as “unused for reference”. The frequency of transmitting max_long_term_frame_idx_plus1 is not specified by this Recommendation | International Standard. However, the encoder should send a memory_management_control_operation command equal to 4 upon receiving an error message, such as an intra refresh request message.

8.2.5.4.4.1 Marking process of all reference pictures as “unused for reference” and setting MaxLongTermFrameIdx to “no long-term frame indices”

This process is invoked when memory_management_control_operation is equal to 5.

All reference pictures are marked as “unused for reference” and the variable MaxLongTermFrameIdx is set equal to “no long-term frame indices”.

8.2.5.4.5 Process for assigning a long-term frame index to the current picture

This process is invoked when memory_management_control_operation is equal to 6.

When a variable LongTermFrameIdx equal to long_term_frame_idx is already assigned to a long-term reference frame or a long-term complementary reference field pair, that frame or complementary field pair and both of its fields are marked as "unused for reference". When LongTermFrameIdx is already assigned to a non-paired reference field, and the field is not the complementary field of the current picture, that field is marked as “unused for reference”.

The current picture is marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

When field_pic_flag is equal to 0, both its fields are also marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

When field_pic_flag is equal to 1 and the current picture is the second field (in decoding order) of a complementary reference field pair, and the first field of the complementary reference field pair is also currently marked as "used for long-term reference), the complementary reference field pair is also marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

After marking the current decoded reference picture, the total number of frames with at least one field marked as “used for reference”, plus the number of complementary field pairs with at least one field marked as “used for reference”, plus the number of non-paired fields marked as “used for reference” shall not be greater than Max(num_ref_frames, 1).

NOTE – Under some circumstances, the above statement may impose a constraint on the order in which a memory_management_control_operation syntax element equal to 6 can appear in the decoded reference picture marking syntax relative to a memory_management_control_operation syntax element equal to 1, 2, or 4.

8.3 Intra prediction process

This process is invoked for I and SI macroblock types.

Inputs to this process are constructed samples prior to the deblocking filter process and, for Intra_NxN prediction modes (where NxN is equal to 4x4 or 8x8), the values of IntraNxNPredMode from neighbouring macroblocks.

Outputs of this process are specified as follows.

– If the macroblock prediction mode is Intra_4x4 or Intra_8x8, the outputs are constructed luma samples prior to the deblocking filter process and (when ChromaArrayType is not equal to 0) chroma prediction samples of the macroblock $pred_C$, where C is equal to Cb and Cr.

– Otherwise, if mb_type is not equal to I_PCM, the outputs are luma prediction samples of the macroblock $pred_L$ and (when ChromaArrayType is not equal to 0) chroma prediction samples of the macroblock $pred_C$, where C is equal to Cb and Cr.

– Otherwise (mb_type is equal to I_PCM), the outputs are constructed luma and (when ChromaArrayType is not equal to 0) chroma samples prior to the deblocking filter process.

The variable MvCnt is set equal to 0.

Depending on the value of mb_type the following applies.

– If mb_type is equal to I_PCM, the sample construction process for I_PCM macroblocks as specified in subclause 8.3.5 is invoked.

– Otherwise (mb_type is not equal to I_PCM), the following applies.

  – The decoding processes for Intra prediction modes are described for the luma component as follows.

    – If the macroblock prediction mode is equal to Intra_4x4, the Intra_4x4 prediction process for luma samples as specified in subclause 8.3.1 is invoked.

    – Otherwise, if the macroblock prediction mode is equal to Intra_8x8, the Intra_8x8 prediction process as specified in subclause 8.3.2 is invoked.

    – Otherwise (the macroblock prediction mode is equal to Intra_16x16), the Intra_16x16 prediction process as specified in subclause 8.3.3 is invoked with S'_L as the input and the outputs are luma prediction samples of the macroblock $pred_L$.

– When ChromaArrayType is not equal to 0, the Intra prediction process for chroma samples as specified in subclause 8.3.4 is invoked with S'_{Cb}, and S'_{Cr} as the inputs and the outputs are chroma prediction samples of the macroblock $pred_{Cb}$ and $pred_{Cr}$.

Samples used in the Intra prediction process are the sample values prior to alteration by any deblocking filter operation.

8.3.1 Intra_4x4 prediction process for luma samples

This process is invoked when the macroblock prediction mode is equal to Intra_4x4.

Inputs to this process are the values of Intra4x4PredMode (if available) or Intra8x8PredMode (if available) from neighbouring macroblocks or macroblock pairs.

The luma component of a macroblock consists of 16 blocks of 4x4 luma samples. These blocks are inverse scanned using the 4x4 luma block inverse scanning process as specified in subclause 6.4.3.

For all 4x4 luma blocks of the luma component of a macroblock with luma4x4BlkIdx = 0..15, the derivation process for the Intra4x4PredMode as specified in subclause 8.3.1.1 is invoked with luma4x4BlkIdx as well as Intra4x4PredMode and Intra8x8PredMode that are previously (in decoding order) derived for adjacent macroblocks as the input and the variable Intra4x4PredMode[luma4x4BlkIdx] as the output.

For each luma block of 4x4 samples indexed using luma4x4BlkIdx = 0..15,

1. The Intra_4x4 sample prediction process in subclause 8.3.1.2 is invoked with luma4x4BlkIdx and the array S'_L containing constructed luma samples prior to the deblocking filter process from adjacent luma blocks as the inputs and the outputs are the Intra_4x4 luma prediction samples $pred4x4_L[x, y]$ with x, y = 0..3.

2. The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the current macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (xO, yO) and x, y = 0..3.

$$pred_L[xO + x, yO + y] = pred4x4_L[x, y] \quad (8\text{-}41)$$

3. The transform coefficient decoding process and picture construction process prior to deblocking filter process in subclause 8.5 is invoked with $pred_L$ and luma4x4BlkIdx as the input and the constructed samples for the current 4x4 luma block S'_L as the output.

8.3.1.1 Derivation process for the Intra4x4PredMode

Inputs to this process are the index of the 4x4 luma block luma4x4BlkIdx and variable arrays Intra4x4PredMode (if available) and Intra8x8PredMode (if available) that are previously (in decoding order) derived for adjacent macroblocks.

Output of this process is the variable Intra4x4PredMode[luma4x4BlkIdx].

Table 8-2 specifies the values for Intra4x4PredMode[luma4x4BlkIdx] and the associated names.

Table 8-2 – Specification of Intra4x4PredMode[luma4x4BlkIdx] and associated names

Intra4x4PredMode[luma4x4BlkIdx]	Name of Intra4x4PredMode[luma4x4BlkIdx]
0	Intra_4x4_Vertical (prediction mode)
1	Intra_4x4_Horizontal (prediction mode)
2	Intra_4x4_DC (prediction mode)
3	Intra_4x4_Diagonal_Down_Left (prediction mode)
4	Intra_4x4_Diagonal_Down_Right (prediction mode)
5	Intra_4x4_Vertical_Right (prediction mode)
6	Intra_4x4_Horizontal_Down (prediction mode)
7	Intra_4x4_Vertical_Left (prediction mode)
8	Intra_4x4_Horizontal_Up (prediction mode)

Intra4x4PredMode[luma4x4BlkIdx] labelled 0, 1, 3, 4, 5, 6, 7, and 8 represent directions of predictions as illustrated in Figure 8-1.

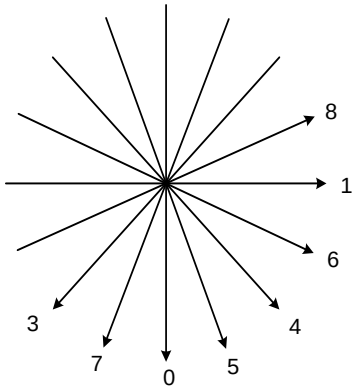


Figure 8-1 – Intra_4x4 prediction mode directions (informative)

Intra4x4PredMode[luma4x4BlkIdx] is derived as follows.

- The process specified in subclause 6.4.10.4 is invoked with luma4x4BlkIdx given as input and the output is assigned to mbAddrA, luma4x4BlkIdxA, mbAddrB, and luma4x4BlkIdxB.
- The variable dcPredModePredictedFlag is derived as follows.
  - If any of the following conditions are true, dcPredModePredictedFlag is set equal to 1
    - the macroblock with address mbAddrA is not available
    - the macroblock with address mbAddrB is not available
    - the macroblock with address mbAddrA is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1
    - the macroblock with address mbAddrB is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1
  - Otherwise, dcPredModePredictedFlag is set equal to 0.
- For N being either replaced by A or B, the variables intraMxMPredModeN are derived as follows.
  - If dcPredModePredictedFlag is equal to 1 or the macroblock with address mbAddrN is not coded in Intra_4x4 or Intra_8x8 macroblock prediction mode, intraMxMPredModeN is set equal to 2 (Intra_4x4_DC prediction mode).
  - Otherwise (dcPredModePredictedFlag is equal to 0 and (the macroblock with address mbAddrN is coded in Intra_4x4 macroblock prediction mode or the macroblock with address mbAddrN is coded in Intra_8x8 macroblock prediction mode)), the following applies.
    - If the macroblock with address mbAddrN is coded in Intra_4x4 macroblock mode, intraMxMPredModeN is set equal to Intra4x4PredMode[luma4x4BlkIdxN], where Intra4x4PredMode is the variable array assigned to the macroblock mbAddrN.
    - Otherwise (the macroblock with address mbAddrN is coded in Intra_8x8 macroblock mode), intraMxMPredModeN is set equal to Intra8x8PredMode[luma4x4BlkIdxN >> 2], where Intra8x8PredMode is the variable array assigned to the macroblock mbAddrN.

– Intra4x4PredMode[luma4x4BlkIdx] is derived by applying the following procedure.

```
predIntra4x4PredMode = Min( intraMxMPredModeA, intraMxMPredModeB )
if( prev_intra4x4_pred_mode_flag[ luma4x4BlkIdx ] )
    Intra4x4PredMode[ luma4x4BlkIdx ] = predIntra4x4PredMode
else                                                                    (8-42)
    if( rem_intra4x4_pred_mode[ luma4x4BlkIdx ] < predIntra4x4PredMode )
        Intra4x4PredMode[ luma4x4BlkIdx ] = rem_intra4x4_pred_mode[ luma4x4BlkIdx ]
    else
        Intra4x4PredMode[ luma4x4BlkIdx ] = rem_intra4x4_pred_mode[ luma4x4BlkIdx ] + 1
```

8.3.1.2 Intra_4x4 sample prediction

This process is invoked for each 4x4 luma block of a macroblock with prediction mode equal to Intra_4x4 followed by the transform decoding process and picture construction process prior to deblocking for each 4x4 luma block.

Inputs to this process are

– the index of a 4x4 luma block luma4x4BlkIdx,

– an ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array cS_L containing constructed luma samples prior to the deblocking filter process of neighbouring macroblocks.

Output of this process are the prediction samples $pred4x4_L$[x, y], with x, y = 0..3 for the 4x4 luma block with index luma4x4BlkIdx.

The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the current macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (xO, yO).

The 13 neighbouring samples p[x, y] that are constructed luma samples prior to the deblocking filter process, with x = -1, y = -1..3 and x = 0..7, y = -1, are derived as follows.

– The luma location (xN, yN) is specified by

$$xN = xO + x \tag{8-43}$$

$$yN = yO + y \tag{8-44}$$

– The derivation process for neighbouring locations in subclause 6.4.11 is invoked for luma locations with (xN, yN) as input and mbAddrN and (xW, yW) as output.

– Each sample p[x, y] with x = -1, y = -1..3 and x = 0..7, y = -1 is derived as follows.

  – If any of the following conditions is true, the sample p[x, y] is marked as “not available for Intra_4x4 prediction”

    – mbAddrN is not available,

    – the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1,

    – the macroblock mbAddrN has mb_type equal to SI and constrained_intra_pred_flag is equal to 1 and the current macroblock does not have mb_type equal to SI,

    – x is greater than 3 and luma4x4BlkIdx is equal to 3 or 11.

  – Otherwise, the sample p[x, y] is marked as “available for Intra_4x4 prediction” and the value of the sample p[x, y] is derived as follows.

    – The location of the upper-left luma sample of the macroblock mbAddrN is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddrN as the input and the output is assigned to (xM, yM).

    – Depending on the variable MbaffFrameFlag and the macroblock mbAddrN, the sample value p[x, y] is derived as follows.

– If MbaffFrameFlag is equal to 1 and the macroblock mbAddrN is a field macroblock,

$$p[x, y] = cS_L[xM + xW, yM + 2 * yW] \quad (8\text{-}45)$$

– Otherwise (MbaffFrameFlag is equal to 0 or the macroblock mbAddrN is a frame macroblock),

$$p[x, y] = cS_L[xM + xW, yM + yW] \quad (8\text{-}46)$$

When samples p[x, -1], with x = 4..7 are marked as "not available for Intra_4x4 prediction," and the sample p[3, -1] is marked as "available for Intra_4x4 prediction," the sample value of p[3, -1] is substituted for sample values p[x, -1], with x = 4..7 and samples p[x, -1], with x = 4..7 are marked as "available for Intra_4x4 prediction".

NOTE – Each block is assumed to be constructed into a picture array prior to decoding of the next block.

Depending on Intra4x4PredMode[luma4x4BlkIdx], one of the Intra_4x4 prediction modes specified in subclauses 8.3.1.2.1 to 8.3.1.2.9 is invoked.

8.3.1.2.1 Specification of Intra_4x4_Vertical prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 0.

This mode shall be used only when the samples p[x, -1] with x = 0..3 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived by

$$pred4x4_L[x, y] = p[x, -1], \text{ with } x, y = 0..3 \quad (8\text{-}47)$$

8.3.1.2.2 Specification of Intra_4x4_Horizontal prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 1.

This mode shall be used only when the samples p[-1, y], with y = 0..3 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived by

$$pred4x4_L[x, y] = p[-1, y], \text{ with } x,y = 0..3 \quad (8\text{-}48)$$

8.3.1.2.3 Specification of Intra_4x4_DC prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 2.

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If all samples p[x, -1], with x = 0..3 and p[-1, y], with y = 0..3 are marked as "available for Intra_4x4 prediction", the values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived by

$$pred4x4_L[x, y] = (p[0, -1] + p[1, -1] + p[2, -1] + p[3, -1] + p[-1, 0] + p[-1, 1] + p[-1, 2] + p[-1, 3] + 4) >> 3 \quad (8\text{-}49)$$

– Otherwise, if any samples p[x, -1], with x = 0..3 are marked as "not available for Intra_4x4 prediction" and all samples p[-1, y], with y = 0..3 are marked as "available for Intra_4x4 prediction", the values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived by

$$pred4x4_L[x, y] = (p[-1, 0] + p[-1, 1] + p[-1, 2] + p[-1, 3] + 2) >> 2 \quad (8\text{-}50)$$

– Otherwise, if any samples p[-1, y], with y = 0..3 are marked as "not available for Intra_4x4 prediction" and all samples p[x, -1], with x = 0 .. 3 are marked as "available for Intra_4x4 prediction", the values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0 .. 3 are derived by

$$pred4x4_L[x, y] = (p[0, -1] + p[1, -1] + p[2, -1] + p[3, -1] + 2) >> 2 \quad (8\text{-}51)$$

– Otherwise (some samples p[x, -1], with x = 0..3 and some samples p[-1, y], with y = 0..3 are marked as "not available for Intra_4x4 prediction"), the values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived by

$$pred4x4_L[x, y] = (1 << (BitDepth_Y - 1)) \quad (8\text{-}52)$$

NOTE – A 4x4 luma block can always be predicted using this mode.

8.3.1.2.4 Specification of Intra_4x4_Diagonal_Down_Left prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 3.

This mode shall be used only when the samples p[x, -1] with x = 0..7 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If x is equal to 3 and y is equal to 3,

$$pred4x4_L[x, y] = (p[6, -1] + 3 * p[7, -1] + 2) >> 2 \quad (8\text{-}53)$$

– Otherwise (x is not equal to 3 or y is not equal to 3),

$$pred4x4_L[x, y] = (p[x + y, -1] + 2 * p[x + y + 1, -1] + p[x + y + 2, -1] + 2) >> 2 \quad (8\text{-}54)$$

8.3.1.2.5 Specification of Intra_4x4_Diagonal_Down_Right prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 4.

This mode shall be used only when the samples p[x, -1] with x = 0..3 and p[-1, y] with y = -1..3 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If x is greater than y,

$$pred4x4_L[x, y] = (p[x - y - 2, -1] + 2 * p[x - y - 1, -1] + p[x - y, -1] + 2) >> 2 \quad (8\text{-}55)$$

– Otherwise, if x is less than y,

$$pred4x4_L[x, y] = (p[-1, y - x - 2] + 2 * p[-1, y - x - 1] + p[-1, y - x] + 2) >> 2 \quad (8\text{-}56)$$

– Otherwise (x is equal to y),

$$pred4x4_L[x, y] = (p[0, -1] + 2 * p[-1, -1] + p[-1, 0] + 2) >> 2 \quad (8\text{-}57)$$

8.3.1.2.6 Specification of Intra_4x4_Vertical_Right prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 5.

This mode shall be used only when the samples p[x, -1] with x = 0..3 and p[-1, y] with y = -1..3 are marked as "available for Intra_4x4 prediction".

Let the variable zVR be set equal to 2 * x – y.

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If zVR is equal to 0, 2, 4, or 6,

$$pred4x4_L[x, y] = (p[x - (y >> 1) - 1, -1] + p[x - (y >> 1), -1] + 1) >> 1 \quad (8\text{-}58)$$

– Otherwise, if zVR is equal to 1, 3, or 5,

$$pred4x4_L[x, y] = (p[x - (y >> 1) - 2, -1] + 2 * p[x - (y >> 1) - 1, -1] + p[x - (y >> 1), -1] + 2) >> 2 \quad (8\text{-}59)$$

– Otherwise, if zVR is equal to -1,

$$pred4x4_L[x, y] = (p[-1, 0] + 2 * p[-1, -1] + p[0, -1] + 2) >> 2 \quad (8\text{-}60)$$

– Otherwise (zVR is equal to -2 or -3),

$$pred4x4_L[x, y] = (p[-1, y - 1] + 2 * p[-1, y - 2] + p[-1, y - 3] + 2) >> 2 \quad (8\text{-}61)$$

8.3.1.2.7 Specification of Intra_4x4_Horizontal_Down prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 6.

This mode shall be used only when the samples p[x, -1] with x = 0..3 and p[-1, y] with y = -1..3 are marked as "available for Intra_4x4 prediction".

Let the variable zHD be set equal to 2 * y – x.

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If zHD is equal to 0, 2, 4, or 6,

$$pred4x4_L[x, y] = (p[-1, y -(x >> 1) - 1] + p[-1, y - (x >> 1)] + 1) >> 1 \quad (8\text{-}62)$$

– Otherwise, if zHD is equal to 1, 3, or 5,

$$pred4x4_L[x, y] = (p[-1, y - (x >> 1) - 2] + 2 * p[-1, y - (x >> 1) - 1] + p[-1, y - (x >> 1)] + 2) >> 2 \quad (8\text{-}63)$$

– Otherwise, if zHD is equal to -1,

$$pred4x4_L[x, y] = (p[-1, 0] + 2 * p[-1, -1] + p[0, -1] + 2) >> 2 \quad (8\text{-}64)$$

– Otherwise (zHD is equal to -2 or -3),

$$pred4x4_L[x, y] = (p[x - 1, -1] + 2 * p[x - 2, -1] + p[x - 3, -1] + 2) >> 2 \quad (8\text{-}65)$$

8.3.1.2.8 Specification of Intra_4x4_Vertical_Left prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 7.

This mode shall be used only when the samples p[x, -1] with x = 0..7 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If y is equal to 0 or 2,

$$pred4x4_L[x, y] = (p[x + (y >> 1), -1] + p[x + (y >> 1) + 1, -1] + 1) >> 1 \quad (8\text{-}66)$$

– Otherwise (y is equal to 1 or 3),

$$pred4x4_L[x, y] = (p[x + (y >> 1), -1] + 2 * p[x + (y >> 1) + 1, -1] + p[x + (y >> 1) + 2, -1] + 2) >> 2 \quad (8\text{-}67)$$

8.3.1.2.9 Specification of Intra_4x4_Horizontal_Up prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 8.

This mode shall be used only when the samples p[-1, y] with y = 0..3 are marked as "available for Intra_4x4 prediction".

Let the variable zHU be set equal to x + 2 * y.

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows:

– If zHU is equal to 0, 2, or 4

$$pred4x4_L[x, y] = (p[-1, y + (x >> 1)] + p[-1, y + (x >> 1) + 1] + 1) >> 1 \quad (8\text{-}68)$$

– Otherwise, if zHU is equal to 1 or 3

$$pred4x4_L[x, y] = (p[-1, y + (x >> 1)] + 2 * p[-1, y + (x >> 1) + 1] + p[-1, y + (x >> 1) + 2] + 2) >> 2 \quad (8\text{-}69)$$

– Otherwise, if zHU is equal to 5,

$$pred4x4_L[x, y] = (p[-1, 2] + 3 * p[-1, 3] + 2) >> 2 \quad (8\text{-}70)$$

– Otherwise (zHU is greater than 5),

$$pred4x4_L[x, y] = p[-1, 3] \quad (8\text{-}71)$$

8.3.2 Intra_8x8 prediction process for luma samples

This process is invoked when the macroblock prediction mode is equal to Intra_8x8.

Inputs to this process are the values of Intra4x4PredMode (if available) or Intra8x8PredMode (if available) from the neighbouring macroblocks or macroblock pairs.

Outputs of this process are 8x8 luma sample arrays as part of the 16x16 luma array of prediction samples of the macroblock $pred_L$.

The luma component of a macroblock consists of 4 blocks of 8x8 luma samples. These blocks are inverse scanned using the inverse 8x8 luma block scanning process as specified in subclause 6.4.5.

For all 8x8 luma blocks of the luma component of a macroblock with luma8x8BlkIdx = 0..3, the derivation process for Intra8x8PredMode as specified in subclause 8.3.2.1 is invoked with luma8x8BlkIdx as well as Intra4x4PredMode and Intra8x8PredMode that are previously (in decoding order) derived for adjacent macroblocks as the input and the variable Intra8x8PredMode[luma8x8BlkIdx] as the output.

For each luma block of 8x8 samples indexed using luma8x8BlkIdx = 0..3, the following applies.

– The Intra_8x8 sample prediction process in subclause 8.3.2.2 is invoked with luma8x8BlkIdx and the array S'_L containing constructed samples prior to the deblocking filter process from adjacent luma blocks as the input and the output are the Intra_8x8 luma prediction samples $pred8x8_L[x, y]$ with x, y = 0..7.

– The position of the upper-left sample of an 8x8 luma block with index luma8x8BlkIdx inside the current macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.5 with luma8x8BlkIdx as the input and the output being assigned to (xO, yO) and x, y = 0..7.

$$pred_L[xO + x, yO + y] = pred8x8_L[x, y] \quad (8\text{-}72)$$

– The transform coefficient decoding process and picture construction process prior to deblocking filter process in subclause 8.5 is invoked with $pred_L$ and luma8x8BlkIdx as the input and the constructed samples for the current 8x8 luma block S'_L as the output.

8.3.2.1 Derivation process for Intra8x8PredMode

Inputs to this process are the index of the 8x8 luma block luma8x8BlkIdx and variable arrays Intra4x4PredMode (if available) and Intra8x8PredMode (if available) that are previously (in decoding order) derived for adjacent macroblocks.

Output of this process is the variable Intra8x8PredMode[luma8x8BlkIdx].

Table 8-3 specifies the values for Intra8x8PredMode[luma8x8BlkIdx] and the associated mnemonic names.

Table 8-3 – Specification of Intra8x8PredMode[luma8x8BlkIdx] and associated names

Intra8x8PredMode[luma8x8BlkIdx]	Name of Intra8x8PredMode[luma8x8BlkIdx]
0	Intra_8x8_Vertical (prediction mode)
1	Intra_8x8_Horizontal (prediction mode)
2	Intra_8x8_DC (prediction mode)
3	Intra_8x8_Diagonal_Down_Left (prediction mode)
4	Intra_8x8_Diagonal_Down_Right (prediction mode)
5	Intra_8x8_Vertical_Right (prediction mode)
6	Intra_8x8_Horizontal_Down (prediction mode)
7	Intra_8x8_Vertical_Left (prediction mode)
8	Intra_8x8_Horizontal_Up (prediction mode)

Intra8x8PredMode[luma8x8BlkIdx] is derived as follows.

– The process specified in subclause 6.4.10.2 is invoked with luma8x8BlkIdx given as input and the output is assigned to mbAddrA, luma8x8BlkIdxA, mbAddrB, and luma8x8BlkIdxB.

– The variable dcPredModePredictedFlag is derived as follows.

  – If any of the following conditions are true, dcPredModePredictedFlag is set equal to 1

    – the macroblock with address mbAddrA is not available

    – the macroblock with address mbAddrB is not available

    – the macroblock with address mbAddrA is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1

    – the macroblock with address mbAddrB is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1

  – Otherwise, dcPredModePredictedFlag is set equal to 0.

– For N being either replaced by A or B, the variables intraMxMPredModeN are derived as follows.

  – If dcPredModePredictedFlag is equal to 1 or (the macroblock with address mbAddrN is not coded in Intra_4x4 macroblock prediction mode and the macroblock with address mbAddrN is not coded in Intra_8x8 macroblock prediction mode), intraMxMPredModeN is set equal to 2 (Intra_8x8_DC prediction mode).

  – Otherwise (dcPredModePredictedFlag is equal to 0 and (the macroblock with address mbAddrN is coded in Intra_4x4 macroblock prediction mode or the macroblock with address mbAddrN is coded in Intra_8x8 macroblock prediction mode)), the following applies.

    – If the macroblock with address mbAddrN is coded in Intra_8x8 macroblock mode, intraMxMPredModeN is set equal to Intra8x8PredMode[luma8x8BlkIdxN], where Intra8x8PredMode is the variable array assigned to the macroblock mbAddrN.

    – Otherwise (the macroblock with address mbAddrN is coded in Intra_4x4 macroblock mode), intraMxMPredModeN is derived by the following procedure, where Intra4x4PredMode is the variable array assigned to the macroblock mbAddrN.

$$intraMxMPredModeN = Intra4x4PredMode[\ luma8x8BlkIdxN * 4 + n\ ] \quad (8\text{-}73)$$

      where the variable n is derived as follows

      – If N is equal to A, depending on the variable MbaffFrameFlag, the variable luma8x8BlkIdx, the current macroblock, and the macroblock mbAddrN, the following applies.

– If MbaffFrameFlag is equal to 1, the current macroblock is a frame coded macroblock, the macroblock mbAddrN is a field coded macroblock, and luma8x8BlkIdx is equal to 2, n is set equal to 3.

– Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a field coded macroblock or the macroblock mbAddrN is a frame coded macroblock or luma8x8BlkIdx is not equal to 2), n is set equal to 1.

– Otherwise (N is equal to B), n is set equal to 2.

– Finally, given intraMxMPredModeA and intraMxMPredModeB, the variable Intra8x8PredMode[luma8x8BlkIdx] is derived by applying the following procedure.

```
predIntra8x8PredMode = Min( intraMxMPredModeA, intraMxMPredModeB )
if( prev_intra8x8_pred_mode_flag[ luma8x8BlkIdx ] )
    Intra8x8PredMode[ luma8x8BlkIdx ] = predIntra8x8PredMode
else                                                                    (8-74)
    if( rem_intra8x8_pred_mode[ luma8x8BlkIdx ] < predIntra8x8PredMode )
        Intra8x8PredMode[ luma8x8BlkIdx ] = rem_intra8x8_pred_mode[ luma8x8BlkIdx ]
    else
        Intra8x8PredMode[ luma8x8BlkIdx ] = rem_intra8x8_pred_mode[ luma8x8BlkIdx ] + 1
```

8.3.2.2 Intra_8x8 sample prediction

This process is invoked for each 8x8 luma block of a macroblock with prediction mode equal to Intra_8x8 followed by the transform decoding process and picture construction process prior to deblocking for each 8x8 luma block.

Inputs to this process are

– the index of an 8x8 luma block luma8x8BlkIdx.

– an ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array cS_L containing constructed luma samples prior to the deblocking filter process of neighbouring macroblocks.

Output of this process are the prediction samples $pred8x8_L$[x, y], with x, y = 0..7 for the 8x8 luma block with index luma8x8BlkIdx.

The position of the upper-left sample of an 8x8 luma block with index luma8x8BlkIdx inside the current macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.5 with luma8x8BlkIdx as the input and the output being assigned to (xO, yO).

The 25 neighbouring samples p[x, y] that are constructed luma samples prior to the deblocking filter process, with x = -1, y = -1..7 and x = 0..15, y = -1, are derived as follows.

– The luma location (xN, yN) is specified by

$$xN = xO + x \tag{8-75}$$

$$yN = yO + y \tag{8-76}$$

– The derivation process for neighbouring locations in subclause 6.4.11 is invoked for luma locations with (xN, yN) as input and mbAddrN and (xW, yW) as output.

– Each sample p[x, y] with x = -1, y = -1..7 and x = 0..15, y = -1 is derived as follows.

  – If any of the following conditions is true, the sample p[x, y] is marked as “not available for Intra_8x8 prediction”

    – mbAddrN is not available,

    – the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1,

  – Otherwise, the sample p[x, y] is marked as “available for Intra_8x8 prediction” and the sample value p[x, y] is derived as follows.

    – The location of the upper-left luma sample of the macroblock mbAddrN is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddrN as the input and the output is assigned to (xM, yM).

– Depending on the variable MbaffFrameFlag and the macroblock mbAddrN, the sample value p[x, y] is derived as follows.

  – If MbaffFrameFlag is equal to 1 and the macroblock mbAddrN is a field macroblock,

$$p[x, y] = cS_L[xM + xW, yM + 2 * yW] \quad (8\text{-}77)$$

  – Otherwise (MbaffFrameFlag is equal to 0 or the macroblock mbAddrN is a frame macroblock),

$$p[x, y] = cS_L[xM + xW, yM + yW] \quad (8\text{-}78)$$

When samples p[x, -1], with x = 8..15 are marked as "not available for Intra_8x8 prediction," and the sample p[7, -1] is marked as "available for Intra_8x8 prediction," the sample value of p[7, -1] is substituted for sample values p[x, -1], with x = 8..15 and samples p[x, -1], with x = 8..15 are marked as "available for Intra_8x8 prediction".

NOTE – Each block is assumed to be constructed into a picture array prior to decoding of the next block.

The reference sample filtering process for Intra_8x8 sample prediction in subclause 8.3.2.2.1 is invoked with the samples p[x, y] with x = -1, y = -1..7 and x = 0..15, y = -1 (if available) as input and p'[x, y] with x = -1, y = -1..7 and x = 0..15, y = -1 as output.

Depending on Intra8x8PredMode[luma8x8BlkIdx], one of the Intra_8x8 prediction modes specified in subclauses 8.3.2.2.2 to 8.3.2.2.10 is invoked.

8.3.2.2.1 Reference sample filtering process for Intra_8x8 sample prediction

Inputs to this process are the reference samples p[x, y] with x = -1, y = -1..7 and x = 0..15, y = -1 (if available) for Intra_8x8 sample prediction.

Outputs of this process are the filtered reference samples p'[x, y] with x = -1, y = -1..7 and x = 0..15, y = -1 for Intra_8x8 sample prediction.

When all samples p[x, -1] with x = 0..7 are marked as "available for Intra_8x8 prediction", the following applies.

– The value of p'[0, -1] is derived as follows.

– If p[-1, -1] is marked as "available for Intra_8x8 prediction", p'[0, -1] is derived by

$$p'[0, -1] = (p[-1, -1] + 2 * p[0, -1] + p[1, -1] + 2) >> 2 \quad (8\text{-}79)$$

– Otherwise (p[-1, -1] is marked as "not available for Intra_8x8 prediction"), p'[0, -1] is derived by

$$p'[0, -1] = (3 * p[0, -1] + p[1, -1] + 2) >> 2 \quad (8\text{-}80)$$

– The values of p'[x, -1], with x = 1..7 are derived by

$$p'[x, -1] = (p[x-1, -1] + 2 * p[x, -1] + p[x+1, -1] + 2) >> 2 \quad (8\text{-}81)$$

When all samples p[x, -1] with x = 7..15 are marked as "available for Intra_8x8 prediction", the following applies.

– The values of p'[x, -1], with x = 8..14 are derived by

$$p'[x, -1] = (p[x-1, -1] + 2 * p[x, -1] + p[x+1, -1] + 2) >> 2 \quad (8\text{-}82)$$

– The value of p'[15, -1] is derived by

$$p'[15, -1] = (p[14, -1] + 3 * p[15, -1] + 2) >> 2 \quad (8\text{-}83)$$

When the sample p[-1, -1] is marked as "available for Intra_8x8 prediction", the value of p'[-1, -1] is derived as follows.

– If the sample p[0, -1] is marked as "not available for Intra_8x8 prediction" or the sample p[-1, 0] is marked as "not available for Intra_8x8 prediction", the following applies.

– If the sample p[0, -1] is marked as “available for Intra_8x8 prediction”, p'[-1, -1] is derived by

$$p'[-1, -1] = (3 * p[-1, -1] + p[0, -1] + 2) >> 2 \quad (8\text{-}84)$$

– Otherwise (the sample p[0, -1] is marked as “not available for Intra_8x8 prediction” and the sample p[-1, 0] is marked as “available for Intra_8x8 prediction”), p'[-1, -1] is derived by

$$p'[-1, -1] = (3 * p[-1, -1] + p[-1, 0] + 2) >> 2 \quad (8\text{-}85)$$

– Otherwise (the sample p[0, -1] is marked as “available for Intra_8x8 prediction” and the sample p[-1, 0] is marked as “available for Intra_8x8 prediction”), p'[-1, -1] is derived by

$$p'[-1, -1] = (p[0, -1] + 2 * p[-1, -1] + p[-1, 0] + 2) >> 2 \quad (8\text{-}86)$$

When all samples p[-1, y] with y = 0..7 are marked as “available for Intra_8x8 prediction”, the following applies.

– The value of p'[-1, 0] is derived as follows.

– If p[-1, -1] is marked as “available for Intra_8x8 prediction”, p'[-1, 0] is derived by

$$p'[-1, 0] = (p[-1, -1] + 2 * p[-1, 0] + p[-1, 1] + 2) >> 2 \quad (8\text{-}87)$$

– Otherwise (if p[-1, -1] is marked as “not available for Intra_8x8 prediction”), p'[-1, 0] is derived by

$$p'[-1, 0] = (3 * p[-1, 0] + p[-1, 1] + 2) >> 2 \quad (8\text{-}88)$$

– The values of p'[-1, y], with y = 1..6 are derived by

$$p'[-1, y] = (p[-1, y-1] + 2 * p[-1, y] + p[-1, y+1] + 2) >> 2 \quad (8\text{-}89)$$

– The value of p'[-1, 7] is derived by

$$p'[-1, 7] = (p[-1, 6] + 3 * p[-1, 7] + 2) >> 2 \quad (8\text{-}90)$$

8.3.2.2.2 Specification of Intra_8x8_Vertical prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 0.

This mode shall be used only when the samples p[x, -1] with x = 0..7 are marked as “available for Intra_8x8 prediction”.

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived by

$$pred8x8_L[x, y] = p'[x, -1], \text{ with } x, y = 0..7 \quad (8\text{-}91)$$

8.3.2.2.3 Specification of Intra_8x8_Horizontal prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 1.

This mode shall be used only when the samples p[-1, y], with y = 0..7 are marked as “available for Intra_8x8 prediction”.

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived by

$$pred8x8_L[x, y] = p'[-1, y], \text{ with } x, y = 0..7 \quad (8\text{-}92)$$

8.3.2.2.4 Specification of Intra_8x8_DC prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 2.

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows.

– If all samples p[x, -1], with x = 0..7 and p[-1, y], with y = 0..7 are marked as "available for Intra_8x8 prediction," the values of the prediction samples pred8x8$_L$[x, y], with x, y = 0..7 are derived by

$$\text{pred8x8}_L[\,x, y\,] = (\sum_{x'=0}^{7} p'[x', -1] + \sum_{y'=0}^{7} p'[-1, y'] + 8) >> 4 \quad (8\text{-}93)$$

– Otherwise, if any samples p[x, -1], with x = 0..7 are marked as "not available for Intra_8x8 prediction" and all samples p[-1, y], with y = 0..7 are marked as "available for Intra_8x8 prediction", the values of the prediction samples pred8x8$_L$[x, y], with x, y = 0..7 are derived by

$$\text{pred8x8}_L[\,x, y\,] = (\sum_{y'=0}^{7} p'[-1, y'] + 4) >> 3 \quad (8\text{-}94)$$

– Otherwise, if any samples p[-1, y], with y = 0..7 are marked as "not available for Intra_8x8 prediction" and all samples p[x, -1], with x = 0..7 are marked as "available for Intra_8x8 prediction", the values of the prediction samples pred8x8$_L$[x, y], with x, y = 0..7 are derived by

$$\text{pred8x8}_L[\,x, y\,] = (\sum_{x'=0}^{7} p'[x', -1] + 4) >> 3 \quad (8\text{-}95)$$

– Otherwise (some samples p[x, -1], with x = 0..7 and some samples p[-1, y], with y = 0..7 are marked as "not available for Intra_8x8 prediction"), the values of the prediction samples pred8x8$_L$[x, y], with x, y = 0..7 are derived by

$$\text{pred8x8}_L[\,x, y\,] = (1 << (\text{BitDepth}_Y - 1)) \quad (8\text{-}96)$$

NOTE – An 8x8 luma block can always be predicted using this mode.

8.3.2.2.5 Specification of Intra_8x8_Diagonal_Down_Left prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 3.

This mode shall be used only when the samples p[x, -1] with x = 0..15 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples pred8x8$_L$[x, y], with x, y = 0..7 are derived as follows.

– If x is equal to 7 and y is equal to 7,

$$\text{pred8x8}_L[\,x, y\,] = (p'[\,14, -1\,] + 3 * p'[15, -1\,] + 2) >> 2 \quad (8\text{-}97)$$

– Otherwise (x is not equal to 7 or y is not equal to 7),

$$\text{pred8x8}_L[\,x, y\,] = (p'[\,x + y, -1\,] + 2 * p'[\,x + y + 1, -1\,] + p'[\,x + y + 2, -1\,] + 2) >> 2 \quad (8\text{-}98)$$

8.3.2.2.6 Specification of Intra_8x8_Diagonal_Down_Right prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 4.

This mode shall be used only when the samples p[x, -1] with x = 0..7 and p[-1, y] with y = -1..7 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples pred8x8$_L$[x, y], with x, y = 0..7 are derived as follows.

– If x is greater than y,

$$\text{pred8x8}_L[\,x, y\,] = (p'[\,x - y - 2, -1] + 2 * p'[\,x - y - 1, -1\,] + p'[\,x - y, -1\,] + 2) >> 2 \quad (8\text{-}99)$$

– Otherwise if x is less than y,

$$\text{pred8x8}_L[\,x, y\,] = (p'[\,-1, y - x - 2\,] + 2 * p'[\,-1, y - x - 1\,] + p'[\,-1, y - x\,] + 2) >> 2 \quad (8\text{-}100)$$

– Otherwise (x is equal to y),

$$pred8x8_L[x, y] = (p'[0, -1] + 2 * p'[-1, -1] + p'[-1, 0] + 2) >> 2 \quad (8\text{-}101)$$

8.3.2.2.7 Specification of Intra_8x8_Vertical_Right prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 5.

This mode shall be used only when the samples p[x, -1] with x = 0..7 and p[-1, y] with y = -1..7 are marked as "available for Intra_8x8 prediction".

Let the variable zVR be set equal to 2 * x – y.

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows.

– If zVR is equal to 0, 2, 4, 6, 8, 10, 12, or 14

$$pred8x8_L[x, y] = (p'[x - (y >> 1) - 1, -1] + p'[x - (y >> 1), -1] + 1) >> 1 \quad (8\text{-}102)$$

– Otherwise, if zVR is equal to 1, 3, 5, 7, 9, 11, or 13

$$pred8x8_L[x, y] = (p'[x - (y >> 1) - 2, -1] + 2 * p'[x - (y >> 1) - 1, -1] + p'[x - (y >> 1), -1] + 2) >> 2 \quad (8\text{-}103)$$

– Otherwise, if zVR is equal to -1,

$$pred8x8_L[x, y] = (p'[-1, 0] + 2 * p'[-1, -1] + p'[0, -1] + 2) >> 2 \quad (8\text{-}104)$$

– Otherwise (zVR is equal to -2, -3, -4, -5, -6, or -7),

$$pred8x8_L[x, y] = (p'[-1, y - 2*x - 1] + 2 * p'[-1, y - 2*x - 2] + p'[-1, y - 2*x - 3] + 2) >> 2 \quad (8\text{-}105)$$

8.3.2.2.8 Specification of Intra_8x8_Horizontal_Down prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 6.

This mode shall be used only when the samples p[x, -1] with x = 0..7 and p[-1, y] with y = -1..7 are marked as "available for Intra_8x8 prediction".

Let the variable zHD be set equal to 2 * y – x.

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows.

– If zHD is equal to 0, 2, 4, 6, 8, 10, 12, or 14

$$pred8x8_L[x, y] = (p'[-1, y -(x >> 1) - 1] + p'[-1, y - (x >> 1)] + 1) >> 1 \quad (8\text{-}106)$$

– Otherwise, if zHD is equal to 1, 3, 5, 7, 9, 11, or 13

$$pred8x8_L[x, y] = (p'[-1, y - (x >> 1) - 2] + 2 * p'[-1, y - (x >> 1) - 1] + p'[-1, y - (x >> 1)] + 2) >> 2 \quad (8\text{-}107)$$

– Otherwise, if zHD is equal to -1,

$$pred8x8_L[x, y] = (p'[-1, 0] + 2 * p'[-1, -1] + p'[0, -1] + 2) >> 2 \quad (8\text{-}108)$$

– Otherwise (zHD is equal to –2, -3, -4, -5, -6, -7),

$$pred8x8_L[x, y] = (p'[x - 2*y - 1, -1] + 2 * p'[x - 2*y - 2, -1] + p'[x - 2*y - 3, -1] + 2) >> 2 \quad (8\text{-}109)$$

8.3.2.2.9 Specification of Intra_8x8_Vertical_Left prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 7.

This mode shall be used only when the samples p[x, -1] with x = 0..15 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows.

– If y is equal to 0, 2, 4 or 6

$$pred8x8_L[x, y] = (p'[x + (y >> 1), -1] + p'[x + (y >> 1) + 1, -1] + 1) >> 1 \quad (8\text{-}110)$$

– Otherwise (y is equal to 1, 3, 5, 7),

$$pred8x8_L[x, y] = (p'[x + (y >> 1), -1] + 2 * p'[x + (y >> 1) + 1, -1] + p'[x + (y >> 1) + 2, -1] + 2) >>2 \quad (8\text{-}111)$$

8.3.2.2.10 Specification of Intra_8x8_Horizontal_Up prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 8.

This mode shall be used only when the samples p[-1, y] with y = 0..7 are marked as "available for Intra_8x8 prediction".

Let the variable zHU be set equal to x + 2 * y.

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows:

– If zHU is equal to 0, 2, 4, 6, 8, 10, or 12

$$pred8x8_L[x, y] = (p'[-1, y + (x >> 1)] + p'[-1, y + (x >> 1) + 1] + 1) >> 1 \quad (8\text{-}112)$$

– Otherwise, if zHU is equal to 1, 3, 5, 7, 9, or 11

$$pred8x8_L[x, y] = (p'[-1, y + (x >> 1)] + 2 * p'[-1, y + (x >> 1) + 1] + p'[-1, y + (x >> 1) + 2] + 2) >>2 \quad (8\text{-}113)$$

– Otherwise, if zHU is equal to 13,

$$pred8x8_L[x, y] = (p'[-1, 6] + 3 * p'[-1, 7] + 2) >> 2 \quad (8\text{-}114)$$

– Otherwise (zHU is greater than 13),

$$pred8x8_L[x, y] = p'[-1, 7] \quad (8\text{-}115)$$

8.3.3 Intra_16x16 prediction process for luma samples

This process is invoked when the macroblock prediction mode is equal to Intra_16x16. It specifies how the Intra prediction luma samples for the current macroblock are derived.

Input to this process is a $(PicWidthInSamples_L)x(PicHeightInSamples_L)$ array cS_L containing constructed luma samples prior to the deblocking filter process of neighbouring macroblocks

Outputs of this process are Intra prediction luma samples for the current macroblock $pred_L[x, y]$.

The 33 neighbouring samples p[x, y] that are constructed luma samples prior to the deblocking filter process, with x = -1, y = -1..15 and with x = 0..15, y = -1, are derived as follows.

– The derivation process for neighbouring locations in subclause 6.4.11 is invoked for luma locations with (x, y) assigned to (xN, yN) as input and mbAddrN and (xW, yW) as output.

– Each sample p[x, y] with x = -1, y = -1..15 and with x = 0..15, y = -1 is derived as follows.

  – If any of the following conditions is true, the sample p[x, y] is marked as "not available for Intra_16x16 prediction"

    – mbAddrN is not available,

    – the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1.

    – the macroblock mbAddrN has mb_type equal to SI and constrained_intra_pred_flag is equal to 1.

– Otherwise, the sample p[x, y] is marked as "available for Intra_16x16 prediction" and the value of the sample p[x, y] is derived as follows.

  – The location of the upper-left luma sample of the macroblock mbAddrN is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddrN as the input and the output is assigned to (xM, yM).

  – Depending on the variable MbaffFrameFlag and the macroblock mbAddrN, the sample value p[x, y] is derived as follows.

    – If MbaffFrameFlag is equal to 1 and the macroblock mbAddrN is a field macroblock,

      $p[x, y] = cS_L[xM + xW, yM + 2 * yW]$ (8-116)

    – Otherwise (MbaffFrameFlag is equal to 0 or the macroblock mbAddrN is a frame macroblock),

      $p[x, y] = cS_L[xM + xW, yM + yW]$ (8-117)

Let $pred_L[x, y]$ with x, y = 0..15 denote the prediction samples for the 16x16 luma block samples.

Intra_16x16 prediction modes are specified in Table 8-4.

Table 8-4 – Specification of Intra16x16PredMode and associated names

Intra16x16PredMode	Name of Intra16x16PredMode
0	Intra_16x16_Vertical (prediction mode)
1	Intra_16x16_Horizontal (prediction mode)
2	Intra_16x16_DC (prediction mode)
3	Intra_16x16_Plane (prediction mode)

Depending on Intra16x16PredMode, one of the Intra_16x16 prediction modes specified in subclauses 8.3.3.1 to 8.3.3.4 is invoked.

8.3.3.1 Specification of Intra_16x16_Vertical prediction mode

This Intra_16x16 prediction mode shall be used only when the samples p[x, -1] with x = 0..15 are marked as "available for Intra_16x16 prediction".

$pred_L[x, y] = p[x, -1]$, with x, y = 0..15 (8-118)

8.3.3.2 Specification of Intra_16x16_Horizontal prediction mode

This Intra_16x16 prediction mode shall be used only when the samples p[-1, y] with y = 0..15 are marked as "available for Intra_16x16 prediction".

$pred_L[x, y] = p[-1, y]$, with x, y = 0..15 (8-119)

8.3.3.3 Specification of Intra_16x16_DC prediction mode

This Intra_16x16 prediction mode operates, depending on whether the neighbouring samples are marked as "available for Intra_16x16 prediction", as follows.

– If all neighbouring samples p[x, -1], with x = 0..15 and p[-1, y], with y = 0..15 are marked as "available for Intra_16x16 prediction", the prediction for all luma samples in the macroblock is given by:

$$pred_L[x, y] = \left(\sum_{x'=0}^{15} p[x',-1] + \sum_{y'=0}^{15} p[-1,y'] + 16\right) >> 5, \text{ with } x, y = 0..15 \quad (8\text{-}120)$$

– Otherwise, if any of the neighbouring samples p[x, -1], with x = 0..15 are marked as "not available for Intra_16x16 prediction" and all of the neighbouring samples p[-1, y], with y = 0..15 are marked as “available for Intra_16x16 prediction”, the prediction for all luma samples in the macroblock is given by:

$$pred_L[\,x, y\,] = (\sum_{y'=0}^{15} p[-1, y'] + 8) >> 4 \text{, with } x, y = 0..15 \quad (8\text{-}121)$$

– Otherwise, if any of the neighbouring samples p[-1, y], with y = 0..15 are marked as "not available for Intra_16x16 prediction" and all of the neighbouring samples p[x, -1], with x = 0..15 are marked as “available for Intra_16x16 prediction”, the prediction for all luma samples in the macroblock is given by:

$$pred_L[\,x, y\,] = (\sum_{x'=0}^{15} p[x', -1] + 8) >> 4 \text{, with } x, y = 0..15 \quad (8\text{-}122)$$

– Otherwise (some of the neighbouring samples p[x, -1], with x = 0..15 and some of the neighbouring samples p[-1, y], with y = 0..15 are marked as “not available for Intra_16x16 prediction”), the prediction for all luma samples in the macroblock is given by:

$$pred_L[\,x, y\,] = (1 << (BitDepth_Y - 1)), \text{ with } x, y = 0..15 \quad (8\text{-}123)$$

8.3.3.4 Specification of Intra_16x16_Plane prediction mode

This Intra_16x16 prediction mode shall be used only when the samples p[x, -1] with x = -1..15 and p[-1, y] with y = 0..15 are marked as “available for Intra_16x16 prediction”.

$$pred_L[\,x, y\,] = Clip1_Y((a + b * (x - 7) + c * (y - 7) + 16) >> 5), \text{ with } x, y = 0..15, \quad (8\text{-}124)$$

where:

$$a = 16 * (p[-1, 15] + p[15, -1]) \quad (8\text{-}125)$$

$$b = (5 * H + 32) >> 6 \quad (8\text{-}126)$$

$$c = (5 * V + 32) >> 6 \quad (8\text{-}127)$$

and H and V are specified in Equations 8-128 and 8-129.

$$H = \sum_{x'=0}^{7} (x'+1) * (p[\,8 + x', -1\,] - p[\,6 - x', -1\,]) \quad (8\text{-}128)$$

$$V = \sum_{y'=0}^{7} (y'+1) * (p[\,-1, 8 + y'\,] - p[\,-1, 6 - y'\,]) \quad (8\text{-}129)$$

8.3.4 Intra prediction process for chroma samples

This process is invoked for I and SI macroblock types. It specifies how the Intra prediction chroma samples for the current macroblock are derived.

Inputs to this process are two (PicWidthInSamples$_C$)x(PicHeightInSamples$_C$) arrays cS_{Cb} and cS_{Cr} containing constructed chroma samples prior to the deblocking filter process of neighbouring macroblocks.

Outputs of this process are Intra prediction chroma samples for the current macroblock $pred_{Cb}[\,x, y\,]$ and $pred_{Cr}[\,x, y\,]$.

Depending on the value of ChromaArrayType, the following applies.

– If ChromaArrayType is equal to 3, the Intra prediction chroma samples for the current macroblock $pred_{Cb}[x, y]$ and $pred_{Cr}[x, y]$ are derived using the Intra prediction process for chroma samples with ChromaArrayType equal to 3 as specified in subclause 8.3.4.5.

– Otherwise (ChromaArrayType is equal to 1 or 2), the following text specifies the Intra prediction chroma samples for the current macroblock $pred_{Cb}[x, y]$ and $pred_{Cr}[x, y]$.

Both chroma blocks (Cb and Cr) of the macroblock use the same prediction mode. The prediction mode is applied to each of the chroma blocks separately. The process specified in this subclause is invoked for each chroma block. In the remainder of this subclause, chroma block refers to one of the two chroma blocks and the subscript C is used as a replacement of the subscript Cb or Cr.

The neighbouring samples p[x, y] that are constructed chroma samples prior to the deblocking filter process, with x = -1, y = -1..MbHeightC - 1 and with x = 0..MbWidthC - 1, y = -1, are derived as follows.

– The derivation process for neighbouring locations in subclause 6.4.11 is invoked for chroma locations with (x, y) assigned to (xN, yN) as input and mbAddrN and (xW, yW) as output.

– Each sample p[x, y] is derived as follows.

  – If any of the following conditions is true, the sample p[x, y] is marked as “not available for Intra chroma prediction”

    – mbAddrN is not available,

    – the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1,

    – the macroblock mbAddrN has mb_type equal to SI and constrained_intra_pred_flag is equal to 1 and the current macroblock does not have mb_type equal to SI.

  – Otherwise, the sample p[x, y] is marked as “available for Intra chroma prediction” and the value of the sample p[x, y] is derived as follows.

    – The location of the upper-left luma sample of the macroblock mbAddrN is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddrN as the input and the output is assigned to (xL, yL).

    – The location (xM, yM) of the upper-left chroma sample of the macroblock mbAddr is derived by

$$xM = (xL >> 4) * MbWidthC \quad (8\text{-}130)$$
$$yM = ((yL >> 4)* MbHeightC) + (yL \% 2) \quad (8\text{-}131)$$

    – Depending on the variable MbaffFrameFlag and the macroblock mbAddrN, the sample value p[x, y] is derived as follows.

      – If MbaffFrameFlag is equal to 1 and the macroblock mbAddrN is a field macroblock,

$$p[x, y] = cS_C[xM + xW, yM + 2 * yW] \quad (8\text{-}132)$$

      – Otherwise (MbaffFrameFlag is equal to 0 or the macroblock mbAddrN is a frame macroblock),

$$p[x, y] = cS_C[xM + xW, yM + yW] \quad (8\text{-}133)$$

Let $pred_C[x, y]$ with x = 0..MbWidthC - 1, y = 0..MbHeightC - 1 denote the prediction samples for the chroma block samples.

Intra chroma prediction modes are specified in Table 8-5.

Table 8-5 – Specification of Intra chroma prediction modes and associated names

intra_chroma_pred_mode	Name of intra_chroma_pred_mode
0	Intra_Chroma_DC (prediction mode)
1	Intra_Chroma_Horizontal (prediction mode)
2	Intra_Chroma_Vertical (prediction mode)
3	Intra_Chroma_Plane (prediction mode)

Depending on intra_chroma_pred_mode, one of the Intra chroma prediction modes specified in subclauses 8.3.4.1 to 8.3.4.4 is invoked.

8.3.4.1 Specification of Intra_Chroma_DC prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 0.

For each chroma block of 4x4 samples indexed by chroma4x4BlkIdx = 0..(1 << (ChromaArrayType + 1)) – 1, the following applies.

– The position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx is derived as

$$xO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 0) \quad (8\text{-}134)$$

$$yO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 1) \quad (8\text{-}135)$$

– Depending on the values of xO and yO, the following applies.

– If (xO, yO) is equal to (0, 0) or xO and yO are greater than 0, the values of the prediction samples $pred_C[x + xO, y + yO]$ with x, y = 0..3 are derived as follows.

  – If all samples p[x + xO, -1], with x = 0..3 and p[-1, y +yO], with y = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{x'=0}^{3} p[x'+xO,-1] + \sum_{y'=0}^{3} p[-1, y'+yO] + 4 \right) >> 3 \text{, with x, y = 0..3.} \quad (8\text{-}136)$$

  – Otherwise, if any samples p[x + xO, -1], with x = 0..3 are marked as "not available for Intra chroma prediction" and all samples p[-1, y +yO], with y = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{y'=0}^{3} p[-1, y'+yO] + 2 \right) >> 2 \text{, with x, y = 0..3.} \quad (8\text{-}137)$$

  – Otherwise, if any samples p[-1, y +yO], with y = 0..3 are marked as "not available for Intra chroma prediction" and all samples p[x + xO, -1], with x = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{x'=0}^{3} p[x'+xO,-1] + 2 \right) >> 2 \text{, with x, y = 0..3.} \quad (8\text{-}138)$$

  – Otherwise (some samples p[x + xO, -1], with x = 0..3 and some samples p[-1, y +yO], with y = 0..3 are marked as "not available for Intra chroma prediction"), the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = (1 << (BitDepth_C - 1)), \text{ with x, y = 0..3.} \quad (8\text{-}139)$$

– Otherwise, if xO is greater than 0 and yO is equal to 0, the values of the prediction samples $pred_C[x + xO, y + yO]$ with x, y = 0..3 are derived as follows.

  – If all samples p[x + xO, -1], with x = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{x'=0}^{3} p[x'+xO,-1] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}140)$$

  – Otherwise, if all samples p[-1, y +yO], with y = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{y'=0}^{3} p[-1, y'+yO] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}141)$$

  – Otherwise (some samples p[x + xO, -1], with x = 0..3 and some samples p[-1, y +yO], with y = 0..3 are marked as "not available for Intra chroma prediction"), the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = (1 << (BitDepth_C - 1)), \text{ with x, y = 0..3.} \quad (8\text{-}142)$$

– Otherwise (xO is equal to 0 and yO is greater than 0), the values of the prediction samples $pred_C[x + xO, y + yO]$ with x, y = 0..3 are derived as follows.

  – If all samples p[-1, y +yO], with y = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{y'=0}^{3} p[-1, y'+yO] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}143)$$

  – Otherwise, if all samples p[x + xO, -1], with x = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{x'=0}^{3} p[x'+xO,-1] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}144)$$

  – Otherwise (some samples p[x + xO, -1], with x = 0..3 and some samples p[-1, y +yO], with y = 0..3 are marked as "not available for Intra chroma prediction"), the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = (1 << (BitDepth_C - 1)), \text{ with x, y = 0..3.} \quad (8\text{-}145)$$

8.3.4.2 Specification of Intra_Chroma_Horizontal prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 1.

This mode shall be used only when the samples p[-1, y] with y = 0..MbHeightC - 1 are marked as "available for Intra chroma prediction".

The values of the prediction samples $pred_C[x, y]$ are derived as follows.

$$pred_C[x, y] = p[-1, y], \text{ with x = 0..MbWidthC - 1 and y = 0..MbHeightC - 1} \quad (8\text{-}146)$$

8.3.4.3 Specification of Intra_Chroma_Vertical prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 2.

This mode shall be used only when the samples p[x, -1] with x = 0..MbWidthC - 1 are marked as "available for Intra chroma prediction".

The values of the prediction samples $pred_C[x, y]$ are derived as follows.

$$pred_C[x, y] = p[x, -1], \text{ with } x = 0..MbWidthC - 1 \text{ and } y = 0..MbHeightC - 1 \quad (8\text{-}147)$$

8.3.4.4 Specification of Intra_Chroma_Plane prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 3.

This mode shall be used only when the samples p[x, -1], with x = 0..MbWidthC - 1 and p[-1, y], with y = -1..MbHeightC - 1 are marked as "available for Intra chroma prediction".

The values of the prediction samples $pred_C[x, y]$ are derived as follows.

Let the variable xCF be set equal to 4 * (ChromaArrayType = = 3) and let the variable yCF be set equal to 4 * (ChromaArrayType != 1).

$$pred_C[x, y] = Clip1_C((a + b * (x – 3 – xCF) + c * (y – 3 – yCF) + 16) >> 5), \text{ with } x = 0..MbWidthC - 1 \text{ and } y = 0..MbHeightC - 1 \quad (8\text{-}148)$$

where:

$$a = 16 * (p[-1, MbHeightC - 1] + p[MbWidthC - 1, -1]) \quad (8\text{-}149)$$

$$b = ((34 – 29 * (ChromaArrayType = = 3)) * H + 32) >> 6 \quad (8\text{-}150)$$

$$c = ((34 – 29 * (ChromaArrayType != 1)) * V + 32) >> 6 \quad (8\text{-}151)$$

and H and V are specified as

$$H = \sum_{x'=0}^{3+xCF} (x'+1) * (p[4 + xCF + x', -1] – p[2 + xCF – x', -1]) \quad (8\text{-}152)$$

$$V = \sum_{y'=0}^{3+yCF} (y'+1) * (p[-1, 4 + yCF + y'] – p[-1, 2 + yCF – y']) \quad (8\text{-}153)$$

8.3.4.5 Intra prediction for chroma samples with ChromaArrayType equal to 3

This process is invoked when ChromaArrayType is equal to 3. This process is invoked for I and SI macroblock types. It specifies how the Intra prediction chroma samples for the current macroblock are derived when ChromaArrayType is equal to 3.

Inputs to this process are constructed samples prior to the deblocking filter process from neighbouring Cb and Cr blocks and for Intra_NxN (where NxN is equal to 4x4 or 8x8) prediction mode, the associated values of IntraNxNPredMode from neighbouring macroblocks.

Outputs of this process are the Intra prediction samples of the Cb and Cr components of the macroblock or in case of the Intra_NxN prediction process, the outputs are NxN Cb sample arrays as part of the 16x16 Cb array of prediction samples of the macroblock, and NxN Cb sample arrays as part of the 16x16 Cb array of prediction samples of the macroblock.

Each Cb, Cr, and luma block with the same block index of the macroblock use the same prediction mode. The prediction mode is applied to each of the Cb and Cr blocks separately. The process specified in this subclause is invoked for each Cb and Cr block.

Depending on the macroblock prediction mode, the following applies.

– If the macroblock prediction mode is equal to Intra_4x4, the following applies.

  – The same process described in subclause 8.3.1 is also applied to Cb or Cr samples, substituting luma with Cb or Cr, substituting luma4x4BlkIdx with cb4x4BlkIdx or cr4x4BlkIdx, substituting $pred4x4_L$ with $pred4x4_{Cb}$ or $pred4x4_{Cr}$, and substituting $BitDepth_Y$ with $BitDepth_C$.

– The output variable Intra4x4PredMode[luma4x4BlkIdx] from the process described in subclause 8.3.1.1 is also used for the 4x4 Cb or 4x4 Cr blocks with index luma4x4BlkIdx equal to index cb4x4BlkIdx or cr4x4BlkIdx.

– The process to derive prediction Cb or Cr samples is identical to the process described in subclause 8.3.1.2 and its subsequent subclauses when substituting luma with Cb or Cr, substituting $pred4x4_L$ with $pred4x4_{Cb}$ or $pred4x4_{Cr}$, and substituting $BitDepth_Y$ with $BitDepth_C$.

– Otherwise, if the macroblock prediction mode is equal to Intra_8x8, the following applies.

– The same process described in subclause 8.3.2 is also applied to Cb or Cr samples, substituting luma with Cb or Cr, substituting luma8x8BlkIdx with cb8x8BlkIdx or cr8x8BlkIdx, substituting $pred8x8_L$ with $pred8x8_{Cb}$ or $pred8x8_{Cr}$, and substituting $BitDepth_Y$ with $BitDepth_C$.

– The output variable Intra8x8PredMode[luma8x8BlkIdx] from the process described in subclause 8.3.2.1 is used for the 8x8 Cb or 8x8 Cr blocks with index luma8x8BlkIdx equal to index cb8x8BlkIdx or cr8x8BlkIdx.

– The process to derive prediction Cb or Cr samples is identical to the process described in subclause 8.3.2.2 and its subsequent subclauses when substituting luma with Cb or Cr, substituting $pred8x8_L$ with $pred8x8_{Cb}$ or $pred8x8_{Cr}$, and substituting $BitDepth_Y$ with $BitDepth_C$.

– Otherwise, if the macroblock prediction mode is equal to Intra_16x16, the following applies.

– The same process described in subclause 8.3.3 and in the subsequent subclause 8.3.3.1 to 8.3.3.4 is also applied to Cb or Cr samples, substituting luma with Cb or Cr, substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$, and substituting $BitDepth_Y$ with $BitDepth_C$.

8.3.5 Sample construction process for I_PCM macroblocks

This process is invoked when mb_type is equal to I_PCM.

The variable dy is derived as follows.

– If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock, dy is set equal to 2.

– Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock), dy is set equal to 1.

The position of the upper-left luma sample of the current macroblock is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with CurrMbAddr as input and the output being assigned to (xP, yP).

The constructed luma samples prior to the deblocking process are generated as specified by:

```
for( i = 0; i < 256; i++ )
   S'L[ xP + ( i % 16 ), yP + dy * ( i / 16 ) ) ] = pcm_sample_luma[ i ]          (8-154)
```

When ChromaArrayType is not equal to 0, the constructed chroma samples prior to the deblocking process are generated as specified by:

```
for( i = 0; i < MbWidthC * MbHeightC; i++ ) {
   S'Cb[ ( xP / SubWidthC ) + ( i % MbWidthC ),
            ( ( yP + SubHeightC – 1 ) / SubHeightC ) + dy * ( i / MbWidthC ) ] =
              pcm_sample_chroma[ i ]                                            (8-155)
   S'Cr[ ( xP / SubWidthC ) + ( i % MbWidthC ),
            ( ( yP + SubHeightC – 1 ) / SubHeightC ) + dy * ( i / MbWidthC ) ] =
              pcm_sample_chroma[ i + MbWidthC * MbHeightC ]
}
```

8.4 Inter prediction process

This process is invoked when decoding P and B macroblock types.

Outputs of this process are Inter prediction samples for the current macroblock that are a 16x16 array $pred_L$ of luma samples and when ChromaArrayType is not equal to 0 two (MbWidthC)x(MbHeightC) arrays $pred_{Cb}$ and $pred_{Cr}$ of chroma samples, one for each of the chroma components Cb and Cr.

The partitioning of a macroblock is specified by mb_type. Each macroblock partition is referred to by mbPartIdx. When the macroblock partitioning consists of partitions that are equal to sub-macroblocks, each sub-macroblock can be further partitioned into sub-macroblock partitions as specified by sub_mb_type. Each sub-macroblock partition is

referred to by subMbPartIdx. When the macroblock partitioning does not consist of sub-macroblocks, subMbPartIdx is set equal to 0.

The following steps are specified for each macroblock partition or for each sub-macroblock partition.

The functions MbPartWidth( ), MbPartHeight( ), SubMbPartWidth( ), and SubMbPartHeight( ) describing the width and height of macroblock partitions and sub-macroblock partitions are specified in Table 7-13, 7-14, 7-17, and 7-18.

The range of the macroblock partition index mbPartIdx is derived as follows.

– If mb_type is equal to B_Skip or B_Direct_16x16, mbPartIdx proceeds over values 0..3.

– Otherwise (mb_type is not equal to B_Skip or B_Direct_16x16), mbPartIdx proceeds over values 0..NumMbPart(mb_type) – 1.

For each value of mbPartIdx, the variables partWidth and partHeight for each macroblock partition or sub-macroblock partition in the macroblock are derived as follows.

– If mb_type is not equal to P_8x8, P_8x8ref0, B_Skip, B_Direct_16x16, or B_8x8, subMbPartIdx is set equal to 0, and partWidth and partHeight are derived as

$$partWidth = MbPartWidth(mb\_type) \quad (8\text{-}156)$$

$$partHeight = MbPartHeight(mb\_type) \quad (8\text{-}157)$$

– Otherwise, if mb_type is equal to P_8x8 or P_8x8ref0, or mb_type is equal to B_8x8 and sub_mb_type[mbPartIdx] is not equal to B_Direct_8x8, subMbPartIdx proceeds over values 0..NumSubMbPart(sub_mb_type) – 1, and partWidth and partHeight are derived as

$$partWidth = SubMbPartWidth(sub\_mb\_type[mbPartIdx]) \quad (8\text{-}158)$$

$$partHeight = SubMbPartHeight(sub\_mb\_type[mbPartIdx]). \quad (8\text{-}159)$$

– Otherwise (mb_type is equal to B_Skip or B_Direct_16x16, or mb_type is equal to B_8x8 and sub_mb_type[mbPartIdx] is equal to B_Direct_8x8), subMbPartIdx proceeds over values 0..3, and partWidth and partHeight are derived as

$$partWidth = 4 \quad (8\text{-}160)$$

$$partHeight = 4 \quad (8\text{-}161)$$

When ChromaArrayType is not equal to 0, the variables partWidthC and partHeightC are derived as

$$partWidthC = partWidth / SubWidthC \quad (8\text{-}162)$$
$$partHeightC = partHeight / SubHeightC \quad (8\text{-}163)$$

Let the variable MvCnt be initially set equal to 0 before any invocation of subclause 8.4.1 for the macroblock.

The Inter prediction process for a macroblock partition mbPartIdx and a sub-macroblock partition subMbPartIdx consists of the following ordered steps

1. Derivation process for motion vector components and reference indices as specified in subclause 8.4.1.

   Inputs to this process are

   – a macroblock partition mbPartIdx,

   – a sub-macroblock partition subMbPartIdx.

   Outputs of this process are

   – luma motion vectors mvL0 and mvL1 and when ChromaArrayType is not equal to 0, the chroma motion vectors mvCL0 and mvCL1,

– reference indices refIdxL0 and refIdxL1,

– prediction list utilization flags predFlagL0 and predFlagL1,

– the sub-macroblock partition motion vector count subMvCnt.

2. The variable MvCnt is incremented by subMvCnt.

3. Derivation process for prediction weights as specified in subclause 8.4.3.

   Inputs to this process are

   – reference indices refIdxL0 and refIdxL1,

   – prediction list utilization flags predFlagL0 and predFlagL1.

   Outputs of this process are

   – variables for weighted prediction $logWD_C$, w_{0C}, w_{1C}, o_{0C}, o_{1C} with C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr.

4. Decoding process for Inter prediction samples as specified in subclause 8.4.2.

   Inputs to this process are

   – a macroblock partition mbPartIdx,

   – a sub-macroblock partition subMbPartIdx,

   – variables specifying partition width and height for luma and chroma (if available), partWidth, partHeight, partWidthC (if available), and partHeightC (if available),

   – luma motion vectors mvL0 and mvL1 and when ChromaArrayType is not equal to 0, the chroma motion vectors mvCL0 and mvCL1,

   – reference indices refIdxL0 and refIdxL1,

   – prediction list utilization flags predFlagL0 and predFlagL1,

   – variables for weighted prediction $logWD_C$, w_{0C}, w_{1C}, o_{0C}, o_{1C} with C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr.

   Outputs of this process are

   – inter prediction samples (pred); which are a (partWidth)x(partHeight) array $predPart_L$ of prediction luma samples and when ChromaArrayType is not equal to 0 two (partWidthC)x(partHeightC) arrays $predPart_{Cr}$, and $predPart_{Cb}$ of prediction chroma samples, one for each of the chroma components Cb and Cr.

For use in derivation processes of variables invoked later in the decoding process, the following assignments are made:

MvL0[mbPartIdx][subMbPartIdx] = mvL0 (8-164)

MvL1[mbPartIdx][subMbPartIdx] = mvL1 (8-165)

RefIdxL0[mbPartIdx] = refIdxL0 (8-166)

RefIdxL1[mbPartIdx] = refIdxL1 (8-167)

PredFlagL0[mbPartIdx] = predFlagL0 (8-168)

PredFlagL1[mbPartIdx] = predFlagL1 (8-169)

The location of the upper-left sample of the partition relative to the upper-left sample of the macroblock is derived by invoking the inverse macroblock partition scanning process as described in subclause 6.4.2.1 with mbPartIdx as the input and (xP, yP) as the output.

The location of the upper-left sample of the macroblock sub-partition relative to the upper-left sample of the macroblock partition is derived by invoking the inverse sub-macroblock partition scanning process as described in subclause 6.4.2.2 with subMbPartIdx as the input and (xS, yS) as the output.

The macroblock prediction is formed by placing the partition or sub-macroblock partition prediction samples in their correct relative positions in the macroblock, as follows.

The variable $pred_L[xP + xS + x, yP + yS + y]$ with x = 0 .. partWidth – 1, y = 0 .. partHeight – 1 is derived by

$$pred_L[xP + xS + x, yP + yS + y] = predPart_L[x, y] \quad (8\text{-}170)$$

When ChromaArrayType is not equal to 0, the variable $pred_C$ with x = 0..partWidthC – 1, y = 0..partHeightC – 1, and C in $pred_C$ and $predPart_C$ being replaced by Cb or Cr is derived by

$$pred_C[xP / SubWidthC + xS / SubWidthC + x, yP / SubHeightC + yS / SubHeightC + y] = predPart_C[x, y] \quad (8\text{-}171)$$

8.4.1 Derivation process for motion vector components and reference indices

Inputs to this process are

– a macroblock partition mbPartIdx,

– a sub-macroblock partition subMbPartIdx.

Outputs of this process are

– luma motion vectors mvL0 and mvL1 and when ChromaArrayType is not equal to 0, the chroma motion vectors mvCL0 and mvCL1,

– reference indices refIdxL0 and refIdxL1,

– prediction list utilization flags predFlagL0 and predFlagL1,

– a sub-partition macroblock motion vector count variable subMvCnt.

For the derivation of the variables mvL0 and mvL1 as well as refIdxL0 and refIdxL1, the following applies.

– If mb_type is equal to P_Skip, the derivation process for luma motion vectors for skipped macroblocks in P and SP slices in subclause 8.4.1.1 is invoked with the output being the luma motion vectors mvL0 and reference indices refIdxL0, and predFlagL0 is set equal to 1. mvL1 and refIdxL1 are marked as not available and predFlagL1 is set equal to 0. The sub-partition motion vector count variable subMvCnt is set equal to 1.

– Otherwise, if mb_type is equal to B_Skip or B_Direct_16x16 or sub_mb_type[mbPartIdx] is equal to B_Direct_8x8, the derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8 in B slices in subclause 8.4.1.2 is invoked with mbPartIdx and subMbPartIdx as the input and the output being the luma motion vectors mvL0, mvL1, the reference indices refIdxL0, refIdxL1, the sub-partition motion vector count subMvCnt, and the prediction utilization flags predFlagL0 and predFlagL1.

– Otherwise, for X being replaced by either 0 or 1 in the variables predFlagLX, mvLX, refIdxLX, and in Pred_LX and in the syntax elements ref_idx_lX and mvd_lX, the following applies.

1. The variables refIdxLX and predFlagLX are derived as follows.

   – If MbPartPredMode(mb_type, mbPartIdx) or SubMbPredMode(sub_mb_type[mbPartIdx]) is equal to Pred_LX or to BiPred,

   $$refIdxLX = ref\_idx\_lX[mbPartIdx] \quad (8\text{-}172)$$

   $$predFlagLX = 1 \quad (8\text{-}173)$$

   – Otherwise, the variables refIdxLX and predFlagLX are specified by

   $$refIdxLX = -1 \quad (8\text{-}174)$$

   $$predFlagLX = 0 \quad (8\text{-}175)$$

2. The variable subMvCnt for sub-partition motion vector count is set equal to predFlagL0 + predFlagL1.

3. The variable currSubMbType is derived as follows.
   – If the macroblock type is equal to B_8x8, currSubMbType is set equal to sub_mb_type[mbPartIdx].
   – Otherwise (the macroblock type is not equal to B_8x8), currSubMbType is set equal to "na".
4. When predFlagLX is equal to 1, the derivation process for luma motion vector prediction in subclause 8.4.1.3 is invoked with mbPartIdx subMbPartIdx, refIdxLX, and currSubMbType as the inputs and the output being mvpLX. The luma motion vectors are derived by

$$mvLX[0] = mvpLX[0] + mvd\_lX[mbPartIdx][subMbPartIdx][0] \quad (8\text{-}176)$$

$$mvLX[1] = mvpLX[1] + mvd\_lX[mbPartIdx][subMbPartIdx][1] \quad (8\text{-}177)$$

When ChromaArrayType is not equal to 0 and predFlagLX (with X being either 0 or 1) is equal to 1, the derivation process for chroma motion vectors in subclause 8.4.1.4 is invoked with mvLX and refIdxLX as input and the output being mvCLX.

8.4.1.1 Derivation process for luma motion vectors for skipped macroblocks in P and SP slices

This process is invoked when mb_type is equal to P_Skip.

Outputs of this process are the motion vector mvL0 and the reference index refIdxL0.

The reference index refIdxL0 for a skipped macroblock is derived as follows.

$$refIdxL0 = 0. \quad (8\text{-}178)$$

For the derivation of the motion vector mvL0 of a P_Skip macroblock type, the following applies.

– The process specified in subclause 8.4.1.3.2 is invoked with mbPartIdx set equal to 0, subMbPartIdx set equal to 0, currSubMbType set equal to "na", and listSuffixFlag set equal to 0 as input and the output is assigned to mbAddrA, mbAddrB, mvL0A, mvL0B, refIdxL0A, and refIdxL0B.
– The variable mvL0 is specified as follows.
  – If any of the following conditions are true, both components of the motion vector mvL0 are set equal to 0.
    – mbAddrA is not available
    – mbAddrB is not available
    – refIdxL0A is equal to 0 and both components of mvL0A are equal to 0
    – refIdxL0B is equal to 0 and both components of mvL0B are equal to 0
  – Otherwise, the derivation process for luma motion vector prediction as specified in subclause 8.4.1.3 is invoked with mbPartIdx = 0, subMbPartIdx = 0, refIdxL0, and currSubMbType = "na" as inputs and the output is assigned to mvL0.

NOTE – The output is directly assigned to mvL0, since the predictor is equal to the actual motion vector.

8.4.1.2 Derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8

This process is invoked when mb_type is equal to B_Skip or B_Direct_16x16, or sub_mb_type[mbPartIdx] is equal to B_Direct_8x8.

Inputs to this process are mbPartIdx and subMbPartIdx.

Outputs of this process are the reference indices refIdxL0, refIdxL1, the motion vectors mvL0 and mvL1, the sub-partition motion vector count subMvCnt, and the prediction list utilization flags, predFlagL0 and predFlagL1.

The derivation process depends on the value of direct_spatial_mv_pred_flag, which is present in the bitstream in the slice header syntax as specified in subclause 7.3.3, and is specified as follows.

– If direct_spatial_mv_pred_flag is equal to 1, the mode in which the outputs of this process are derived is referred to as spatial direct prediction mode.
– Otherwise (direct_spatial_mv_pred_flag is equal to 0), mode in which the outputs of this process are derived is referred to as temporal direct prediction mode.

Both spatial and temporal direct prediction mode use the co-located motion vectors and reference indices as specified in subclause 8.4.1.2.1.

The motion vectors and reference indices are derived as follows.

– If spatial direct prediction mode is used, the direct motion vector and reference index prediction mode specified in subclause 8.4.1.2.2 is used, with subMvCnt being an output.

– Otherwise (temporal direct prediction mode is used), the direct motion vector and reference index prediction mode specified in subclause 8.4.1.2.3 is used and the variable subMvCnt is derived as follows.

  – If subMbPartIdx is equal to 0, subMvCnt is set equal to 2.

  – Otherwise (subMbPartIdx is not equal to 0), subMvCnt is set equal to 0.

8.4.1.2.1 Derivation process for the co-located 4x4 sub-macroblock partitions

Inputs to this process are mbPartIdx and subMbPartIdx.

Outputs of this process are the picture colPic, the co-located macroblock mbAddrCol, the motion vector mvCol, the reference index refIdxCol, and the variable vertMvScale (which can be One_To_One, Frm_To_Fld or Fld_To_Frm).

When RefPicList1[0] is a frame or a complementary field pair, let firstRefPicL1Top and firstRefPicL1Bottom be the top and bottom fields of RefPicList1[0], respectively, and let the following variables be specified as

topAbsDiffPOC = Abs(DiffPicOrderCnt(firstRefPicL1Top, CurrPic)) (8-179)

bottomAbsDiffPOC = Abs(DiffPicOrderCnt(firstRefPicL1Bottom, CurrPic)) (8-180)

The variable colPic specifies the picture that contains the co-located macroblock as specified in Table 8-6.

Table 8-6 – Specification of the variable colPic

field_pic_flag	RefPicList1[0] is …	mb_field_decoding_flag	additional condition	colPic
1	a field of a decoded frame			the frame containing RefPicList1[0]
	a decoded field			RefPicList1[0]
0	a decoded frame			RefPicList1[0]
	a complementary field pair	0	topAbsDiffPOC < bottomAbsDiffPOC	firstRefPicL1Top
			topAbsDiffPOC >= bottomAbsDiffPOC	firstRefPicL1Bottom
		1	(CurrMbAddr & 1) = = 0	firstRefPicL1Top
			(CurrMbAddr & 1) != 0	firstRefPicL1Bottom

When direct_8x8_inference_flag is equal to 1, subMbPartIdx is set as follows.

subMbPartIdx = mbPartIdx (8-181)

Let PicCodingStruct(X) be a function with the argument X being either CurrPic or colPic. It is specified in Table 8-7.

Table 8-7 – Specification of PicCodingStruct(X)

X is coded with field_pic_flag equal to …	mb_adaptive_frame_field_flag	PicCodingStruct(X)
1		FLD
0	0	FRM
0	1	AFRM

With luma4x4BlkIdx = mbPartIdx * 4 + subMbPartIdx, the inverse 4x4 luma block scanning process as specified in subclause 6.4.3 is invoked with luma4x4BlkIdx as the input and (x, y) assigned to (xCol, yCol) as the output.

Table 8-8 specifies the co-located macroblock address mbAddrCol, yM, and the variable vertMvScale in two steps:

1. Specification of a macroblock address mbAddrX depending on PicCodingStruct(CurrPic), and PicCodingStruct(colPic).

   NOTE – It is not possible for CurrPic and colPic picture coding types to be either (FRM, AFRM) or (AFRM, FRM) because these picture coding types must be separated by an IDR picture.

2. Specification of mbAddrCol, yM, and vertMvScale depending on mb_field_decoding_flag and the variable fieldDecodingFlagX, which is derived as follows.

   – If the macroblock mbAddrX in the picture colPic is a field macroblock, fieldDecodingFlagX is set equal to 1

   – Otherwise (the macroblock mbAddrX in the picture colPic is a frame macroblock), fieldDecodingFlagX is set equal to 0.

Unspecified values in Table 8-8 indicate that the value of the corresponding variable is not relevant for the current table row.

mbAddrCol is set equal to CurrMbAddr or to one of the following values.

$$mbAddrCol1 = 2 * PicWidthInMbs * (CurrMbAddr / PicWidthInMbs) + (CurrMbAddr \% PicWidthInMbs) + PicWidthInMbs * (yCol / 8) \quad (8\text{-}182)$$

$$mbAddrCol2 = 2 * CurrMbAddr + (yCol / 8) \quad (8\text{-}183)$$

$$mbAddrCol3 = 2 * CurrMbAddr + bottom\_field\_flag \quad (8\text{-}184)$$

$$mbAddrCol4 = PicWidthInMbs * (CurrMbAddr / (2 * PicWidthInMbs)) + (CurrMbAddr \% PicWidthInMbs) \quad (8\text{-}185)$$

$$mbAddrCol5 = CurrMbAddr / 2 \quad (8\text{-}186)$$

$$mbAddrCol6 = 2 * (CurrMbAddr / 2) + ((topAbsDiffPOC < bottomAbsDiffPOC) ? 0 : 1) \quad (8\text{-}187)$$

$$mbAddrCol7 = 2 * (CurrMbAddr / 2) + (yCol / 8) \quad (8\text{-}188)$$

Table 8-8 – Specification of mbAddrCol, yM, and vertMvScale

PicCodingStruct(CurrPic)	PicCodingStruct(colPic)	mbAddrX	mb_field_decoding_flag	fieldDecodingFlagX	mbAddrCol	yM	vertMvScale
FLD	FLD				CurrMbAddr	yCol	One_To_One
	FRM				mbAddrCol1	(2 * yCol) % 16	Frm_To_Fld
	AFRM	2*CurrMbAddr		0	mbAddrCol2	(2 * yCol) % 16	Frm_To_Fld
				1	mbAddrCol3	yCol	One_To_One
FRM	FLD				mbAddrCol4	8 * ((CurrMbAddr / PicWidthInMbs) % 2) + 4 * (yCol / 8)	Fld_To_Frm
	FRM				CurrMbAddr	yCol	One_To_One
AFRM	FLD		0		mbAddrCol5	8 * (CurrMbAddr % 2) +4 * (yCol / 8)	Fld_To_Frm
			1		mbAddrCol5	yCol	One_To_One
	AFRM	CurrMbAddr	0	0	CurrMbAddr	yCol	One_To_One
				1	mbAddrCol6	8 * (CurrMbAddr % 2) + 4 * (yCol / 8)	Fld_To_Frm
		CurrMbAddr	1	0	mbAddrCol7	(2 * yCol) % 16	Frm_To_Fld
				1	CurrMbAddr	yCol	One_To_One

Let mbPartIdxCol be the macroblock partition index of the co-located partition and subMbPartIdxCol the sub-macroblock partition index of the co-located sub-macroblock partition. The partition in the macroblock mbAddrCol inside the picture colPic covering the sample (xCol, yM) is assigned to mbPartIdxCol and the sub-macroblock partition inside the partition mbPartIdxCol covering the sample (xCol, yM) in the macroblock mbAddrCol inside the picture colPic is assigned to subMbPartIdxCol.

The prediction utilization flags predFlagL0Col and predFlagL1Col are set equal to PredFlagL0[mbPartIdxCol] and PredFlagL1[mbPartIdxCol], respectively, which are the prediction utilization flags that have been assigned to the macroblock partition mbAddrCol\mbPartIdxCol inside the picture colPic.

The motion vector mvCol and the reference index refIdxCol are derived as follows.

– If the macroblock mbAddrCol is coded in Intra macroblock prediction mode or both prediction utilization flags, predFlagL0Col and predFlagL1Col are equal to 0, both components of mvCol are set equal to 0 and refIdxCol is set equal to –1.

– Otherwise, the following applies.

  – If predFlagL0Col is equal to 1, the motion vector mvCol and the reference index refIdxCol are set equal to MvL0[mbPartIdxCol][subMbPartIdxCol] and RefIdxL0[mbPartIdxCol], respectively, which are the motion vector mvL0 and the reference index refIdxL0 that have been assigned to the (sub-)macroblock partition mbAddrCol\mbPartIdxCol\subMbPartIdxCol inside the picture colPic.

  – Otherwise (predFlagL0Col is equal to 0 and predFlagL1Col is equal to 1), the motion vector mvCol and the reference index refIdxCol are set equal to MvL1[mbPartIdxCol][subMbPartIdxCol] and RefIdxL1[mbPartIdxCol], respectively, which are the motion vector mvL1 and the reference index refIdxL1

that have been assigned to the (sub-)macroblock partition mbAddrCol\mbPartIdxCol\subMbPartIdxCol inside the picture colPic.

8.4.1.2.2 Derivation process for spatial direct luma motion vector and reference index prediction mode

This process is invoked when direct_spatial_mv_pred_flag is equal to 1 and any of the following conditions is true.

- mb_type is equal to B_Skip
- mb_type is equal to B_Direct_16x16
- sub_mb_type[mbPartIdx] is equal to B_Direct_8x8.

Inputs to this process are mbPartIdx, subMbPartIdx.

Outputs of this process are the reference indices refIdxL0, refIdxL1, the motion vectors mvL0 and mvL1, the sub-partition motion vector count subMvCnt, and the prediction list utilization flags, predFlagL0 and predFlagL1.

The reference indices refIdxL0 and refIdxL1 and the variable directZeroPredictionFlag are derived by applying the following ordered steps.

1. Let the variable currSubMbType be set equal to sub_mb_type[mbPartIdx].
2. The process specified in subclause 8.4.1.3.2 is invoked with mbPartIdx = 0, subMbPartIdx = 0, currSubMbType, and listSuffixFlag = 0 as inputs and the output is assigned to the motion vectors mvL0N and the reference indices refIdxL0N with N being replaced by A, B, or C.
3. The process specified in subclause 8.4.1.3.2 is invoked with mbPartIdx = 0, subMbPartIdx = 0, currSubMbType, and listSuffixFlag = 1 as inputs and the output is assigned to the motion vectors mvL1N and the reference indices refIdxL1N with N being replaced by A, B, or C.

   NOTE 1 – The motion vectors mvL0N, mvL1N and the reference indices refIdxL0N, refIdxL1N are identical for all 4x4 sub-macroblock partitions of a macroblock.

4. The reference indices refIdxL0, refIdxL1, and directZeroPredictionFlag are derived by

$$refIdxL0 = MinPositive(refIdxL0A, MinPositive(refIdxL0B, refIdxL0C)) \quad (8\text{-}189)$$
$$refIdxL1 = MinPositive(refIdxL1A, MinPositive(refIdxL1B, refIdxL1C)) \quad (8\text{-}190)$$
$$directZeroPredictionFlag = 0 \quad (8\text{-}191)$$

   where

$$MinPositive(x, y) = \begin{cases} Min(x, y) & \text{if } x >= 0 \text{ and } y >= 0 \\ Max(x, y) & \text{otherwise} \end{cases} \quad (8\text{-}192)$$

5. When both reference indices refIdxL0 and refIdxL1 are less than 0,

$$refIdxL0 = 0 \quad (8\text{-}193)$$
$$refIdxL1 = 0 \quad (8\text{-}194)$$
$$directZeroPredictionFlag = 1 \quad (8\text{-}195)$$

The process specified in subclause 8.4.1.2.1 is invoked with mbPartIdx, subMbPartIdx given as input and the output is assigned to refIdxCol and mvCol.

The variable colZeroFlag is derived as follows.

- If all of the following conditions are true, colZeroFlag is set equal to 1.
  - RefPicList1[0] is currently marked as "used for short-term reference",
  - refIdxCol is equal to 0,
  - both motion vector components mvCol[0] and mvCol[1] lie in the range of -1 to 1 in units specified as follows.
    - If the co-located macroblock is a frame macroblock, the units of mvCol[0] and mvCol[1] are units of quarter luma frame samples.

– Otherwise (the co-located macroblock is a field macroblock), the units of mvCol[0] and mvCol[1] are units of quarter luma field samples.

NOTE 2 – For purposes of determining the condition above, the value mvCol[1] is not scaled to use the units of a motion vector for the current macroblock in cases when the current macroblock is a frame macroblock and the co-located macroblock is a field macroblock or when the current macroblock is a field macroblock and the co-located macroblock is a frame macroblock. This aspect differs from the use of mvCol[1] in the temporal direct mode as specified in subclause 8.4.1.2.3, which applies scaling to the motion vector of the co-located macroblock to use the same units as the units of a motion vector for the current macroblock, using Equation 8-198 or Equation 8-199 in these cases.

– Otherwise, colZeroFlag is set equal to 0.

The motion vectors mvLX (with X being 0 or 1) are derived as follows.

– If any of the following conditions is true, both components of the motion vector mvLX are set equal to 0.

  – directZeroPredictionFlag is equal to 1

  – refIdxLX is less than 0

  – refIdxLX is equal to 0 and colZeroFlag is equal to 1

– Otherwise, the process specified in subclause 8.4.1.3 is invoked with mbPartIdx = 0, subMbPartIdx = 0, refIdxLX, and currSubMbType as inputs and the output is assigned to mvLX.

NOTE 3 – The motion vector mvLX returned from subclause 8.4.1.3 is identical for all 4x4 sub-macroblock partitions of a macroblock for which the process is invoked.

The prediction utilization flags predFlagL0 and predFlagL1 are derived as specified using Table 8-9.

Table 8-9 – Assignment of prediction utilization flags

refIdxL0	refIdxL1	predFlagL0	predFlagL1
>= 0	>= 0	1	1
>= 0	< 0	1	0
< 0	>= 0	0	1

The variable subMvCnt is derived as follows.

– If subMbPartIdx is not equal to 0, subMvCnt is set equal to 0.

– Otherwise (subMbPartIdx is equal to 0), subMvCnt is set equal to predFlagL0 + predFLagL1.

8.4.1.2.3 Derivation process for temporal direct luma motion vector and reference index prediction mode

This process is invoked when direct_spatial_mv_pred_flag is equal to 0 and any of the following conditions is true.

– mb_type is equal to B_Skip

– mb_type is equal to B_Direct_16x16

– sub_mb_type[mbPartIdx] is equal to B_Direct_8x8.

Inputs to this process are mbPartIdx and subMbPartIdx.

Outputs of this process are the motion vectors mvL0 and mvL1, the reference indices refIdxL0 and refIdxL1, and the prediction list utilization flags, predFlagL0 and predFlagL1.

The process specified in subclause 8.4.1.2.1 is invoked with mbPartIdx, subMbPartIdx given as input and the output is assigned to colPic, mbAddrCol, mvCol, refIdxCol, and vertMvScale.

The reference indices refIdxL0 and refIdxL1 are derived as follows.

refIdxL0 = ((refIdxCol < 0) ? 0 : MapColToList0(refIdxCol)) (8-196)

refIdxL1 = 0 (8-197)

NOTE 1 – If the current macroblock is a field macroblock, refIdxL0 and refIdxL1 index a list of fields; otherwise (the current macroblock is a frame macroblock), refIdxL0 and refIdxL1 index a list of frames or complementary reference field pairs.

Let refPicCol be a frame, a field, or a complementary field pair that was referred by the reference index refIdxCol when decoding the co-located macroblock mbAddrCol inside the picture colPic. The function MapColToList0(refIdxCol) is specified as follows.

– If vertMvScale is equal to One_To_One, the following applies.
  – If field_pic_flag is equal to 0 and the current macroblock is a field macroblock, the following applies.
    – Let refIdxL0Frm be the lowest valued reference index in the current reference picture list RefPicList0 that references the frame or complementary field pair that contains the field refPicCol. RefPicList0 shall contain a frame or complementary field pair that contains the field refPicCol. The return value of MapColToList0( ) is specified as follows.
      – If the field referred to by refIdxCol has the same parity as the current macroblock, MapColToList0(refIdxCol) returns the reference index (refIdxL0Frm << 1).
      – Otherwise (the field referred by refIdxCol has the opposite parity of the current macroblock), MapColToList0(refIdxCol) returns the reference index ((refIdxL0Frm << 1) + 1).
  – Otherwise (field_pic_flag is equal to 1 or the current macroblock is a frame macroblock), MapColToList0(refIdxCol) returns the lowest valued reference index refIdxL0 in the current reference picture list RefPicList0 that references refPicCol. RefPicList0 shall contain refPicCol.

– Otherwise, if vertMvScale is equal to Frm_To_Fld, the following applies.
  – If field_pic_flag is equal to 0, let refIdxL0Frm be the lowest valued reference index in the current reference picture list RefPicList0 that references refPicCol. MapColToList0(refIdxCol) returns the reference index (refIdxL0Frm << 1). RefPicList0 shall contain refPicCol.
  – Otherwise (field_pic_flag is equal to 1), MapColToList0(refIdxCol) returns the lowest valued reference index refIdxL0 in the current reference picture list RefPicList0 that references the field of refPicCol with the same parity as the current picture CurrPic. RefPicList0 shall contain the field of refPicCol with the same parity as the current picture CurrPic.

– Otherwise (vertMvScale is equal to Fld_To_Frm), MapColToList0(refIdxCol) returns the lowest valued reference index refIdxL0 in the current reference picture list RefPicList0 that references the frame or complementary field pair that contains refPicCol. RefPicList0 shall contain a frame or complementary field pair that contains the field refPicCol.

NOTE 2 – A decoded reference picture that was marked as "used for short-term reference" when it was referenced in the decoding process of the picture containing the co-located macroblock may have been modified to be marked as "used for long-term reference" before being used for reference for inter prediction using the direct prediction mode for the current macroblock.

Depending on the value of vertMvScale the vertical component of mvCol is modified as follows.

– If vertMvScale is equal to Frm_To_Fld

$$mvCol[1] = mvCol[1] / 2 \quad (8\text{-}198)$$

– Otherwise, if vertMvScale is equal to Fld_To_Frm

$$mvCol[1] = mvCol[1] * 2 \quad (8\text{-}199)$$

– Otherwise (vertMvScale is equal to One_To_One), mvCol[1] remains unchanged.

The variables currPicOrField, pic0, and pic1, are derived as follows.

– If field_pic_flag is equal to 0 and the current macroblock is a field macroblock, the following applies.
  – currPicOrField is the field of the current picture CurrPic that has the same parity as the current macroblock.
  – pic1 is the field of RefPicList1[0] that has the same parity as the current macroblock.
  – The variable pic0 is derived as follows.
    – If refIdxL0 % 2 is equal to 0, pic0 is the field of RefPicList0[refIdxL0 / 2] that has the same parity as the current macroblock.
    – Otherwise (refIdxL0 % 2 is not equal to 0), pic0 is the field of RefPicList0[refIdxL0 / 2] that has the opposite parity of the current macroblock.

– Otherwise (field_pic_flag is equal to 1 or the current macroblock is a frame macroblock), currPicOrField is the current picture CurrPic, pic1 is the decoded reference picture RefPicList1[0], and pic0 is the decoded reference picture RefPicList0[refIdxL0].

The two motion vectors mvL0 and mvL1 for each 4x4 sub-macroblock partition of the current macroblock are derived as follows:

NOTE 3 – It is often the case that many of the 4x4 sub-macroblock partitions share the same motion vectors and reference pictures. In these cases, temporal direct mode motion compensation can calculate the inter prediction sample values in larger units than 4x4 luma sample blocks. For example, when direct_8x8_inference_flag is equal to 1, at least each 8x8 luma sample quadrant of the macroblock shares the same motion vectors and reference pictures.

– If the reference index refIdxL0 refers to a long-term reference picture, or DiffPicOrderCnt(pic1, pic0) is equal to 0, the motion vectors mvL0, mvL1 for the direct mode partition are derived by

mvL0 = mvCol (8-200)

mvL1 = 0 (8-201)

– Otherwise, the motion vectors mvL0, mvL1 are derived as scaled versions of the motion vector mvCol of the co-located sub-macroblock partition as specified below (see Figure 8-2)

tx = (16 384 + Abs(td / 2)) / td (8-202)

DistScaleFactor = Clip3(-1024, 1023, (tb * tx + 32) >> 6) (8-203)

mvL0 = (DistScaleFactor * mvCol + 128) >> 8 (8-204)

mvL1 = mvL0 – mvCol (8-205)

where tb and td are derived as follows.

tb = Clip3(-128, 127, DiffPicOrderCnt(currPicOrField, pic0)) (8-206)

td = Clip3(-128, 127, DiffPicOrderCnt(pic1, pic0)) (8-207)

NOTE 4 – mvL0 and mvL1 cannot exceed the ranges specified in Annex A.

The prediction utilization flags predFlagL0 and predFlagL1 are both set equal to 1.

Figure 8-2 illustrates the temporal direct-mode motion vector inference when the current picture is temporally between the reference picture from reference picture list 0 and the reference picture from reference picture list 1.

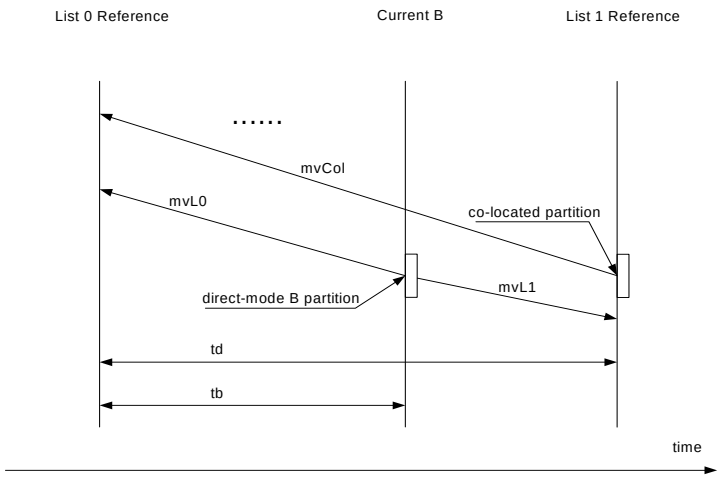


Figure 8-2 – Example for temporal direct-mode motion vector inference (informative)

8.4.1.3 Derivation process for luma motion vector prediction

Inputs to this process are

– the macroblock partition index mbPartIdx,

– the sub-macroblock partition index subMbPartIdx,

– the reference index of the current partition refIdxLX (with X being 0 or 1),

– the variable currSubMbType.

Output of this process is the prediction mvpLX of the motion vector mvLX (with X being 0 or 1).

The derivation process for the neighbouring blocks for motion data in subclause 8.4.1.3.2 is invoked with mbPartIdx, subMbPartIdx, currSubMbType, and listSuffixFlag = X (with X being 0 or 1 for refIdxLX being refIdxL0 or refIdxL1, respectively) as the input and with mbAddrN\mbPartIdxN\subMbPartIdxN, reference indices refIdxLXN and the motion vectors mvLXN with N being replaced by A, B, or C as the output.

The derivation process for median luma motion vector prediction in subclause 8.4.1.3.1 is invoked with mbAddrN\mbPartIdxN\subMbPartIdxN, mvLXN, refIdxLXN with N being replaced by A, B, or C and refIdxLX as the input and mvpLX as the output, unless one of the following is true.

– MbPartWidth(mb_type) is equal to 16, MbPartHeight(mb_type) is equal to 8, mbPartIdx is equal to 0, and refIdxLXB is equal to refIdxLX,

$$mvpLX = mvLXB \tag{8-208}$$

– MbPartWidth(mb_type) is equal to 16, MbPartHeight(mb_type) is equal to 8, mbPartIdx is equal to 1, and refIdxLXA is equal to refIdxLX,

$$mvpLX = mvLXA \tag{8-209}$$

– MbPartWidth(mb_type) is equal to 8, MbPartHeight(mb_type) is equal to 16, mbPartIdx is equal to 0, and refIdxLXA is equal to refIdxLX,

$$mvpLX = mvLXA \tag{8-210}$$

– MbPartWidth(mb_type) is equal to 8, MbPartHeight(mb_type) is equal to 16, mbPartIdx is equal to 1, and refIdxLXC is equal to refIdxLX,

$$mvpLX = mvLXC \tag{8-211}$$

Figure 8-3 illustrates the non-median prediction as specified in the four bulleted items above.

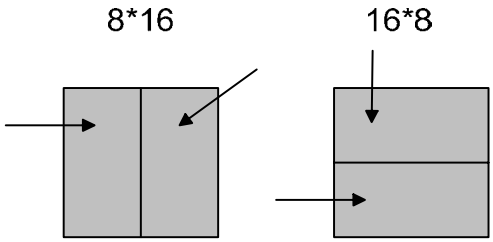


Figure 8-3 – Directional segmentation prediction (informative)

8.4.1.3.1 Derivation process for median luma motion vector prediction

Inputs to this process are

– the neighbouring partitions mbAddrN\mbPartIdxN\subMbPartIdxN (with N being replaced by A, B, or C),

– the motion vectors mvLXN (with N being replaced by A, B, or C) of the neighbouring partitions,

– the reference indices refIdxLXN (with N being replaced by A, B, or C) of the neighbouring partitions, and

– the reference index refIdxLX of the current partition.

Output of this process is the motion vector prediction mvpLX.

The variable mvpLX is derived as follows:

– When both partitions mbAddrB\mbPartIdxB\subMbPartIdxB and mbAddrC\mbPartIdxC\subMbPartIdxC are not available and mbAddrA\mbPartIdxA\subMbPartIdxA is available,

$$mvLXB = mvLXA \tag{8-212}$$

$$mvLXC = mvLXA \tag{8-213}$$

$$refIdxLXB = refIdxLXA \tag{8-214}$$

$$refIdxLXC = refIdxLXA \tag{8-215}$$

– Depending on reference indices refIdxLXA, refIdxLXB, or refIdxLXC, the following applies.

  – If one and only one of the reference indices refIdxLXA, refIdxLXB, or refIdxLXC is equal to the reference index refIdxLX of the current partition, the following applies. Let refIdxLXN be the reference index that is equal to refIdxLX, the motion vector mvLXN is assigned to the motion vector prediction mvpLX:

$$mvpLX = mvLXN \tag{8-216}$$

  – Otherwise, each component of the motion vector prediction mvpLX is given by the median of the corresponding vector components of the motion vector mvLXA, mvLXB, and mvLXC:

$$mvpLX[0] = Median(mvLXA[0], mvLXB[0], mvLXC[0]) \tag{8-217}$$

$$mvpLX[1] = Median(mvLXA[1], mvLXB[1], mvLXC[1]) \tag{8-218}$$

8.4.1.3.2 Derivation process for motion data of neighbouring partitions

Inputs to this process are

– the macroblock partition index mbPartIdx,

– the sub-macroblock partition index subMbPartIdx,

– the current sub-macroblock type currSubMbType,

– the list suffix flag listSuffixFlag.

Outputs of this process are (with N being replaced by A, B, or C)

– mbAddrN\mbPartIdxN\subMbPartIdxN specifying neighbouring partitions,

– the motion vectors mvLXN of the neighbouring partitions, and

– the reference indices refIdxLXN of the neighbouring partitions.

Variable names that include the string "LX" are interpreted with the X being equal to listSuffixFlag.

The partitions mbAddrN\mbPartIdxN\subMbPartIdxN with N being either A, B, or C are derived in the following ordered steps.

1. Let mbAddrD\mbPartIdxD\subMbPartIdxD be variables specifying an additional neighbouring partition.

– The process in subclause 6.4.10.7 is invoked with mbPartIdx, currSubMbType, and subMbPartIdx as input and the output is assigned to mbAddrN\mbPartIdxN\subMbPartIdxN with N being replaced by A, B, C, or D.

2. When the partition mbAddrC\mbPartIdxC\subMbPartIdxC is not available, the following applies

$$mbAddrC = mbAddrD \tag{8-219}$$

$$mbPartIdxC = mbPartIdxD \tag{8-220}$$

$$subMbPartIdxC = subMbPartIdxD \tag{8-221}$$

The motion vectors mvLXN and reference indices refIdxLXN (with N being A, B, or C) are derived as follows.

– If the macroblock partition or sub-macroblock partition mbAddrN\mbPartIdxN\subMbPartIdxN is not available or mbAddrN is coded in Intra prediction mode or predFlagLX of mbAddrN\mbPartIdxN\subMbPartIdxN is equal to 0, both components of mvLXN are set equal to 0 and refIdxLXN is set equal to –1.

– Otherwise, the following applies.

  – The motion vector mvLXN and reference index refIdxLXN are set equal to MvLX[mbPartIdxN][subMbPartIdxN] and RefIdxLX[mbPartIdxN], respectively, which are the motion vector mvLX and reference index refIdxLX that have been assigned to the (sub-)macroblock partition mbAddrN\mbPartIdxN\subMbPartIdxN.

  – The variables mvLXN[1] and refIdxLXN are further processed as follows.

    – If the current macroblock is a field macroblock and the macroblock mbAddrN is a frame macroblock

$$mvLXN[1] = mvLXN[1] / 2 \tag{8-222}$$

$$refIdxLXN = refIdxLXN * 2 \tag{8-223}$$

    – Otherwise, if the current macroblock is a frame macroblock and the macroblock mbAddrN is a field macroblock

$$mvLXN[1] = mvLXN[1] * 2 \tag{8-224}$$

$$refIdxLXN = refIdxLXN / 2 \tag{8-225}$$

– Otherwise, the vertical motion vector component mvLXN[1] and the reference index refIdxLXN remain unchanged.

8.4.1.4 Derivation process for chroma motion vectors

This process is only invoked when ChromaArrayType is not equal to 0.

Inputs to this process are a luma motion vector mvLX and a reference index refIdxLX.

Output of this process is a chroma motion vector mvCLX.

A chroma motion vector is derived from the corresponding luma motion vector.

The precision of the chroma motion vector components is 1 ÷ (4 * SubWidthC) horizontally and 1 ÷ (4 * SubHeightC) vertically.

NOTE – For example, when using the 4:2:0 chroma format, since the units of luma motion vectors are one-quarter luma sample units and chroma has half horizontal and vertical resolution compared to luma, the units of chroma motion vectors are one-eighth chroma sample units, i.e., a value of 1 for the chroma motion vector refers to a one-eighth chroma sample displacement. For example, when the luma vector applies to 8x16 luma samples, the corresponding chroma vector in 4:2:0 chroma format applies to 4x8 chroma samples and when the luma vector applies to 4x4 luma samples, the corresponding chroma vector in 4:2:0 chroma format applies to 2x2 chroma samples.

For the derivation of the motion vector mvCLX, the following applies.

– If ChromaArrayType is not equal to 1 or the current macroblock is a frame macroblock, the horizontal and vertical components of the chroma motion vector mvCLX are derived as

$$mvCLX[0] = mvLX[0] \quad (8\text{-}226)$$
$$mvCLX[1] = mvLX[1] \quad (8\text{-}227)$$

– Otherwise (ChromaArrayType is equal to 1 and the current macroblock is a field macroblock), only the horizontal component of the chroma motion vector mvCLX[0] is derived using Equation 8-226. The vertical component of the chroma motion vector mvCLX[1] is dependent on the parity of the current field or the current macroblock and the reference picture, which is referred by the reference index refIdxLX. mvCLX[1] is derived from mvLX[1] according to Table 8-10.

Table 8-10 – Derivation of the vertical component of the chroma vector in field coding mode

Parity conditions		**mvCLX[1]**
Reference picture (refIdxLX)	Current field (picture/macroblock)	
Top field	Bottom field	mvLX[1] + 2
Bottom field	Top field	mvLX[1] – 2
Otherwise		mvLX[1]

8.4.2 Decoding process for Inter prediction samples

Inputs to this process are

– a macroblock partition mbPartIdx,

– a sub-macroblock partition subMbPartIdx.

– variables specifying partition width and height for luma and chroma (if available), partWidth, partHeight, partWidthC (if available) and partHeightC (if available)

– luma motion vectors mvL0 and mvL1 and when ChromaArrayType is not equal to 0 chroma motion vectors mvCL0 and mvCL1

– reference indices refIdxL0 and refIdxL1

– prediction list utilization flags, predFlagL0 and predFlagL1,

– variables for weighted prediction $logWD_C$, w_{0C}, w_{1C}, o_{0C}, o_{1C} with C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr.

Outputs of this process are

– the Inter prediction samples predPart, which are a (partWidth)x(partHeight) array $predPart_L$ of prediction luma samples, and when ChromaArrayType is not equal to 0 two (partWidthC)x(partHeightC) arrays $predPart_{Cb}$, $predPart_{Cr}$ of prediction chroma samples, one for each of the chroma components Cb and Cr.

Let $predPartL0_L$ and $predPartL1_L$ be (partWidth)x(partHeight) arrays of predicted luma sample values and when ChromaArrayType is not equal to 0 $predPartL0_{Cb}$, $predPartL1_{Cb}$, $predPartL0_{Cr}$, and $predPartL1_{Cr}$ be (partWidthC)x(partHeightC) arrays of predicted chroma sample values.

For LX being replaced by either L0 or L1 in the variables predFlagLX, RefPicListX, refIdxLX, refPicLX, predPartLX, the following is specified.

When predFlagLX is equal to 1, the following applies.

– The reference picture consisting of an ordered two-dimensional array $refPicLX_L$ of luma samples and when ChromaArrayType is not equal to 0 two ordered two-dimensional arrays $refPicLX_{Cb}$ and $refPicLX_{Cr}$ of chroma samples is derived by invoking the process specified in subclause 8.4.2.1 with refIdxLX and RefPicListX given as input.

– The array $predPartLX_L$ and when ChromaArrayType is not equal to 0 the arrays $predPartLX_{Cb}$ and $predPartLX_{Cr}$ are derived by invoking the process specified in subclause 8.4.2.2 with the current partition specified by mbPartIdx\subMbPartIdx, the motion vectors mvLX, mvCLX (if available), and the reference arrays with $refPicLX_L$, $refPicLX_{Cb}$ (if available), and $refPicLX_{Cr}$ (if available) given as input.

For C being replaced by L, Cb (if available), or Cr (if available), the array $predPart_C$ of the prediction samples of component C is derived by invoking the process specified in subclause 8.4.2.3 with the current partition specified by mbPartIdx and subMbPartIdx, the prediction utilization flags predFlagL0 and predFlagL1, the arrays $predPartL0_C$ and $predPartL1_C$, and the variables for weighted prediction $logWD_C$, w_{0C}, w_{1C}, o_{0C}, o_{1C} given as input.

8.4.2.1 Reference picture selection process

Input to this process is a reference index refIdxLX.

Output of this process is a reference picture consisting of a two-dimensional array of luma samples $refPicLX_L$ and, when ChromaArrayType is not equal to 0, two two-dimensional arrays of chroma samples $refPicLX_{Cb}$ and $refPicLX_{Cr}$.

Depending on field_pic_flag, the reference picture list RefPicListX (which has been derived as specified in subclause 8.2.4) consists of the following.

– If field_pic_flag is equal to 1, each entry of RefPicListX is a reference field or a field of a reference frame.

– Otherwise (field_pic_flag is equal to 0), each entry of RefPicListX is a reference frame or a complementary reference field pair.

For the derivation of the reference picture, the following applies.

– If field_pic_flag is equal to 1, the reference field or field of a reference frame RefPicListX[refIdxLX] is the output. The output reference field or field of a reference frame consists of a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array of luma samples $refPicLX_L$ and, when ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays of chroma samples $refPicLX_{Cb}$ and $refPicLX_{Cr}$.

– Otherwise (field_pic_flag is equal to 0), the following applies.

  – If the current macroblock is a frame macroblock, the reference frame or complementary reference field pair RefPicListX[refIdxLX] is the output. The output reference frame or complementary reference field pair consists of a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array of luma samples $refPicLX_L$ and, when ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays of chroma samples $refPicLX_{Cb}$ and $refPicLX_{Cr}$.

  – Otherwise (the current macroblock is a field macroblock), the following applies.

    – Let refFrame be the reference frame or complementary reference field pair RefPicListX[refIdxLX / 2].

    – The field of refFrame is selected as follows.

      – If refIdxLX % 2 is equal to 0, the field of refFrame that has the same parity as the current macroblock is the output.

– Otherwise (refIdxLX % 2 is equal to 1), the field of refFrame that has the opposite parity as the current macroblock is the output.

– The output reference field or field of a reference frame consists of a (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$ / 2) array of luma samples refPicLX$_L$ and, when ChromaArrayType is not equal to 0, two (PicWidthInSamples$_C$)x(PicHeightInSamples$_C$ / 2) arrays of chroma samples refPicLX$_{Cb}$ and refPicLX$_{Cr}$.

Depending on separate_colour_plane_flag, the following applies.

– If separate_colour_plane_flag is equal to 0, the reference picture sample arrays refPicLX$_L$, refPicLX$_{Cb}$ (if available), and refPicLX$_{Cr}$ (if available) correspond to decoded sample arrays S_L, S_{Cb} (if available), S_{Cr} (if available) derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.

– Otherwise (separate_colour_plane_flag is equal to 1), the following applies.

  – If colour_plane_id is equal to 0, the reference picture sample array refPicLX$_L$ corresponds to the decoded sample array S_L derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.

  – Otherwise, if colour_plane_id is equal to 1, the reference picture sample array refPicLX$_L$ corresponds to the decoded sample array S_{Cb} derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.

  – Otherwise (colour_plane_id is equal to 2), the reference picture sample array refPicLX$_L$ corresponds to the decoded sample array S_{Cr} derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.

8.4.2.2 Fractional sample interpolation process

Inputs to this process are

– the current partition given by its partition index mbPartIdx and its sub-macroblock partition index subMbPartIdx,

– the width and height partWidth, partHeight of this partition in luma-sample units,

– a luma motion vector mvLX given in quarter-luma-sample units,

– when ChromaArrayType is not equal to 0, a chroma motion vector mvCLX with a precision of one-(4*SubWidthC)-th chroma-sample units horizontally and one-(4*SubHeightC)-th chroma-sample units vertically, and

– the selected reference picture sample arrays refPicLX$_L$, and when ChromaArrayType is not equal to 0, refPicLX$_{Cb}$, and refPicLX$_{Cr}$.

Outputs of this process are

– a (partWidth)x(partHeight) array predPartLX$_L$ of prediction luma sample values and

– when ChromaArrayType is not equal to 0, two (partWidthC)x(partHeightC) arrays predPartLX$_{Cb}$, and predPartLX$_{Cr}$ of prediction chroma sample values.

Let (xA_L, yA_L) be the location given in full-sample units of the upper-left luma sample of the current partition given by mbPartIdx\subMbPartIdx relative to the upper-left luma sample location of the given two-dimensional array of luma samples.

Let ($xInt_L$, $yInt_L$) be a luma location given in full-sample units and ($xFrac_L$, $yFrac_L$) be an offset given in quarter-sample units. These variables are used only inside this subclause for specifying general fractional-sample locations inside the reference sample arrays refPicLX$_L$, refPicLX$_{Cb}$ (if available), and refPicLX$_{Cr}$ (if available).

For each luma sample location ($0 <= x_L < partWidth$, $0 <= y_L < partHeight$) inside the prediction luma sample array predPartLX$_L$, the corresponding prediction luma sample value predPartLX$_L$[x_L, y_L] is derived as follows:

– The variables $xInt_L$, $yInt_L$, $xFrac_L$, and $yFrac_L$ are derived by

$$xInt_L = xA_L + (mvLX[0] >> 2) + x_L \quad (8\text{-}228)$$
$$yInt_L = yA_L + (mvLX[1] >> 2) + y_L \quad (8\text{-}229)$$

$xFrac_L = mvLX[\ 0\ ] \& 3$ (8-230)
$yFrac_L = mvLX[\ 1\ ] \& 3$ (8-231)

– The prediction luma sample value $predPartLX_L[\ x_L, y_L\ ]$ is derived by invoking the process specified in subclause 8.4.2.2.1 with ($xInt_L$, $yInt_L$), ($xFrac_L$, $yFrac_L$) and $refPicLX_L$ given as input.

When ChromaArrayType is not equal to 0, the following applies.

Let ($xInt_C$, $yInt_C$) be a chroma location given in full-sample units and ($xFrac_C$, $yFrac_C$) be an offset given in one-(4*SubWidthC)-th chroma-sample units horizontally and one-(4*SubHeightC)-th chroma-sample units vertically. These variables are used only inside this subclause for specifying general fractional-sample locations inside the reference sample arrays $refPicLX_{Cb}$, and $refPicLX_{Cr}$.

For each chroma sample location ($0 <= x_C < partWidthC$, $0 <= y_C < partHeightC$) inside the prediction chroma sample arrays $predPartLX_{Cb}$ and $predPartLX_{Cr}$, the corresponding prediction chroma sample values $predPartLX_{Cb}[\ x_C, y_C\ ]$ and $predPartLX_{Cr}[\ x_C, y_C\ ]$ are derived as follows:

– Depending on ChromaArrayType, the variables $xInt_C$, $yInt_C$, $xFrac_C$, and $yFrac_C$ are derived as follows.

  – If ChromaArrayType is equal to 1,

$xInt_C = (xA_L / SubWidthC) + (mvCLX[\ 0\ ] >> 3) + x_C$ (8-232)
$yInt_C = (yA_L / SubHeightC) + (mvCLX[\ 1\ ] >> 3) + y_C$ (8-233)

$xFrac_C = mvCLX[\ 0\ ] \& 7$ (8-234)
$yFrac_C = mvCLX[\ 1\ ] \& 7$ (8-235)

  – Otherwise, if ChromaArrayType is equal to 2,

$xInt_C = (xA_L / SubWidthC) + (mvCLX[\ 0\ ] >> 3) + x_C$ (8-236)
$yInt_C = (yA_L / SubHeightC) + (mvCLX[\ 1\ ] >> 2) + y_C$ (8-237)

$xFrac_C = mvCLX[\ 0\ ] \& 7$ (8-238)
$yFrac_C = (mvCLX[\ 1\ ] \& 3) << 1$ (8-239)

  – Otherwise (ChromaArrayType is equal to 3),

$xInt_C = xA_L + (mvLX[\ 0\ ] >> 2) + x_C$ (8-240)
$yInt_C = yA_L + (mvLX[\ 1\ ] >> 2) + y_C$ (8-241)

$xFrac_C = (mvCX[\ 0\ ] \& 3)$ (8-242)
$yFrac_C = (mvCX[\ 1\ ] \& 3)$ (8-243)

– Depending on ChromaArrayType, the following applies.

  – If ChromaArrayType is not equal to 3, the following applies.

    – The prediction sample value $predPartLX_{Cb}[\ x_C, y_C\ ]$ is derived by invoking the process specified in subclause 8.4.2.2.2 with ($xInt_C$, $yInt_C$), ($xFrac_C$, $yFrac_C$) and $refPicLX_{Cb}$ given as input.

    – The prediction sample value $predPartLX_{Cr}[\ x_C, y_C\ ]$ is derived by invoking the process specified in subclause 8.4.2.2.2 with ($xInt_C$, $yInt_C$), ($xFrac_C$, $yFrac_C$) and $refPicLX_{Cr}$ given as input.

  – Otherwise (ChromaArrayType is equal to 3), the following applies.

    – The prediction sample value $predPartLX_{Cb}[\ x_C, y_C\ ]$ is derived by invoking the process specified in subclause 8.4.2.2.1 with ($xInt_C$, $yInt_C$), ($xFrac_C$, $yFrac_C$) and $refPicLX_{Cb}$ given as input.

    – The prediction sample value $predPartLX_{Cr}[\ x_C, y_C\ ]$ is derived by invoking the process specified in subclause 8.4.2.2.1 with ($xInt_C$, $yInt_C$), ($xFrac_C$, $yFrac_C$) and $refPicLX_{Cr}$ given as input.

8.4.2.2.1 Luma sample interpolation process

Inputs to this process are

– a luma location in full-sample units ($xInt_L$, $yInt_L$),

– a luma location offset in fractional-sample units ($xFrac_L$, $yFrac_L$), and

– the luma sample array of the selected reference picture $refPicLX_L$.

Output of this process is a predicted luma sample value $predPartLX_L[x_L, y_L]$.

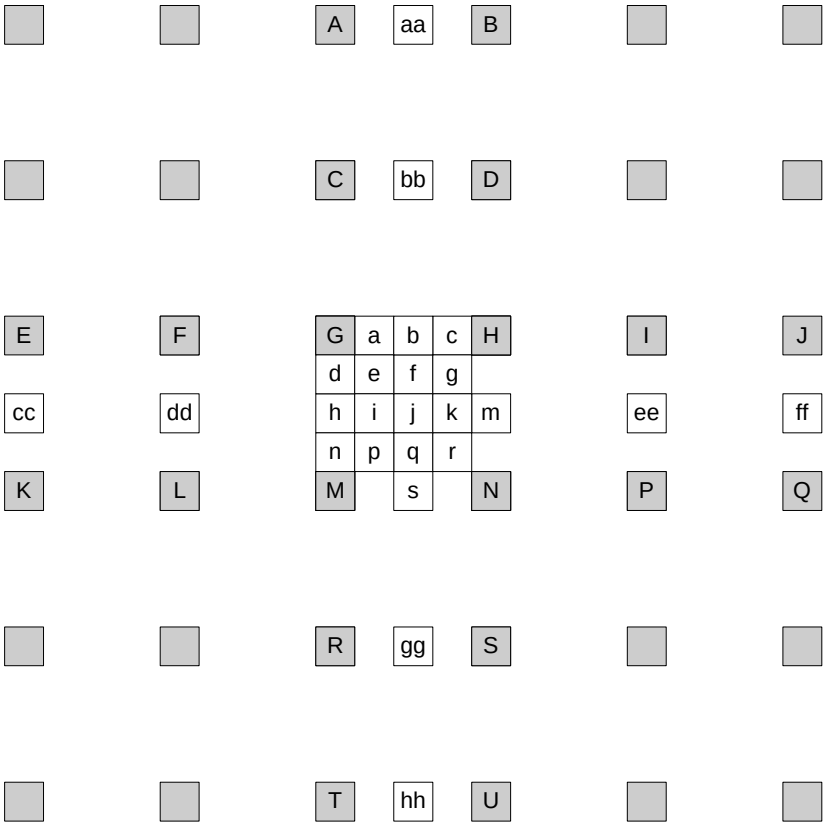


Figure 8-4 – Integer samples (shaded blocks with upper-case letters) and fractional sample positions (un-shaded blocks with lower-case letters) for quarter sample luma interpolation

The variable $refPicHeightEffective_L$, which is the height of the effective reference picture luma array, is derived as follows.

– If MbaffFrameFlag is equal to 0 or mb_field_decoding_flag is equal to 0, $refPicHeightEffective_L$ is set equal to $PicHeightInSamples_L$.

– Otherwise (MbaffFrameFlag is equal to 1 and mb_field_decoding_flag is equal to 1), $refPicHeightEffective_L$ is set equal to $PicHeightInSamples_L$ / 2.

In Figure 8-4, the positions labelled with upper-case letters within shaded blocks represent luma samples at full-sample locations inside the given two-dimensional array $refPicLX_L$ of luma samples. These samples may be used for generating the predicted luma sample value $predPartLX_L[x_L, y_L]$. The locations (xZ_L, yZ_L) for each of the corresponding luma samples Z, where Z may be A, B, C, D, E, F, G, H, I, J, K, L, M, N, P, Q, R, S, T, or U, inside the given array $refPicLX_L$ of luma samples are derived as follows:

$$xZ_L = Clip3(0, PicWidthInSamples_L – 1, xInt_L + xDZ_L)$$
$$yZ_L = Clip3(0, refPicHeightEffective_L – 1, yInt_L + yDZ_L) \quad (8\text{-}244)$$

Table 8-11 specifies (xDZ_L, yDZ_L) for different replacements of Z.

Table 8-11 – Differential full-sample luma locations

Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U
xDZ_L	0	1	0	1	-2	-1	0	1	2	3	-2	-1	0	1	2	3	0	1	0	1
yDZ_L	-2	-2	-1	-1	0	0	0	0	0	0	1	1	1	1	1	1	2	2	3	3

Given the luma samples 'A' to 'U' at full-sample locations (xA_L, yA_L) to (xU_L, yU_L), the luma samples 'a' to 's' at fractional sample positions are derived by the following rules. The luma prediction values at half sample positions are derived by applying a 6-tap filter with tap values (1, -5, 20, 20, -5, 1). The luma prediction values at quarter sample positions are derived by averaging samples at full and half sample positions. The process for each fractional position is described below.

– The samples at half sample positions labelled b are derived by first calculating intermediate values denoted as b_1 by applying the 6-tap filter to the nearest integer position samples in the horizontal direction. The samples at half sample positions labelled h are derived by first calculating intermediate values denoted as h_1 by applying the 6-tap filter to the nearest integer position samples in the vertical direction:

$$b_1 = (E - 5 * F + 20 * G + 20 * H - 5 * I + J) \quad (8\text{-}245)$$
$$h_1 = (A - 5 * C + 20 * G + 20 * M - 5 * R + T) \quad (8\text{-}246)$$

The final prediction values b and h are derived using:

$$b = Clip1_Y((b_1 + 16) >> 5) \quad (8\text{-}247)$$
$$h = Clip1_Y((h_1 + 16) >> 5) \quad (8\text{-}248)$$

– The samples at half sample position labelled as j are derived by first calculating intermediate value denoted as j_1 by applying the 6-tap filter to the intermediate values of the closest half sample positions in either the horizontal or vertical direction because these yield an equal result.

$$j_1 = cc - 5 * dd + 20 * h_1 + 20 * m_1 - 5 * ee + ff, \text{ or} \quad (8\text{-}249)$$
$$j_1 = aa - 5 * bb + 20 * b_1 + 20 * s_1 - 5 * gg + hh \quad (8\text{-}250)$$

where intermediate values denoted as aa, bb, gg, s_1 and hh are derived by applying the 6-tap filter horizontally in the same manner as the derivation of b_1 and intermediate values denoted as cc, dd, ee, m_1 and ff are derived by applying the 6-tap filter vertically in the same manner as the derivation of h_1. The final prediction value j are derived using:

$$j = Clip1_Y((j_1 + 512) >> 10) \quad (8\text{-}251)$$

– The final prediction values s and m are derived from s_1 and m_1 in the same manner as the derivation of b and h, as given by:

$$s = Clip1_Y((s_1 + 16) >> 5) \quad (8\text{-}252)$$
$$m = Clip1_Y((m_1 + 16) >> 5) \quad (8\text{-}253)$$

– The samples at quarter sample positions labelled as a, c, d, n, f, i, k, and q are derived by averaging with upward rounding of the two nearest samples at integer and half sample positions using:

$$a = (G + b + 1) >> 1 \quad (8\text{-}254)$$
$$c = (H + b + 1) >> 1 \quad (8\text{-}255)$$
$$d = (G + h + 1) >> 1 \quad (8\text{-}256)$$
$$n = (M + h + 1) >> 1 \quad (8\text{-}257)$$
$$f = (b + j + 1) >> 1 \quad (8\text{-}258)$$
$$i = (h + j + 1) >> 1 \quad (8\text{-}259)$$
$$k = (j + m + 1) >> 1 \quad (8\text{-}260)$$
$$q = (j + s + 1) >> 1 \quad (8\text{-}261)$$

– The samples at quarter sample positions labelled as e, g, p, and r are derived by averaging with upward rounding of the two nearest samples at half sample positions in the diagonal direction using:

$$e = (b + h + 1) >> 1 \quad (8\text{-}262)$$
$$g = (b + m + 1) >> 1 \quad (8\text{-}263)$$
$$p = (h + s + 1) >> 1 \quad (8\text{-}264)$$
$$r = (m + s + 1) >> 1 \quad (8\text{-}265)$$

The luma location offset in fractional-sample units ($xFrac_L$, $yFrac_L$) specifies which of the generated luma samples at full-sample and fractional-sample locations is assigned to the predicted luma sample value $predPartLX_L[x_L, y_L]$. This assignment is done according to Table 8-12. The value of $predPartLX_L[x_L, y_L]$ is the output.

Table 8-12 – Assignment of the luma prediction sample $predPartLX_L[x_L, y_L]$

$xFrac_L$	0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3
$yFrac_L$	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
$predPartLX_L[x_L, y_L]$	G	d	h	n	a	e	i	p	b	f	j	q	c	g	k	r

8.4.2.2.2 Chroma sample interpolation process

This process is only invoked when ChromaArrayType is equal to 1 or 2.

Inputs to this process are

– a chroma location in full-sample units ($xInt_C$, $yInt_C$),

– a chroma location offset in fractional-sample units ($xFrac_C$, $yFrac_C$), and

– chroma component samples from the selected reference picture $refPicLX_C$.

Output of this process is a predicted chroma sample value $predPartLX_C[x_C, y_C]$.

In Figure 8-5, the positions labelled with A, B, C, and D represent chroma samples at full-sample locations inside the given two-dimensional array $refPicLX_C$ of chroma samples.

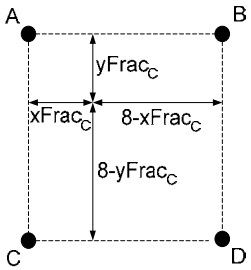


Figure 8-5 – Fractional sample position dependent variables in chroma interpolation and surrounding integer position samples A, B, C, and D

The variable $refPicHeightEffective_C$, which is the height of the effective reference picture chroma array, is derived as follows.

– If MbaffFrameFlag is equal to 0 or mb_field_decoding_flag is equal to 0, $refPicHeightEffective_C$ is set equal to $PicHeightInSamples_C$.

– Otherwise (MbaffFrameFlag is equal to 1 and mb_field_decoding_flag is equal to 1), $refPicHeightEffective_C$ is set equal to $PicHeightInSamples_C$ / 2.

The sample coordinates specified in Equations 8-266 through 8-273 are used for generating the predicted chroma sample value $predPartLX_C[\ x_C, y_C\ ]$.

$$xA_C = Clip3(\ 0, PicWidthInSamples_C - 1, xInt_C\ ) \quad (8\text{-}266)$$
$$xB_C = Clip3(\ 0, PicWidthInSamples_C - 1, xInt_C + 1\ ) \quad (8\text{-}267)$$
$$xC_C = Clip3(\ 0, PicWidthInSamples_C - 1, xInt_C\ ) \quad (8\text{-}268)$$
$$xD_C = Clip3(\ 0, PicWidthInSamples_C - 1, xInt_C + 1\ ) \quad (8\text{-}269)$$

$$yA_C = Clip3(\ 0, refPicHeightEffective_C - 1, yInt_C\ ) \quad (8\text{-}270)$$
$$yB_C = Clip3(\ 0, refPicHeightEffective_C - 1, yInt_C\ ) \quad (8\text{-}271)$$
$$yC_C = Clip3(\ 0, refPicHeightEffective_C - 1, yInt_C + 1\ ) \quad (8\text{-}272)$$
$$yD_C = Clip3(\ 0, refPicHeightEffective_C - 1, yInt_C + 1\ ) \quad (8\text{-}273)$$

Given the chroma samples A, B, C, and D at full-sample locations specified in Equations 8-266 through 8-273, the predicted chroma sample value $predPartLX_C[\ x_C, y_C\ ]$ is derived as follows:

$$predPartLX_C[\ x_C, y_C\ ] = (\ (\ 8 - xFrac_C\ ) * (\ 8 - yFrac_C\ ) * A + xFrac_C * (\ 8 - yFrac_C\ ) * B + (\ 8 - xFrac_C\ ) * yFrac_C * C + xFrac_C * yFrac_C * D + 32\ ) >> 6 \quad (8\text{-}274)$$

8.4.2.3 Weighted sample prediction process

Inputs to this process are

- mbPartIdx: the current partition given by the partition index
- subMbPartIdx: the sub-macroblock partition index
- predFlagL0 and predFlagL1: prediction list utilization flags
- $predPartLX_L$: a (partWidth)x(partHeight) array of prediction luma samples (with LX being replaced by L0 or L1 depending on predFlagL0 and predFlagL1)
- when ChromaArrayType is not equal to 0, $predPartLX_{Cb}$ and $predPartLX_{Cr}$: (partWidthC)x(partHeightC) arrays of prediction chroma samples, one for each of the chroma components Cb and Cr (with LX being replaced by L0 or L1 depending on predFlagL0 and predFlagL1)
- variables for weighted prediction $logWD_C$, w_{0C}, w_{1C}, o_{0C}, o_{1C} with C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr

Outputs of this process are

- $predPart_L$: a (partWidth)x(partHeight) array of prediction luma samples and
- when ChromaArrayType is not equal to 0, $predPart_{Cb}$, and $predPart_{Cr}$: (partWidthC)x(partHeightC) arrays of prediction chroma samples, one for each of the chroma components Cb and Cr.

For macroblocks or partitions with predFlagL0 equal to 1 in P and SP slices, the following applies.

- If weighted_pred_flag is equal to 0, the default weighted sample prediction process as described in subclause 8.4.2.3.1 is invoked with the same inputs and outputs as the process described in this subclause.
- Otherwise (weighted_pred_flag is equal to 1), the explicit weighted prediction process as described in subclause 8.4.2.3.2 is invoked with the same inputs and outputs as the process described in this subclause.

For macroblocks or partitions with predFlagL0 or predFlagL1 equal to 1 in B slices, the following applies.

- If weighted_bipred_idc is equal to 0, the default weighted sample prediction process as described in subclause 8.4.2.3.1 is invoked with the same inputs and outputs as the process described in this subclause.
- Otherwise, if weighted_bipred_idc is equal to 1, the explicit weighted sample prediction process as described in subclause 8.4.2.3.2, for macroblocks or partitions with predFlagL0 or predFlagL1 equal to 1 with the same inputs and outputs as the process described in this subclause.
- Otherwise (weighted_bipred_idc is equal to 2), the following applies.
  - If predFlagL0 is equal to 1 and predFlagL1 is equal to 1, the implicit weighted sample prediction as described in subclause 8.4.2.3.2 is invoked with the same inputs and outputs as the process described in this subclause.

– Otherwise (predFlagL0 or predFlagL1 are equal to 1 but not both), the default weighted sample prediction process as described in subclause 8.4.2.3.1 is invoked with the same inputs and outputs as the process described in this subclause.

8.4.2.3.1 Default weighted sample prediction process

Input to this process are the same as specified in subclause 8.4.2.3.

Output of this process are the same as specified in subclause 8.4.2.3.

Depending on the available component for which the prediction block is derived, the following applies.

– If the luma sample prediction values $predPart_L[x, y]$ are derived, the following applies with C set equal to L, x set equal to 0 .. partWidth - 1, and y set equal to 0 .. partHeight - 1.

– Otherwise, if the chroma Cb component sample prediction values $predPart_{Cb}[x, y]$ are derived, the following applies with C set equal to Cb, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

– Otherwise (the chroma Cr component sample prediction values $predPart_{Cr}[x, y]$ are derived), the following applies with C set equal to Cr, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

The prediction sample values are derived as follows.

– If predFlagL0 is equal to 1 and predFlagL1 is equal to 0

$$predPart_C[x, y] = predPartL0_C[x, y] \quad (8\text{-}275)$$

– Otherwise, if predFlagL0 is equal to 0 and predFlagL1 is equal to 1

$$predPart_C[x, y] = predPartL1_C[x, y] \quad (8\text{-}276)$$

– Otherwise (predFlagL0 and predFlagL1 are equal to 1),

$$predPart_C[x, y] = (predPartL0_C[x, y] + predPartL1_C[x, y] + 1) >> 1. \quad (8\text{-}277)$$

8.4.2.3.2 Weighted sample prediction process

Input to this process are the same as specified in subclause 8.4.2.3.

Output of this process are the same as specified in subclause 8.4.2.3.

Depending on the available component for which the prediction block is derived, the following applies.

– If the luma sample prediction values $predPart_L[x, y]$ are derived, the following applies with C set equal to L, x set equal to 0 .. partWidth - 1, and y set equal to 0 .. partHeight - 1.

– Otherwise, if the chroma Cb component sample prediction values $predPart_{Cb}[x, y]$ are derived, the following applies with C set equal to Cb, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

– Otherwise (the chroma Cr component sample prediction values $predPart_{Cr}[x, y]$ are derived), the following applies with C set equal to Cr, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

The prediction sample values are derived as follows.

– If the predFlagL0 is equal to 1 and predFlagL1 is equal to 0, the final predicted sample values $predPart_C[x, y]$ are derived by

$$\begin{aligned} &\text{if(} logWD_C >= 1 \text{)} \\ &\quad predPart_C[x, y] = Clip1_C(((predPartL0_C[x, y] * w_{0C} + 2^{logWD_C - 1}) >> logWD_C) + o_{0C}) \\ &\text{else} \\ &\quad predPart_C[x, y] = Clip1_C(predPartL0_C[x, y] * w_{0C} + o_{0C}) \end{aligned} \quad (8\text{-}278)$$

– Otherwise, if the predFlagL0 is equal to 0 and predFlagL1 is equal to 1, the final predicted sample values $predPart_C[x, y]$ are derived by

$$\begin{aligned} &\text{if(} logWD_C >= 1 \text{)} \\ &\quad predPart_C[x, y] = Clip1_C(((predPartL1_C[x, y] * w_{1C} + 2^{logWD_C - 1}) >> logWD_C) + o_{1C}) \\ &\text{else} \\ &\quad predPart_C[x, y] = Clip1_C(predPartL1_C[x, y] * w_{1C} + o_{1C}) \end{aligned} \tag{8-279}$$

– Otherwise (both predFlagL0 and predFlagL1 are equal to 1), the final predicted sample values $predPart_C[x, y]$ are derived by

$$\begin{aligned} predPart_C[x, y] = Clip1_C(((predPartL0_C[x, y] * w_{0C} + predPartL1_C[x, y] * w_{1C} + 2^{logWD_C}) >> \\ (logWD_C + 1)) + ((o_{0C} + o_{1C} + 1) >> 1)) \end{aligned} \tag{8-280}$$

8.4.3 Derivation process for prediction weights

Inputs to this process are

– the reference indices refIdxL0 and refIdxL1

– the prediction utilization flags predFlagL0 and predFlagL1

Outputs of this process are

– variables for weighted prediction $logWD_C$, w_{0C}, w_{1C}, o_{0C}, o_{1C} with C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr

For C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr, the variables $logWD_C$, w_{0C}, w_{1C}, o_{0C}, o_{1C} are derived as follows.

– If weighted_bipred_idc is equal to 2 and the (slice_type % 5) is equal to 1, implicit mode weighted prediction is used as follows.

$$logWD_C = 5 \tag{8-281}$$

$$o_{0C} = 0 \tag{8-282}$$

$$o_{1C} = 0 \tag{8-283}$$

and w_{0C} and w_{1C} are derived as follows.

  – The variables currPicOrField, pic0, and pic1 are derived as follows:
    – If field_pic_flag is equal to 0 and the current macroblock is a field macroblock, the following applies.
      – currPicOrField is the field of the current picture CurrPic that has the same parity as the current macroblock.
      – The variable pic0 is derived as follows.
        – If refIdxL0 % 2 is equal to 0, pic0 is the field of RefPicList0[refIdxL0 / 2] that has the same parity as the current macroblock.
        – Otherwise (refIdxL0 % 2 is not equal to 0), pic0 is the field of RefPicList0[refIdxL0 / 2] that has the opposite parity of the current macroblock.
      – The variable pic1 is derived as follows.
        – If refIdxL1 % 2 is equal to 0, pic1 is the field of RefPicList1[refIdxL1 / 2] that has the same parity as the current macroblock.
        – Otherwise (refIdxL1 % 2 is not equal to 0), pic1 is the field of RefPicList1[refIdxL1 / 2] that has the opposite parity of the current macroblock.
    – Otherwise (field_pic_flag is equal to 1 or the current macroblock is a frame macroblock), currPicOrField is the current picture CurrPic, pic1 is RefPicList1[refIdxL1], and pic0 is RefPicList0[refIdxL0].

– The variables tb, td, tx, and DistScaleFactor are derived from the values of currPicOrField, pic0, pic1 using Equations 8-206, 8-207, 8-202, and 8-203, respectively.

– If DiffPicOrderCnt(pic1, pic0) is equal to 0 or one or both of pic1 and pic0 is marked as "used for long-term reference" or (DistScaleFactor >> 2) < -64 or (DistScaleFactor >> 2) > 128, w_{0C} and w_{1C} are derived as

$$w_{0C} = 32 \quad (8\text{-}284)$$

$$w_{1C} = 32 \quad (8\text{-}285)$$

- Otherwise,

$$w_{0C} = 64 - (\text{DistScaleFactor} >> 2) \quad (8\text{-}286)$$

$$w_{1C} = \text{DistScaleFactor} >> 2 \quad (8\text{-}287)$$

– Otherwise (weighted_pred_flag is equal to 1 in slices with (slice_type % 5) equal to 0 or 3 or weighted_bipred_idc equal to 1 in slices with (slice_type % 5) equal to 1), explicit mode weighted prediction is used as follows.

– The variables refIdxL0WP and refIdxL1WP are derived as follows.

– If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock

$$\text{refIdxL0WP} = \text{refIdxL0} >> 1 \quad (8\text{-}288)$$

$$\text{refIdxL1WP} = \text{refIdxL1} >> 1 \quad (8\text{-}289)$$

– Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock),

$$\text{refIdxL0WP} = \text{refIdxL0} \quad (8\text{-}290)$$

$$\text{refIdxL1WP} = \text{refIdxL1} \quad (8\text{-}291)$$

– The variables logWD_C, w_{0C}, w_{1C}, o_{0C}, and o_{1C} are derived as follows.

– If C is equal to L for luma samples

$$\text{logWD}_C = \text{luma\_log2\_weight\_denom} \quad (8\text{-}292)$$

$$w_{0C} = \text{luma\_weight\_l0[refIdxL0WP]} \quad (8\text{-}293)$$

$$w_{1C} = \text{luma\_weight\_l1[refIdxL1WP]} \quad (8\text{-}294)$$

$$o_{0C} = \text{luma\_offset\_l0[refIdxL0WP]} * (1 << (\text{BitDepth}_Y - 8)) \quad (8\text{-}295)$$

$$o_{1C} = \text{luma\_offset\_l1[refIdxL1WP]} * (1 << (\text{BitDepth}_Y - 8)) \quad (8\text{-}296)$$

– Otherwise (C is equal to Cb or Cr for chroma samples, with iCbCr = 0 for Cb, iCbCr = 1 for Cr),

$$\text{logWD}_C = \text{chroma\_log2\_weight\_denom} \quad (8\text{-}297)$$

$$w_{0C} = \text{chroma\_weight\_l0[refIdxL0WP][iCbCr]} \quad (8\text{-}298)$$

$$w_{1C} = \text{chroma\_weight\_l1[refIdxL1WP][iCbCr]} \quad (8\text{-}299)$$

$$o_{0C} = \text{chroma\_offset\_l0[refIdxL0WP][iCbCr]} * (1 << (\text{BitDepth}_C - 8)) \quad (8\text{-}300)$$

$$o_{1C} = \text{chroma\_offset\_l1[refIdxL1WP][iCbCr]} * (1 << (\text{BitDepth}_C - 8)) \quad (8\text{-}301)$$

When explicit mode weighted prediction is used and predFlagL0 and predFlagL1 are equal to 1, the following constraint shall be obeyed for C equal to L and, when ChromaArrayType is not equal to 0, Cb and Cr

$$-128 <= w_{0C} + w_{1C} <= ((\text{logWD}_C == 7) ? 127 : 128) \quad (8\text{-}302)$$

NOTE – For implicit mode weighted prediction, weights w_{0C} and w_{1C} are each guaranteed to be in the range of -64..128 and the constraint expressed in Equation 8-302, although not explicitly imposed, will always be met. For explicit mode weighted prediction with logWD_C equal to 7, when one of the two weights w_{0C} or w_{1C} is inferred to be equal to 128 (as a consequence of luma_weight_l0_flag, luma_weight_l1_flag, chroma_weight_l0_flag, or chroma_weight_l1_flag equal to 0), the other weight (w_{1C} or w_{0C}) must have a negative value in order for the constraint expressed in Equation 8-302 to hold (and therefore the other flag luma_weight_l0_flag, luma_weight_l1_flag, chroma_weight_l0_flag, or chroma_weight_l1_flag must be equal to 1).

8.5 Transform coefficient decoding process and picture construction process prior to deblocking filter process

Inputs to this process are Intra16x16DCLevel (if available), Intra16x16ACLevel (if available), CbIntra16x16DCLevel (if available), CbIntra16x16ACLevel (if available), CrIntra16x16DCLevel (if available), CrIntra16x16ACLevel (if available), LumaLevel (if available), LumaLevel8x8 (if available), ChromaDCLevel (if available), ChromaACLevel (if available), CbLevel (if available), CrLevel (if available), CbLevel8x8 (if available), CrLevel8x8 (if available), and available Inter or Intra prediction sample arrays for the current macroblock for the applicable components pred_L, pred_{Cb}, or pred_{Cr}.

NOTE 1 – When decoding a macroblock in Intra_4x4 (or Intra_8x8) prediction mode, the luma component of the macroblock prediction array may not be complete, since for each 4x4 (or 8x8) luma block, the Intra_4x4 (or Intra_8x8) prediction process for luma samples as specified in subclause 8.3.1 (or 8.3.2) and the process specified in this subclause are iterated. When ChromaArrayType is equal to 3, the Cb and Cr component of the macroblock prediction array may not be complete for the same reason.

Outputs of this process are the constructed sample arrays prior to the deblocking filter process for the applicable components S'_L, S'_{Cb}, or S'_{Cr}.

NOTE 2 – When decoding a macroblock in Intra_4x4 (or Intra_8x8) prediction mode, the luma component of the macroblock constructed sample arrays prior to the deblocking filter process may not be complete, since for each 4x4 (or 8x8) luma block, the Intra_4x4 (or Intra_8x8) prediction process for luma samples as specified in subclause 8.3.1 (or 8.3.2) and the process specified in this subclause are iterated. When ChromaArrayType is equal to 3, the Cb and Cr component of the macroblock constructed sample arrays prior to the deblocking filter process may not be complete for the same reason.

This subclause specifies transform coefficient decoding and picture construction prior to the deblocking filter process.

When the current macroblock is coded as P_Skip or B_Skip, all values of LumaLevel, LumaLevel8x8, CbLevel, CbLevel8x8, CrLevel, CrLevel8x8, ChromaDCLevel, ChromaACLevel are set equal to 0 for the current macroblock.

8.5.1 Specification of transform decoding process for 4x4 luma residual blocks

This specification applies when transform_size_8x8_flag is equal to 0.

When the current macroblock prediction mode is not equal to Intra_16x16, the variable LumaLevel contains the levels for the luma transform coefficients. For a 4x4 luma block indexed by luma4x4BlkIdx = 0..15, the following ordered steps are specified.

1. The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with LumaLevel[luma4x4BlkIdx] as the input and the two-dimensional array c as the output.
2. The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c as the input and r as the output.
3. When qpprime_y_zero_transform_bypass_flag is equal to 1, QP'_Y is equal to 0, the macroblock prediction mode is equal to Intra_4x4, and Intra4x4PredMode[luma4x4BlkIdx] is equal to 0 or 1, the intra residual transform-bypass decoding process as specified in subclause 8.5.14 is invoked with nW set equal to 4, nH set equal to 4, horPredFlag set equal to Intra4x4PredMode[luma4x4BlkIdx], and the 4x4 array r as the inputs, and the output is a modified version of the 4x4 array r.

4. The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (xO, yO).

5. The 4x4 array u with elements u_{ij} for i, j = 0..3 is derived as

$$u_{ij} = Clip1_Y(pred_L[xO + j, yO + i] + r_{ij}) \quad (8\text{-}303)$$

When qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the bitstream shall not contain data that result in a value of u_{ij} as computed by Equation 8-303 that is not equal to $pred_L[xO + j, yO + i] + r_{ij}$.

6. The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with u and luma4x4BlkIdx as the inputs.

8.5.2 Specification of transform decoding process for luma samples of Intra_16x16 macroblock prediction mode

When the current macroblock prediction mode is equal to Intra_16x16, the variables Intra16x16DCLevel and Intra16x16ACLevel contain the levels for the luma transform coefficients. The transform coefficient decoding proceeds in the following ordered steps:

1. The 4x4 luma DC transform coefficients of all 4x4 luma blocks of the macroblock are decoded.

   a. The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with Intra16x16DCLevel as the input and the two-dimensional array c as the output.

   b. The scaling and transformation process for luma DC transform coefficients for Intra_16x16 macroblock type as specified in subclause 8.5.9 is invoked with $BitDepth_Y$, QP'_Y, and c as the input and dcY as the output.

2. The 16x16 array rMb is derived by processing the 4x4 luma blocks indexed by luma4x4BlkIdx = 0..15, and for each 4x4 luma block, the following ordered steps are specified.

   a. The variable lumaList, which is a list of 16 entries, is derived. The first entry of lumaList is the corresponding value from the array dcY. Figure 8-6 shows the assignment of the indices of the array dcY to the luma4x4BlkIdx. The two numbers in the small squares refer to indices i and j in dcY_{ij}, and the numbers in large squares refer to luma4x4BlkIdx.

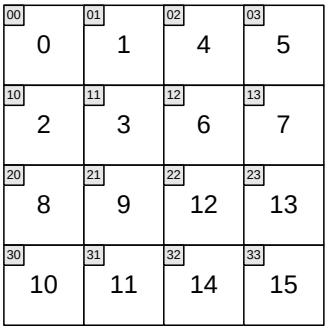


Figure 8-6 – Assignment of the indices of dcY to luma4x4BlkIdx

The elements in lumaList with index k = 1..15 are specified as

$$lumaList[k] = Intra16x16ACLevel[luma4x4BlkIdx][k - 1] \quad (8\text{-}304)$$

   b. The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with lumaList as the input and the two-dimensional array c as the output.

   c. The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c as the input and r as the output.

d. The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (xO, yO).

e. The elements rMb[x, y] of the 16x16 array rMb with x = xO..xO + 3 and y = yO..yO + 3 are derived by

$$rMb[xO + j, yO + i] = r_{ij} \quad (8\text{-}305)$$

3. When qpprime_y_zero_transform_bypass_flag is equal to 1, QP'_Y is equal to 0, and Intra16x16PredMode is equal to 0 or 1, the intra residual transform-bypass decoding process as specified in subclause 8.5.14 is invoked with nW set equal to 16, nH set equal to 16, horPredFlag set equal to Intra16x16PredMode, and the 16x16 array rMb as the inputs, and the output is a modified version of the 16x16 array rMb.

4. The 16x16 array u with elements u_{ij} for i, j = 0..15 is derived as

$$u_{ij} = Clip1_Y(pred_L[j, i] + rMb[j, i]) \quad (8\text{-}306)$$

When qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the bitstream shall not contain data that result in a value of u_{ij} as computed by Equation 8-306 that is not equal to $pred_L[j, i] + rMb[j, i]$.

5. The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with u as the input.

8.5.3 Specification of transform decoding process for 8x8 luma residual blocks

This specification applies when transform_size_8x8_flag is equal to 1.

The variable LumaLevel8x8[luma8x8BlkIdx] with luma8x8BlkIdx = 0..3 contains the levels for the luma transform coefficients for the luma 8x8 block with index luma8x8BlkIdx.

For an 8x8 luma block indexed by luma8x8BlkIdx = 0..3, the following ordered steps are specified.

1. The inverse scanning process for 8x8 luma transform coefficients as described in subclause 8.5.7 is invoked with LumaLevel8x8[luma8x8BlkIdx] as the input and the two-dimensional array c as the output.

2. The scaling and transformation process for residual 8x8 blocks as specified in subclause 8.5.12 is invoked with c as the input and r as the output.

3. When qpprime_y_zero_transform_bypass_flag is equal to 1, QP'_Y is equal to 0, the macroblock prediction mode is equal to Intra_8x8, and Intra8x8PredMode[luma8x8BlkIdx] is equal to 0 or 1, the intra residual transform-bypass decoding process as specified in subclause 8.5.14 is invoked with nW set equal to 8, nH set equal to 8, horPredFlag set equal to Intra8x8PredMode[luma8x8BlkIdx], and the 8x8 array r as the inputs, and the output is a modified version of the 8x8 array r.

4. The position of the upper-left sample of an 8x8 luma block with index luma8x8BlkIdx inside the macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.5 with luma8x8BlkIdx as the input and the output being assigned to (xO, yO).

5. The 8x8 array u with elements u_{ij} for i, j = 0..7 is derived as

$$u_{ij} = Clip1_Y(pred_L[xO + j, yO + i] + r_{ij}) \quad (8\text{-}307)$$

When qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the bitstream shall not contain data that result in a value of u_{ij} as computed by Equation 8-307 that is not equal to $pred_L[xO + j, yO + i] + r_{ij}$.

6. The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with u and luma8x8BlkIdx as the inputs.

8.5.4 Specification of transform decoding process for chroma samples

This process is invoked for each chroma component Cb and Cr separately when ChromaArrayType is not equal to 0.

Depending on ChromaArrayType, the following applies.

– If ChromaArrayType is equal to 3, the transform decoding process for chroma samples with ChromaArrayType equal to 3 as specified in subclause 8.5.5 is invoked.

– Otherwise (ChromaArrayType is not equal to 3), the following text specifies the transform decoding process for chroma samples.

For each chroma component, the variables ChromaDCLevel[iCbCr] and ChromaACLevel[iCbCr], with iCbCr set equal to 0 for Cb and iCbCr set equal to 1 for Cr, contain the levels for both components of the chroma transform coefficients.

Let the variable numChroma4x4Blks be set equal to (MbWidthC / 4) * (MbHeightC / 4).

For each chroma component, the transform decoding proceeds separately in the following ordered steps:

1. The numChroma4x4Blks chroma DC transform coefficients of the 4x4 chroma blocks of the component indexed by iCbCr of the macroblock are decoded.

   a. Depending on the variable ChromaArrayType, the following applies.

   – If ChromaArrayType is equal to 1, the 2x2 array c is derived using the inverse raster scanning process applied to ChromaDCLevel as follows

$$c = \begin{bmatrix} \text{ChromaDCLevel}[\text{iCbCr}][0] & \text{ChromaDCLevel}[\text{iCbCr}][1] \\ \text{ChromaDCLevel}[\text{iCbCr}][2] & \text{ChromaDCLevel}[\text{iCbCr}][3] \end{bmatrix} \tag{8-308}$$

   – Otherwise (ChromaArrayType is equal to 2), the 2x4 array c is derived using the inverse raster scanning process applied to ChromaDCLevel as follows

$$c = \begin{bmatrix} \text{ChromaDCLevel}[\text{iCbCr}][0] & \text{ChromaDCLevel}[\text{iCbCr}][2] \\ \text{ChromaDCLevel}[\text{iCbCr}][1] & \text{ChromaDCLevel}[\text{iCbCr}][5] \\ \text{ChromaDCLevel}[\text{iCbCr}][3] & \text{ChromaDCLevel}[\text{iCbCr}][6] \\ \text{ChromaDCLevel}[\text{iCbCr}][4] & \text{ChromaDCLevel}[\text{iCbCr}][7] \end{bmatrix} \tag{8-309}$$

   b. The scaling and transformation process for chroma DC transform coefficients as specified in subclause 8.5.10 is invoked with c as the input and dcC as the output.

2. The (MbWidthC)x(MbHeightC) array rMb is derived by processing the 4x4 chroma blocks indexed by chroma4x4BlkIdx = 0..numChroma4x4Blks – 1 of the component indexed by iCbCr, and for each 4x4 chroma block, the following ordered steps are specified.

   a. The variable chromaList, which is a list of 16 entries, is derived. The first entry of chromaList is the corresponding value from the array dcC. Figure 8-7 shows the assignment of the indices of the array dcC to the chroma4x4BlkIdx. The two numbers in the small squares refer to indices i and j in dcC_{ij}, and the numbers in large squares refer to chroma4x4BlkIdx.

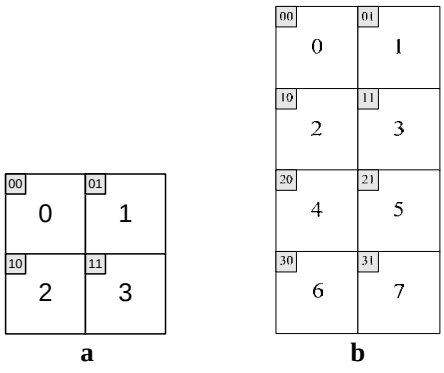


Figure 8-7 – Assignment of the indices of dcC to chroma4x4BlkIdx: (a) ChromaArrayType equal to 1, (b) ChromaArrayType equal to 2

The elements in chromaList with index k = 1..15 are specified as

$$chromaList[k] = ChromaACLevel[chroma4x4BlkIdx][k - 1] \quad (8\text{-}310)$$

b. The inverse scanning process for transform coefficients as specified in subclause 8.5.10 is invoked with chromaList as the input and the two-dimensional array c as the output.

c. The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c as the input and r as the output.

d. The position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx inside the macroblock is derived by

$$xO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 0) \quad (8\text{-}311)$$

$$yO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 1) \quad (8\text{-}312)$$

e. The elements rMb[x, y] of the (MbWidthC)x(MbHeightC) array rMb with x = xO..xO + 3 and y = yO..yO + 3 are derived by

$$rMb[xO + j, yO + i] = r_{ij} \quad (8\text{-}313)$$

3. When qpprime_y_zero_transform_bypass_flag is equal to 1, QP'_Y is equal to 0, the macroblock prediction mode is equal to Intra_4x4, Intra_8x8, or Intra_16x16, and intra_chroma_pred_mode is equal to 1 or 2, the intra residual transform-bypass decoding process as specified in subclause 8.5.14 is invoked with nW set equal to MbWidthC, nH set equal to MbHeightC, horPredFlag set equal to (intra_chroma_pred_mode – 1), and the (MbWidthC)x(MbHeightC) array rMb as the inputs, and the output is a modified version of the (MbWidthC)x(MbHeightC) array rMb.

4. The (MbWidthC)x(MbHeightC) array u with elements u_{ij} for i = 0..MbHeight – 1 and j = 0..MbWidth – 1 is derived as

$$u_{ij} = Clip1_C(pred_C[j, i] + rMb[j, i]) \quad (8\text{-}314)$$

When qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the bitstream shall not contain data that result in a value of u_{ij} as computed by Equation 8-314 that is not equal to $pred_C[j, i] + rMb[j, i]$.

5. The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with u as the input.

8.5.5 Specification of transform decoding process for chroma samples with ChromaArrayType equal to 3

This process is invoked for each chroma component Cb and Cr separately when ChromaArrayType is equal to 3.

Depending on the macroblock prediction mode and transform_size_8x8_flag, the following applies.

– If the macroblock prediction mode is equal to Intra_16x16, the transform decoding process for Cb or Cr residual blocks shall be identical to the process described in subclause 8.5.2 when substituting luma with Cb or Cr, substituting Intra16x16DCLevel with CbIntra16x16DCLevel or CrIntra16x16DCLevel, substituting Intra16x16ACLevel with CbIntra16x16ACLevel or CrIntra16x16ACLevel, and substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$, substituting luma4x4BlkIdx with cb4x4BlkIdx or cr4x4BlkIdx, substituting lumaList with CbList or CrList, substituting $BitDepth_Y$ with $BitDepth_C$, substituting QP'_Y with QP'_C, and substituting $Clip1_Y$ with $Clip1_C$.

– Otherwise, if transform_size_8x8_flag is equal to 1, the transform decoding process for 8x8 Cb or 8x8 Cr residual blocks shall be identical to the process described in subclause 8.5.3 when substituting luma with Cb or Cr, substituting LumaLevel8x8 with CbLevel8x8 or CrLevel8x8, substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$, substituting luma8x8BlkIdx with cb8x8BlkIdx or cr8x8BlkIdx, and substituting $Clip1_Y$ with $Clip1_C$.

– Otherwise (the macroblock prediction mode is not equal to Intra_16x16 and transform_size_8x8_flag is equal to 0), the transform decoding process for 4x4 Cb or 4x4 Cr residual blocks shall be identical to the process described in subclause 8.5.1 when substituting luma with Cb or Cr, substituting LumaLevel with CbLevel or CrLevel, substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$, substituting luma4x4BlkIdx with cb4x4BlkIdx or cr4x4BlkIdx, and substituting $Clip1_Y$ with $Clip1_C$. During the scaling of 4x4 block transform coefficient levels that is specified within subclause 8.5.11, which is invoked as part of the process specified in subclause 8.5.1, the input 4x4 array c is

treated as not relating to a luma residual block coded using Intra_16x16 prediction mode and not relating to a chroma residual block.

8.5.6 Inverse scanning process for transform coefficients

Input to this process is a list of 16 values.

Output of this process is a variable c containing a two-dimensional array of 4x4 values. In the case of transform coefficients, these 4x4 values represent levels assigned to locations in the transform block. In the case of applying the inverse scanning process to a scaling list, the output variable c contains a two-dimensional array representing a 4x4 scaling matrix.

The inverse scanning process for transform coefficients maps the sequence of transform coefficient levels to the transform coefficient level positions. Table 8-13 specifies the two mappings: inverse zig-zag scan and inverse field scan. The inverse zig-zag scan is used for transform coefficients in frame macroblocks and the inverse field scan is used for transform coefficients in field macroblocks.

The inverse scanning process for scaling lists maps the sequence of scaling list entries to the positions in the corresponding scaling matrix. For this mapping, the inverse zig-zag scan is used.

Figure 8-8 illustrates the scans.

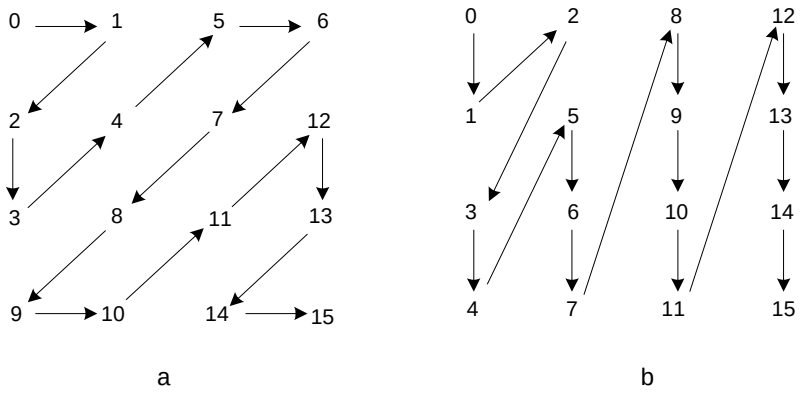


Figure 8-8 – 4x4 block scans. (a) Zig-zag scan. (b) Field scan (informative)

Table 8-13 provides the mapping from the index idx of input list of 16 elements to indices i and j of the two-dimensional array c.

Table 8-13 – Specification of mapping of idx to c_{ij} for zig-zag and field scan

idx	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
zig-zag	c_{00}	c_{01}	c_{10}	c_{20}	c_{11}	c_{02}	c_{03}	c_{12}	c_{21}	c_{30}	c_{31}	c_{22}	c_{13}	c_{23}	c_{32}	c_{33}
field	c_{00}	c_{10}	c_{01}	c_{20}	c_{30}	c_{11}	c_{21}	c_{31}	c_{02}	c_{12}	c_{22}	c_{32}	c_{03}	c_{13}	c_{23}	c_{33}

8.5.7 Inverse scanning process for 8x8 transform coefficients

Input to this process is a list of 64 values.

Output of this process is a variable c containing a two-dimensional array of 8x8 values. In the case of transform coefficients, these 8x8 values represent levels assigned to locations in the transform block. In the case of applying the inverse scanning process to a scaling list, the output variable c contains a two-dimensional array representing an 8x8 scaling matrix.

The inverse scanning process for transform coefficients maps the sequence of transform coefficient levels to the transform coefficient level positions. Table 8-14 specifies the two mappings: inverse 8x8 zig-zag scan and inverse 8x8

field scan. The inverse 8x8 zig-zag scan is used for transform coefficients in frame macroblocks and the inverse 8x8 field scan is used for transform coefficients in field macroblocks.

The inverse scanning process for scaling lists maps the sequence of scaling list entries to the positions in the corresponding scaling matrix. For this mapping, the inverse zig-zag scan is used.

Figure 8-9 illustrates the scans.

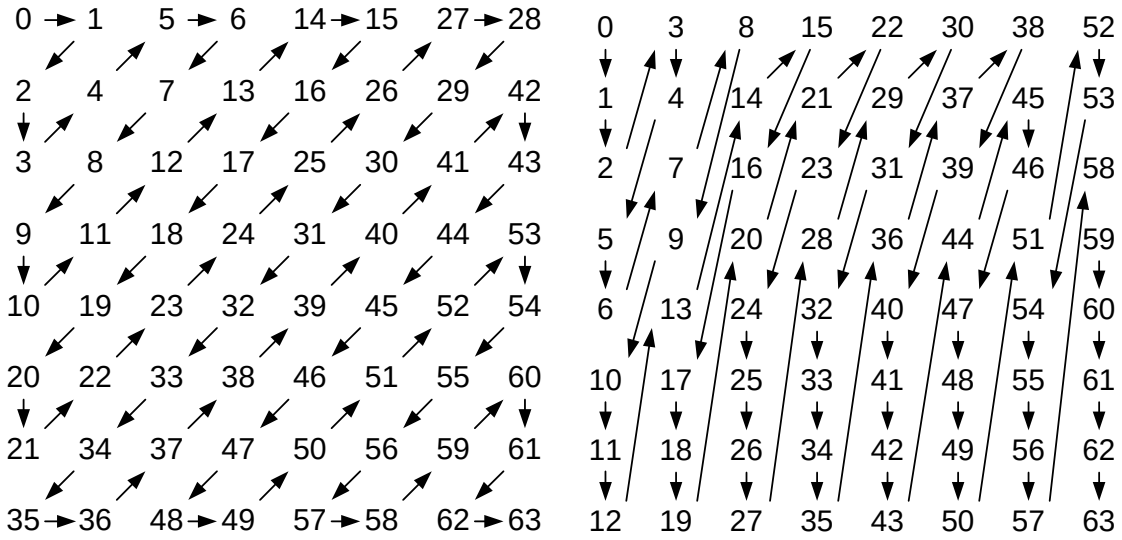


Figure 8-9 – 8x8 block scans. (a) 8x8 zig-zag scan. (b) 8x8 field scan (informative)

Table 8-14 provides the mapping from the index idx of the input list of 64 elements to indices i and j of the two-dimensional array c.

Table 8-14 – Specification of mapping of idx to c_{ij} for 8x8 zig-zag and 8x8 field scan

idx	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
zig-zag	c_{00}	c_{01}	c_{10}	c_{20}	c_{11}	c_{02}	c_{03}	c_{12}	c_{21}	c_{30}	c_{40}	c_{31}	c_{22}	c_{13}	c_{04}	c_{05}
field	c_{00}	c_{10}	c_{20}	c_{01}	c_{11}	c_{30}	c_{40}	c_{21}	c_{02}	c_{31}	c_{50}	c_{60}	c_{70}	c_{41}	c_{12}	c_{03}

Table 8-14 (continued) – Specification of mapping of idx to cij for 8x8 zig-zag and 8x8 field scan

idx	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
zig-zag	c_{14}	c_{23}	c_{32}	c_{41}	c_{50}	c_{60}	c_{51}	c_{42}	c_{33}	c_{24}	c_{15}	c_{06}	c_{07}	c_{16}	c_{25}	c_{34}
field	c_{22}	c_{51}	c_{61}	c_{71}	c_{32}	c_{13}	c_{04}	c_{23}	c_{42}	c_{52}	c_{62}	c_{72}	c_{33}	c_{14}	c_{05}	c_{24}

Table 8-14 (continued) – Specification of mapping of idx to cij for 8x8 zig-zag and 8x8 field scan

idx	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
zig-zag	c_{43}	c_{52}	c_{61}	c_{70}	c_{71}	c_{62}	c_{53}	c_{44}	c_{35}	c_{26}	c_{17}	c_{27}	c_{36}	c_{45}	c_{54}	c_{63}
field	c_{43}	c_{53}	c_{63}	c_{73}	c_{34}	c_{15}	c_{06}	c_{25}	c_{44}	c_{54}	c_{64}	c_{74}	c_{35}	c_{16}	c_{26}	c_{45}

Table 8-14 (concluded) – Specification of mapping of idx to cij for 8x8 zig-zag and 8x8 field scan

idx	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
zig-zag	c_{72}	c_{73}	c_{64}	c_{55}	c_{46}	c_{37}	c_{47}	c_{56}	c_{65}	c_{74}	c_{75}	c_{66}	c_{57}	c_{67}	c_{76}	c_{77}
field	c_{55}	c_{65}	c_{75}	c_{36}	c_{07}	c_{17}	c_{46}	c_{56}	c_{66}	c_{76}	c_{27}	c_{37}	c_{47}	c_{57}	c_{67}	c_{77}

8.5.8 Derivation process for the chroma quantisation parameters and scaling function

Outputs of this process are:

– QP_C: the chroma quantisation parameter for each chroma component Cb and Cr

– QS_C: the additional chroma quantisation parameter for each chroma component Cb and Cr required for decoding SP and SI slices (if applicable)

NOTE 1 – QP quantisation parameter values QP_Y and QS_Y are always in the range of $-QpBdOffset_Y$ to 51, inclusive. QP quantisation parameter values QP_C and QS_C are always in the range of $-QpBdOffset_C$ to 51, inclusive.

The value of QP_C for a chroma component is determined from the current value of QP_Y and the value of chroma_qp_index_offset (for Cb) or second_chroma_qp_index_offset (for Cr).

NOTE 2 – The scaling equations are specified such that the equivalent transform coefficient level scaling factor doubles for every increment of 6 in QP_Y. Thus, there is an increase in the factor used for scaling of approximately 12 % for each increase of 1 in the value of QP_Y.

The value of QP_C for each chroma component is determined as specified in Table 8-15 based on the index denoted as qP_I.

The variable qP_{Offset} for each chroma component is derived as follows.

– If the chroma component is the Cb component, qP_{Offset} is specified as

$$qP_{Offset} = \text{chroma\_qp\_index\_offset} \tag{8-315}$$

– Otherwise (the chroma component is the Cr component), qP_{Offset} is specified as

$$qP_{Offset} = \text{second\_chroma\_qp\_index\_offset} \tag{8-316}$$

The value of qP_I for each chroma component is derived as

$$qP_I = \text{Clip3}(-QpBdOffset_C, 51, QP_Y + qP_{Offset}) \tag{8-317}$$

The value of QP'_C for the chroma components is derived as

$$QP'_C = QP_C + QpBdOffset_C \tag{8-318}$$

Table 8-15 – Specification of QP_C as a function of qP_I

qP_I	<30	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
QP_C	$=qP_I$	29	30	31	32	32	33	34	34	35	35	36	36	37	37	37	38	38	38	39	39	39	39

When the current slice is an SP or SI slice, QS_C is derived using the above process, substituting QP_Y with QS_Y and QP_C with QS_C.

The 4x4 matrix weightScale(i, j) is specified as follows.

– The variable mbIsInterFlag is derived as follows.

  – If the current macroblock is coded using Inter macroblock prediction modes, mbIsInterFlag is set equal to 1.

  – Otherwise (the current macroblock is coded using Intra macroblock prediction modes), mbIsInterFlag is set equal to 0.

– The variable iYCbCr derived as follows.
  – If separate_colour_plane_flag is equal to 1, iYCbCr is set equal to colour_plane_id.
  – Otherwise (separate_colour_plane_flag is equal to 0), the following applies.
    – If the input array c relates to a luma residual block, iYCbCr is set equal to 0.
    – Otherwise, if the input array c relates to a chroma residual block and the chroma component is equal to Cb, iYCbCr is set equal to 1.
    – Otherwise (the input array c relates to a chroma residual block and the chroma component is equal to Cr), iYCbCr is set equal to 2.
– The inverse scanning process for transform coefficients as specified in subclause 8.5.6 is invoked with ScalingList4x4[iYCbCr + ((mbIsInterFlag = = 1) ? 3 : 0)] as the input and the output is assigned to the 4x4 matrix weightScale.

LevelScale(m, i, j) is specified by

LevelScale(m, i, j) = weightScale(i, j) * normAdjust(m, i, j) (8-319)

where

$$\text{normAdjust}(m,i,j) = \begin{cases} v_{m0} & \text{for } (i\,\%\,2,\ j\,\%\,2) \text{ equal to } (0,0), \\ v_{m1} & \text{for } (i\,\%\,2,\ j\,\%\,2) \text{ equal to } (1,1), \\ v_{m2} & \text{otherwise;} \end{cases} \tag{8-320}$$

where the first and second subscripts of v are row and column indices, respectively, of the matrix specified as:

$$v = \begin{bmatrix} 10 & 16 & 13 \\ 11 & 18 & 14 \\ 13 & 20 & 16 \\ 14 & 23 & 18 \\ 16 & 25 & 20 \\ 18 & 29 & 23 \end{bmatrix}. \tag{8-321}$$

The 8x8 matrix weightScale8x8(i, j) is specified as follows.

– The variable mbIsInterFlag is derived as follows.
  – If the current macroblock is coded using Inter macroblock prediction modes, mbIsInterFlag is set equal to 1.
  – Otherwise (the current macroblock is coded using Intra macroblock prediction modes), mbIsInterFlag is set equal to 0.
– The variable iYCbCr derived as follows.
  – If separate_colour_plane_flag is equal to 1, iYCbCr is set equal to colour_plane_id.
  – Otherwise (separate_colour_plane_flag is equal to 0), the following applies.
    – If the input array c relates to a luma residual block, iYCbCr is set equal to 0.
    – Otherwise, if the input array c relates to a chroma residual block and the chroma component is equal to Cb, iYCbCr is set equal to 1.
    – Otherwise (the input array c relates to a chroma residual block and the chroma component is equal to Cr), iYCbCr is set equal to 2.
– The inverse scanning process for 8x8 transform coefficients as specified in subclause 8.5.7 is invoked with ScalingList8x8[mbIsInterFlag] as the input and the output is assigned to the 8x8 matrix weightScale8x8.

LevelScale(m, i, j) is specified by

LevelScale8x8(m, i, j) = weightScale8x8(i, j) * normAdjust8x8(m, i, j) (8-322)

where

$$\text{normAdjust8x8}(m,i,j) = \begin{cases} v_{m0} & \text{for } (i \,\%\, 4, j \,\%\, 4) \text{ equal to } (0,0), \\ v_{m1} & \text{for } (i \,\%\, 2, j \,\%\, 2) \text{ equal to } (1,1), \\ v_{m2} & \text{for } (i \,\%\, 4, j \,\%\, 4) \text{ equal to } (2,2), \\ v_{m3} & \text{for } (i \,\%\, 4, j \,\%\, 2) \text{ equal to } (0,1) \text{ or } (i \,\%\, 2, j \,\%\, 4) \text{ equal to } (1,0), \\ v_{m4} & \text{for } (i \,\%\, 4, j \,\%\, 4) \text{ equal to } (0,2) \text{ or } (i \,\%\, 4, j \,\%\, 4) \text{ equal to } (2,0), \\ v_{m5} & \text{otherwise;} \end{cases} \tag{8-323}$$

where the first and second subscripts of v are row and column indices, respectively, of the matrix specified as:

$$v = \begin{bmatrix} 20 & 18 & 32 & 19 & 25 & 24 \\ 22 & 19 & 35 & 21 & 28 & 26 \\ 26 & 23 & 42 & 24 & 33 & 31 \\ 28 & 25 & 45 & 26 & 35 & 33 \\ 32 & 28 & 51 & 30 & 40 & 38 \\ 36 & 32 & 58 & 34 & 46 & 43 \end{bmatrix}. \tag{8-324}$$

8.5.9 Scaling and transformation process for DC transform coefficients for Intra_16x16 macroblock type

Inputs to this process are

– the variables bitDepth and qP,

– transform coefficient level values for DC transform coefficients of Intra_16x16 macroblocks as a 4x4 array c with elements c_{ij}, where i and j form a two-dimensional frequency index.

Outputs of this process are 16 scaled DC values for 4x4 blocks of Intra_16x16 macroblocks as a 4x4 array dcY with elements dcY_{ij}.

Depending on the values of qpprime_y_zero_transform_bypass_flag and QP'_Y, the following applies.

– If qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the output dcY is derived as

$$dcY_{ij} = c_{ij} \quad \text{with} \quad i, j = 0..3 \tag{8-325}$$

– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or QP'_Y is not equal to 0), the following text of this process specifies the output.

The inverse transform for the 4x4 luma DC transform coefficients is specified by:

$$f = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} & c_{02} & c_{03} \\ c_{10} & c_{11} & c_{12} & c_{13} \\ c_{20} & c_{21} & c_{22} & c_{23} \\ c_{30} & c_{31} & c_{32} & c_{33} \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix}. \tag{8-326}$$

The bitstream shall not contain data that results in any element f_{ij} of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})}-1$, inclusive.

After the inverse transform, the scaling is performed as follows.

– If qP is greater than or equal to 36, the scaled result is derived as

$$dcY_{ij} = (f_{ij} * \text{LevelScale}(qP \,\%\, 6, 0, 0)) << (qP / 6 - 6), \quad \text{with} \quad i, j = 0...3 \tag{8-327}$$

– Otherwise (qP is less than 36), the scaled result is derived as

$$dcY_{ij} = (f_{ij} * \text{LevelScale}(qP \,\%\, 6, 0, 0) + (1 << (5 - qP / 6))) >> (6 - qP / 6), \quad \text{with} \quad i, j = 0...3 \tag{8-328}$$

The bitstream shall not contain data that results in any element dcY_{ij} of dcY with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

NOTE 1 – When entropy_coding_mode_flag is equal to 0 and qP is less than 10 and profile_idc is equal to 66, 77, or 88, the range of values that can be represented for the elements c_{ij} of c is not sufficient to represent the full range of values of the elements dcY_{ij} of dcY that could be necessary to form a close approximation of the content of any possible source picture by use of the Intra_16x16 macroblock type.

NOTE 2 – Since the range limit imposed on the elements dcY_{ij} of dcY is imposed after the right shift in Equation 8-328, a larger range of values must be supported in the decoder prior to the right shift.

8.5.10 Scaling and transformation process for chroma DC transform coefficients

This process is only invoked when ChromaArrayType is equal to 1 or 2.

Inputs to this process are transform coefficient level values for chroma DC transform coefficients of one chroma component of the macroblock as an (MbWidthC / 4)x(MbHeightC / 4) array c with elements c_{ij}, where i and j form a two-dimensional frequency index.

Outputs of this process are the scaled DC values as an (MbWidthC / 4)x(MbHeightC / 4) array dcC with elements dcC_{ij}.

The variables bitDepth and qP are set equal to $BitDepth_C$ and QP'_C, respectively.

Depending on the values of qpprime_y_zero_transform_bypass_flag and QP'_Y, the following applies.

– If qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the output dcC is derived as

$$dcC_{ij} = c_{ij} \text{ with } i = 0..(MbWidthC / 4) - 1 \text{ and } j = 0..(MbHeightC / 4) - 1. \quad (8\text{-}329)$$

– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or QP'_Y is not equal to 0), the following applies.

  – The transformation process for chroma DC transform coefficients as specified in subclause 8.5.10.1 is invoked with bitDepth and c as the inputs and the output is assigned to the (MbWidthC / 4)x(MbHeightC / 4) array f of chroma DC values with elements f_{ij}.

  – The scaling process for chroma DC transform coefficients as specified in subclause 8.5.10.2 is invoked with bitDepth, qP, and f as the inputs and the output is assigned to the (MbWidthC / 4)x(MbHeightC / 4) array dcY of scaled chroma DC values with elements dcY_{ij}.

8.5.10.1 Transformation process for chroma DC transform coefficients

Inputs of this process are transform coefficient level values for chroma DC transform coefficients of one chroma component of the macroblock as an (MbWidthC / 4)x(MbHeightC / 4) array c with elements c_{ij}, where i and j form a two-dimensional frequency index.

Outputs of this process are the DC values as an (MbWidthC / 4)x(MbHeightC / 4) array f with elements f_{ij}.

Depending on the variable ChromaArrayType, the inverse transform is specified as follows.

– If ChromaArrayType is equal to 1, the inverse transform for the 2x2 chroma DC transform coefficients is specified as

$$f = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} \\ c_{10} & c_{11} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \quad (8\text{-}330)$$

– Otherwise, (ChromaArrayType is equal to 2), the inverse transform for the 2x4 chroma DC transform coefficients is specified as

$$f = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} \\ c_{10} & c_{11} \\ c_{20} & c_{21} \\ c_{30} & c_{31} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \quad (8\text{-}331)$$

8.5.10.2 Scaling process for chroma DC transform coefficients

Inputs of this process are

– the variables bitDepth and qP

– DC values as an (MbWidthC / 4)x(MbHeightC / 4) array f with elements f_{ij}

Outputs of this process are scaled DC values as an (MbWidthC / 4)x(MbHeightC / 4) array dcC with elements dcC_{ij}.

The bitstream shall not contain data that results in any element f_{ij} of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

Scaling is performed depending on the variable ChromaArrayType as follows.

– If ChromaArrayType is equal to 1, the scaled result is derived as

$$dcC_{ij} = ((f_{ij} * LevelScale(qP \% 6, 0, 0)) << (qP/ 6)) >> 5, \quad with \quad i, j = 0, 1 \tag{8-332}$$

– Otherwise (ChromaArrayType is equal to 2), the following applies.

– The variable qP_{DC} is derived as

$$qP_{DC} = qP + 3 \tag{8-333}$$

– Depending on the value of qP_{DC}, the following applies.

– If qP_{DC} is greater than or equal to 36, the scaled result is derived as

$$dcC_{ij} = (f_{ij} * LevelScale(qP_{DC} \% 6, 0, 0)) << (qP_{DC} / 6 - 6), \quad \text{with } i = 0..3, j = 0, 1 \tag{8-334}$$

– Otherwise (qP_{DC} is less than 36), the scaled result is derived as

$$dcC_{ij} = (f_{ij} * LevelScale(qP_{DC} \% 6, 0, 0) + 2^{5 - qP_{DC}/6}) >> (6 - qP_{DC} / 6), \quad \text{with } i = 0..3, j = 0,1 \tag{8-335}$$

The bitstream shall not contain data that results in any element dcC_{ij} of dcC with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

NOTE 1 – When entropy_coding_mode_flag is equal to 0 and qP is less than 4 and profile_idc is equal to 66, 77, or 88, the range of values that can be represented for the elements c_{ij} of c in subclause 8.5.10.1 may not be sufficient to represent the full range of values of the elements dcC_{ij} of dcC that could be necessary to form a close approximation of the content of any possible source picture.

NOTE 2 – Since the range limit imposed on the elements dcC_{ij} of dcC is imposed after the right shift in Equation 8-332 or 8-335, a larger range of values must be supported in the decoder prior to the right shift.

8.5.11 Scaling and transformation process for residual 4x4 blocks

Input to this process is a 4x4 array c with elements c_{ij} which is either an array relating to a residual block of the luma component or an array relating to a residual block of a chroma component.

Outputs of this process are residual sample values as 4x4 array r with elements r_{ij}.

The variable bitDepth is derived as follows.

– If the input array c relates to a luma residual block, bitDepth is set equal to $BitDepth_Y$.

– Otherwise (the input array c relates to a chroma residual block), bitDepth is set equal to $BitDepth_C$.

The variable sMbFlag is derived as follows.

- If mb_type is equal to SI or the macroblock prediction mode is equal to Inter in an SP slice, sMbFlag is set equal to 1,
- Otherwise (mb_type not equal to SI and the macroblock prediction mode is not equal to Inter in an SP slice), sMbFlag is set equal to 0.

The variable qP is derived as follows.

– If the input array c relates to a luma residual block and sMbFlag is equal to 0

$$qP = QP'_Y \tag{8-336}$$

– Otherwise, if the input array c relates to a luma residual block and sMbFlag is equal to 1

$$qP = QS_Y \tag{8-337}$$

– Otherwise, if the input array c relates to a chroma residual block and sMbFlag is equal to 0

$$qP = QP'_C \tag{8-338}$$

– Otherwise (the input array c relates to a chroma residual block and sMbFlag is equal to 1),

$$qP = QS_C \tag{8-339}$$

Depending on the values of qpprime_y_zero_transform_bypass_flag and QP'_Y, the following applies.

– If qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the output r is derived as

$$r_{ij} = c_{ij} \text{ with } i, j = 0..3 \tag{8-340}$$

– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or QP'_Y is not equal to 0), the following applies.

  – The scaling process for residual 4x4 blocks as specified in subclause 8.5.11.1 is invoked with bitDepth, qP, and c as the inputs and the output is assigned to the 4x4 array d of scaled transform coefficients with elements d_{ij}.

  – The transformation process for residual 4x4 blocks as specified in subclause 8.5.11.2 is invoked with bitDepth and d as the inputs and the output is assigned to the 4x4 array r of residual sample values with elements r_{ij}.

8.5.11.1 Scaling process for residual 4x4 blocks

Inputs of this process are

– the variables bitDepth and qP

– a 4x4 array c with elements c_{ij} which is either an array relating to a residual block of luma component or an array relating to a residual block of a chroma component

Output of this process is a 4x4 array of scaled transform coefficients d with elements d_{ij}.

The bitstream shall not contain data that results in any element c_{ij} of c with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})}-1$, inclusive.

Scaling of 4x4 block transform coefficient levels c_{ij} proceeds as follows.

– If all of the following conditions are true

  – i is equal to 0

  – j is equal to 0

  – c relates to a luma residual block coded using Intra_16x16 prediction mode or c relates to a chroma residual block

  the variable d_{00} is derived by

$$d_{00} = c_{00} \tag{8-341}$$

  – Otherwise, the following applies.

  – If qP is greater than or equal to 24, the scaled result is derived as follows

$$d_{ij} = (c_{ij} * \text{LevelScale}(qP \% 6, i, j)) << (qP / 6 - 4), \text{ with } i,j = 0..3 \text{ except as noted above} \tag{8-342}$$

  – Otherwise (qP is less than 24), the scaled result is derived as follows

$$d_{ij} = (c_{ij} * \text{LevelScale}(qP \% 6, i, j) + 2^{3-qP/6}) >> (4 - qP / 6), \text{ with } i, j = 0..3 \text{ except as noted above} \tag{8-343}$$

The bitstream shall not contain data that results in any element d_{ij} of d with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 1$, inclusive.

8.5.11.2 Transformation process for residual 4x4 blocks

Inputs of this process are

– the variable bitDepth

– a 4x4 array of scaled transform coefficients d with elements d_{ij}

Outputs of this process are residual sample values as 4x4 array r with elements r_{ij}.

The bitstream shall not contain data that results in any element d_{ij} of d with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)} - 1$, inclusive.

The transform process shall convert the block of scaled transform coefficients to a block of output samples in a manner mathematically equivalent to the following.

First, each (horizontal) row of scaled transform coefficients is transformed using a one-dimensional inverse transform as follows.

A set of intermediate values is computed as follows.

$$e_{i0} = d_{i0} + d_{i2}, \quad \text{with} \quad i = 0..3 \tag{8-344}$$

$$e_{i1} = d_{i0} - d_{i2}, \quad \text{with} \quad i = 0..3 \tag{8-345}$$

$$e_{i2} = (d_{i1} >> 1) - d_{i3}, \quad \text{with} \quad i = 0..3 \tag{8-346}$$

$$e_{i3} = d_{i1} + (d_{i3} >> 1), \quad \text{with} \quad i = 0..3 \tag{8-347}$$

The bitstream shall not contain data that results in any element e_{ij} of e with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)} - 1$, inclusive.

Then, the transformed result is computed from these intermediate values as follows.

$$f_{i0} = e_{i0} + e_{i3}, \quad \text{with} \quad i = 0..3 \tag{8-348}$$

$$f_{i1} = e_{i1} + e_{i2}, \quad \text{with} \quad i = 0..3 \tag{8-349}$$

$$f_{i2} = e_{i1} - e_{i2}, \quad \text{with} \quad i = 0..3 \tag{8-350}$$

$$f_{i3} = e_{i0} - e_{i3}, \quad \text{with} \quad i = 0..3 \tag{8-351}$$

The bitstream shall not contain data that results in any element f_{ij} of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)} - 1$, inclusive.

Then, each (vertical) column of the resulting matrix is transformed using the same one-dimensional inverse transform as follows.

A set of intermediate values is computed as follows.

$$g_{0j} = f_{0j} + f_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-352}$$

$$g_{1j} = f_{0j} - f_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-353}$$

$$g_{2j} = (f_{1j} >> 1) - f_{3j}, \quad \text{with} \quad j = 0..3 \tag{8-354}$$

$$g_{3j} = f_{1j} + (f_{3j} >> 1), \quad \text{with} \quad j = 0..3 \tag{8-355}$$

The bitstream shall not contain data that results in any element g_{ij} of g with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)} - 1$, inclusive.

Then, the transformed result is computed from these intermediate values as follows.

$$h_{0j} = g_{0j} + g_{3j}, \quad \text{with} \quad j = 0..3 \tag{8-356}$$

$$h_{1j} = g_{1j} + g_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-357}$$

$$h_{2j} = g_{1j} - g_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-358}$$

$$h_{3j} = g_{0j} - g_{3j}, \quad \text{with} \quad j = 0..3 \tag{8-359}$$

The bitstream shall not contain data that results in any element h_{ij} of h with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)} - 33$, inclusive.

After performing both the one-dimensional horizontal and the one-dimensional vertical inverse transforms to produce an array of transformed samples, the final constructed residual sample values is derived as

$$r_{ij} = (h_{ij} + 2^5) >> 6 \quad \text{with} \quad i, j = 0..3 \tag{8-360}$$

8.5.12 Scaling and transformation process for residual 8x8 blocks

Input to this process is an 8x8 array c with elements c_{ij} which is either an array relating to an 8x8 residual block of the luma component or, when ChromaArrayType is equal to 3, an array relating to an 8x8 residual block of a chroma component.

NOTE 1 – When separate_colour_plane_flag is equal to 1, all residual blocks are considered to be associated with the luma component for purposes of the decoding process of each coded picture (prior to the final assignment of the decoded picture to a particular luma or chroma picture array according to the value of colour_plane_id).

Outputs of this process are residual sample values as 8x8 array r with elements r_{ij}.

The variables bitDepth and qP are derived as follows.

- If the input array c relates to a luma residual block, bitDepth is set equal to $BitDepth_Y$ and QP is set equal to QP'_Y.
- Otherwise (the input array c relates to a chroma residual block), bitDepth is set equal to $BitDepth_C$ and QP is set equal to QP'_C.

NOTE 2 – When separate_colour_plane_flag is equal to 1, all residual blocks are considered to be associated with the luma component for purposes of the decoding process of each colour component of a picture.

Depending on the values of qpprime_y_zero_transform_bypass_flag and QP'_Y, the following applies.

– If qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the output r is derived as

$$r_{ij} = c_{ij} \quad \text{with} \quad i, j = 0..7 \tag{8-361}$$

– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or QP'Y is not equal to 0), the following applies.

  – The scaling process for residual 8x8 blocks as specified in subclause 8.5.12.1 is invoked with bitDepth, qP, and c as the inputs and the output is assigned to the 8x8 array d of scaled transform coefficients with elements d_{ij}.

  – The transformation process for residual 8x8 blocks as specified in subclause 8.5.12.2 is invoked with bitDepth and d as the inputs and the output is assigned to the 8x8 array r of residual sample values with elements r_{ij}.

8.5.12.1 Scaling process for residual 8x8 blocks

Inputs of this process are

– the variables bitDepth and qP

– an 8x8 array c with elements c_{ij} which is either an array relating to a residual block of luma component or an array relating to a residual block of a chroma component

Output of this process is an 8x8 array of scaled transform coefficients d with elements d_{ij}.

The bitstream shall not contain data that results in any element c_{ij} of c with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

The scaling process for 8x8 block transform coefficient levels c_{ij} proceeds as follows.

– If qP is greater than or equal to 36, the scaled result is derived as

$$d_{ij} = (c_{ij} * LevelScale8x8(qP \% 6, i, j)) << (qP / 6 – 6), \text{ with } i,j = 0..7 \quad (8\text{-}362)$$

– Otherwise (qP is less than 36), the scaled result is derived as

$$d_{ij} = (c_{ij} * LevelScale8x8(qP \% 6, i, j)) + 2^{5-QP'_Y/6}) >> (6 – qP /6), \text{ with } i,j = 0..7 \quad (8\text{-}363)$$

The bitstream shall not contain data that results in any element d_{ij} of d with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

8.5.12.2 Transformation process for residual 8x8 blocks

Inputs of this process are

– the variable bitDepth

– an 8x8 array of scaled transform coefficients d with elements d_{ij}

Outputs of this process are residual sample values as 8x8 array r with elements r_{ij}.

The bitstream shall not contain data that results in any element d_{ij} of d with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)} – 1$, inclusive.

The transform process shall convert the block of scaled transform coefficients to a block of output samples in a manner mathematically equivalent to the following.

First, each (horizontal) row of scaled transform coefficients is transformed using a one-dimensional inverse transform as follows.

– A set of intermediate values e_{ij} is derived by

$$e_{i0} = d_{i0} + d_{i4}, \text{ with } i = 0..7 \quad (8\text{-}364)$$

$$e_{i1} = – d_{i3} + d_{i5} – d_{i7} – (d_{i7} >> 1), \text{ with } i = 0..7 \quad (8\text{-}365)$$

$$e_{i2} = d_{i0} – d_{i4}, \text{ with } i = 0..7 \quad (8\text{-}366)$$

$$e_{i3} = d_{i1} + d_{i7} – d_{i3} – (d_{i3} >> 1), \text{ with } i = 0..7 \quad (8\text{-}367)$$

$$e_{i4} = (d_{i2} >> 1) – d_{i6}, \text{ with } i = 0..7 \quad (8\text{-}368)$$

$$e_{i5} = – d_{i1} + d_{i7} + d_{i5} + (d_{i5} >> 1), \text{ with } i = 0..7 \quad (8\text{-}369)$$

$$e_{i6} = d_{i2} + (d_{i6} >> 1), \text{ with } i = 0..7 \quad (8\text{-}370)$$

$$e_{i7} = d_{i3} + d_{i5} + d_{i1} + (d_{i1} >> 1), \text{ with } i = 0..7 \quad (8\text{-}371)$$

– A second set of intermediate results f_{ij} is computed from the intermediate values e_{ij} as

$$f_{i0} = e_{i0} + e_{i6}, \text{ with } i = 0..7 \quad (8\text{-}372)$$

$$f_{i1} = e_{i1} + (e_{i7} >> 2), \text{ with } i = 0..7 \quad (8\text{-}373)$$

$$f_{i2} = e_{i2} + e_{i4}, \text{ with } i = 0..7 \quad (8\text{-}374)$$

$$f_{i3} = e_{i3} + (e_{i5} >> 2), \text{ with } i = 0..7 \quad (8\text{-}375)$$

$$f_{i4} = e_{i2} - e_{i4}, \text{ with } i = 0..7 \quad (8\text{-}376)$$

$$f_{i5} = (e_{i3} >> 2) - e_{i5}, \text{ with } i = 0..7 \quad (8\text{-}377)$$

$$f_{i6} = e_{i0} - e_{i6}, \text{ with } i = 0..7 \quad (8\text{-}378)$$

$$f_{i7} = e_{i7} - (e_{i1} >> 2), \text{ with } i = 0..7 \quad (8\text{-}379)$$

– Then, the transformed result g_{ij} is computed from these intermediate values f_{ij} as

$$g_{i0} = f_{i0} + f_{i7}, \text{ with } i = 0..7 \quad (8\text{-}380)$$

$$g_{i1} = f_{i2} + f_{i5}, \text{ with } i = 0..7 \quad (8\text{-}381)$$

$$g_{i2} = f_{i4} + f_{i3}, \text{ with } i = 0..7 \quad (8\text{-}382)$$

$$g_{i3} = f_{i6} + f_{i1}, \text{ with } i = 0..7 \quad (8\text{-}383)$$

$$g_{i4} = f_{i6} - f_{i1}, \text{ with } i = 0..7 \quad (8\text{-}384)$$

$$g_{i5} = f_{i4} - f_{i3}, \text{ with } i = 0..7 \quad (8\text{-}385)$$

$$g_{i6} = f_{i2} - f_{i5}, \text{ with } i = 0..7 \quad (8\text{-}386)$$

$$g_{i7} = f_{i0} - f_{i7}, \text{ with } i = 0..7 \quad (8\text{-}387)$$

Then, each (vertical) column of the resulting matrix is transformed using the same one-dimensional inverse transform as follows.

– A set of intermediate values h_{ij} is computed from the horizontally transformed value g_{ij} as

$$h_{0j} = g_{0j} + g_{4j}, \text{ with } j = 0..7 \quad (8\text{-}388)$$

$$h_{1j} = -g_{3j} + g_{5j} - g_{7j} - (g_{7j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}389)$$

$$h_{2j} = g_{0j} - g_{4j}, \text{ with } j = 0..7 \quad (8\text{-}390)$$

$$h_{3j} = g_{1j} + g_{7j} - g_{3j} - (g_{3j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}391)$$

$$h_{4j} = (g_{2j} >> 1) - g_{6j}, \text{ with } j = 0..7 \quad (8\text{-}392)$$

$$h_{5j} = -g_{1j} + g_{7j} + g_{5j} + (g_{5j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}393)$$

$$h_{6j} = g_{2j} + (g_{6j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}394)$$

$$h_{7j} = g_{3j} + g_{5j} + g_{1j} + (g_{1j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}395)$$

– A second set of intermediate results k_{ij} is computed from the intermediate values h_{ij} as

$$k_{0j} = h_{0j} + h_{6j}, \text{ with } j = 0..7 \quad (8\text{-}396)$$

$$k_{1j} = h_{1j} + (h_{7j} >> 2), \text{ with } j = 0..7 \quad (8\text{-}397)$$

$$k_{2j} = h_{2j} + h_{4j}, \text{ with } j = 0..7 \quad (8\text{-}398)$$

$$k_{3j} = h_{3j} + (h_{5j} >> 2), \text{ with } j = 0..7 \quad (8\text{-}399)$$

$$k_{4j} = h_{2j} – h_{4j}, \text{ with } j = 0..7 \quad (8\text{-}400)$$

$$k_{5j} = (h_{3j} >> 2) – h_{5j}, \text{ with } j = 0..7 \quad (8\text{-}401)$$

$$k_{6j} = h_{0j} – h_{6j}, \text{ with } j = 0..7 \quad (8\text{-}402)$$

$$k_{7j} = h_{7j} – (h_{1j} >> 2), \text{ with } j = 0..7 \quad (8\text{-}403)$$

– Then, the transformed result m_{ij} is computed from these intermediate values k_{ij} as

$$m_{0j} = k_{0j} + k_{7j}, \text{ with } j = 0..7 \quad (8\text{-}404)$$

$$m_{1j} = k_{2j} + k_{5j}, \text{ with } j = 0..7 \quad (8\text{-}405)$$

$$m_{2j} = k_{4j} + k_{3j}, \text{ with } j = 0..7 \quad (8\text{-}406)$$

$$m_{3j} = k_{6j} + k_{1j}, \text{ with } j = 0..7 \quad (8\text{-}407)$$

$$m_{4j} = k_{6j} – k_{1j}, \text{ with } j = 0..7 \quad (8\text{-}408)$$

$$m_{5j} = k_{4j} – k_{3j}, \text{ with } j = 0..7 \quad (8\text{-}409)$$

$$m_{6j} = k_{2j} – k_{5j}, \text{ with } j = 0..7 \quad (8\text{-}410)$$

$$m_{7j} = k_{0j} – k_{7j}, \text{ with } j = 0..7 \quad (8\text{-}411)$$

The bitstream shall not contain data that results in any element e_{ij}, f_{ij}, g_{ij}, h_{ij}, or k_{ij} for i and j in the range of 0..7, inclusive, that exceeds the range of integer values from $–2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} – 1$, inclusive.

The bitstream shall not contain data that results in any element m_{ij} for i and j in the range of 0..7, inclusive, that exceeds the range of integer values from $–2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} – 33$, inclusive.

After performing both the one-dimensional horizontal and the one-dimensional vertical inverse transforms to produce an array of transformed samples, the final constructed residual sample values are derived as

$$r_{ij} = (m_{ij} + 2^5) >> 6 \quad \text{with} \quad i, j = 0..7 \tag{8-412}$$

8.5.13 Picture construction process prior to deblocking filter process

Inputs to this process are

– a sample array u with elements u_{ij} which is a 16x16 luma block or an (MbWidthC)x(MbHeightC) chroma block or a 4x4 luma block or a 4x4 chroma block or an 8x8 luma block or, when ChromaArrayType is equal to 3, an 8x8 chroma block

– when u is not a 16x16 luma block or an (MbWidthC)x(MbHeightC) chroma block, a block index luma4x4BlkIdx or chroma4x4BlkIdx or luma8x8BlkIdx or cb4x4BlkIdx or cr4x4BlkIdx or cb8x8BlkIdx or cr8x8BlkIdx

The position of the upper-left luma sample of the current macroblock is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with CurrMbAddr as input and the output being assigned to (xP, yP).

When u is a luma block, for each sample u_{ij} of the luma block, the following applies.

– Depending on the size of the block u, the following applies.

  – If u is a 16x16 luma block, the position (xO, yO) of the upper-left sample of the 16x16 luma block inside the macroblock is set equal to (0, 0) and the variable nE is set equal to 16.

  – Otherwise, if u is an 4x4 luma block, the position of the upper-left sample of the 4x4 luma block with index luma4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (xO, yO), and the variable nE is set equal to 4.

  – Otherwise (u is an 8x8 luma block), the position of the upper-left sample of the 8x8 luma block with index luma8x8BlkIdx inside the macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.5 with luma8x8BlkIdx as the input and the output being assigned to (xO, yO), and the variable nE is set equal to 8.

– Depending on the variable MbaffFrameFlag and the current macroblock, the following applies.

  – If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock

$$S'_L[xP + xO + j, yP + 2 * (yO + i)] = u_{ij} \quad \text{with } i, j = 0..nE - 1 \tag{8-413}$$

  – Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock),

$$S'_L[xP + xO + j, yP + yO + i] = u_{ij} \quad \text{with } i, j = 0..nE - 1 \tag{8-414}$$

When u is a chroma block, for each sample u_{ij} of the chroma block, the following applies.

– The subscript C in the variable S'_C is replaced with Cb for the Cb chroma component and with Cr for the Cr chroma component.

– Depending on the size of the block u, the following applies.

  – If u is an (MbWidthC)x(MbHeightC) Cb or Cr block, the variable nW is set equal to MbWidthC, the variable nH is set equal to MbHeightC, and the position (xO, yO) of the upper-left sample of the (nW)x(nH) Cb or Cr block inside the macroblock is set equal to (0, 0).

  – Otherwise, if u is a 4x4 Cb or Cr block, the variables nW and nH are set equal to 4 and, depending on the variable ChromaArrayType, the position of the upper-left sample of a 4x4 Cb or Cr block with index chroma4x4BlkIdx inside the macroblock is derived as follows.

    – If ChromaArrayType is equal to 1 or 2, the following applies.

$$xO = \text{InverseRasterScan}(\text{chroma4x4BlkIdx}, 4, 4, 8, 0) \tag{8-415}$$

$$yO = \text{InverseRasterScan}(\text{chroma4x4BlkIdx}, 4, 4, 8, 1) \tag{8-416}$$

– Otherwise (ChromaArrayType is equal to 3), the position of the upper-left sample of the 4x4 Cb block with index cb4x4BlkIdx or the 4x4 Cr block with index cr4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 Cb or Cr block scanning process in subclause 6.4.4 with cb4x4BlkIdx or cr4x4BlkIdx as the input and the output being assigned to (xO, yO).

– Otherwise (u is an 8x8 Cb or Cr block when ChromaArrayType is equal to 3), the variables nW and nH are set equal to 8 and the position of the upper-left sample of the 8x8 Cb block with index cb8x8BlkIdx or the Cr block with index cr8x8BlkIdx inside the macroblock is derived by invoking the inverse 8x8 Cb or Cr block scanning process in subclause 6.4.6 with cb8x8BlkIdx or cr8x8BlkIdx as the input and the output being assigned to (xO, yO).

– Depending on the variable MbaffFrameFlag and the current macroblock, the following applies.

  – If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock

$$S'_C[\ (\ xP\ /\ subWidthC\ )\ +\ xO\ +\ j,\ (\ (\ yP\ +\ SubHeightC\ -\ 1\ )\ /\ SubHeightC\ )\ +\ 2\ *\ (\ yO\ +\ i\ )\ ]\ =\ u_{ij} \quad \text{with } i = 0..nH - 1 \text{ and } j = 0..nW - 1 \tag{8-417}$$

  – Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock),

$$S'_C[\ (\ xP/\ subWidthC\ )\ +\ xO\ +\ j,\ (\ yP\ /\ SubHeightC\ )\ +\ yO\ +\ i\ ]\ =\ u_{ij} \quad \text{with } i = 0..nH - 1 \text{ and } j = 0..nW - 1 \tag{8-418}$$

8.5.14 Intra residual transform-bypass decoding process

This process is invoked when qpprime_y_zero_transform_bypass_flag is equal to 1, QP'_Y is equal to 0, the macroblock prediction mode is equal to Intra_4x4, Intra_8x8, or Intra_16x16, and the applicable intra prediction mode is equal to the vertical or horizontal mode. The process for the Cb and Cr components is applied in the same way as for the luma (L or Y) component.

Inputs to this process are

– two variables nW and nH

– a variable horPredFlag

– an (nW)x(nH) array r with elements r_{ij} which is either an array relating to a residual transform-bypass block of the luma component or an array relating to a residual transform-bypass block of the Cb and Cr component.

Output of this process is a modified version of the (nW)x(nH) array r with elements r_{ij} containing the result of the intra residual transform-bypass decoding process.

Let f be a temporary (nW)x(nH) array with elements f_{ij}, which are derived by

$$f_{ij} = r_{ij} \quad \text{with } i = 0..nH - 1 \text{ and } j = 0..nW - 1 \tag{8-419}$$

Depending on horPredFlag, the following applies.

– If horPredFlag is equal to 0, the modified array r is derived by.

$$r_{ij} = \sum_{k=0}^{i} f_{kj} \quad \text{with } i = 0..nH - 1 \text{ and } j = 0..nW - 1 \tag{8-420}$$

– Otherwise (horPredFlag is equal to 1), the modified array r is derived by

$$r_{ij} = \sum_{k=0}^{j} f_{ik} \quad \text{with } i = 0..nH - 1 \text{ and } j = 0..nW - 1 \tag{8-421}$$

8.6 Decoding process for P macroblocks in SP slices or SI macroblocks

This process is invoked when decoding P macroblock types in an SP slice type or an SI macroblock type in SI slices.

Inputs to this process are the prediction residual transform coefficient levels and the predicted samples for the current macroblock.

Outputs of this process are the decoded samples of the current macroblock prior to the deblocking filter process.

This subclause specifies the transform coefficient decoding process and picture construction process for P macroblock types in SP slices and SI macroblock type in SI slices.

NOTE – SP slices make use of Inter predictive coding to exploit temporal redundancy in the sequence, in a similar manner to P slice coding. Unlike P slice coding, however, SP slice coding allows identical reconstruction of a slice even when different reference pictures are being used. SI slices make use of spatial prediction, in a similar manner to I slices. SI slice coding allows identical reconstruction to a corresponding SP slice. The properties of SP and SI slices aid in providing functionalities for bitstream switching, splicing, random access, fast-forward, fast reverse, and error resilience/recovery.

An SP slice consists of macroblocks coded either as I macroblock types or P macroblock types.

An SI slice consists of macroblocks coded either as I macroblock types or SI macroblock type.

The transform coefficient decoding process and picture construction process prior to deblocking filter process for I macroblock types in SI slices is invoked as specified in subclause 8.5. SI macroblock type is decoded as described below.

When the current macroblock is coded as P_Skip, all values of LumaLevel, ChromaDCLevel, ChromaACLevel are set equal to 0 for the current macroblock.

8.6.1 SP decoding process for non-switching pictures

This process is invoked, when decoding P macroblock types in SP slices in which sp_for_switch_flag is equal to 0.

Inputs to this process are Inter prediction samples for the current macroblock from subclause 8.4 and the prediction residual transform coefficient levels.

Outputs of this process are the decoded samples of the current macroblock prior to the deblocking filter process.

This subclause applies to all macroblocks in SP slices in which sp_for_switch_flag is equal to 0, except those with macroblock prediction mode equal to Intra_4x4 or Intra_16x16. It does not apply to SI slices.

8.6.1.1 Luma transform coefficient decoding process

Inputs to this process are Inter prediction luma samples for the current macroblock $pred_L$ from subclause 8.4 and the prediction residual transform coefficient levels, LumaLevel, and the index of the 4x4 luma block luma4x4BlkIdx.

The position of the upper-left sample of the 4x4 luma block with index luma4x4BlkIdx inside the current macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (x, y).

Let the variable p be a 4x4 array of prediction samples with element p_{ij} being derived as follows.

$$p_{ij} = pred_L[\ x + j, y + i\ ] \quad \text{with } i, j = 0..3 \tag{8-422}$$

The variable p is transformed producing transform coefficients c^p according to:

$$c^p = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 1 \\ 1 & -2 & 2 & -1 \end{bmatrix} \begin{bmatrix} p_{00} & p_{01} & p_{02} & p_{03} \\ p_{10} & p_{11} & p_{12} & p_{13} \\ p_{20} & p_{21} & p_{22} & p_{23} \\ p_{30} & p_{31} & p_{32} & p_{33} \end{bmatrix} \begin{bmatrix} 1 & 2 & 1 & 1 \\ 1 & 1 & -1 & -2 \\ 1 & -1 & -1 & 2 \\ 1 & -2 & 1 & -1 \end{bmatrix} \tag{8-423}$$

The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with LumaLevel[luma4x4BlkIdx] as the input and the two-dimensional array c^r with elements c_{ij}^r as the output.

The prediction residual transform coefficients c^r are scaled using quantisation parameter QP_Y, and added to the transform coefficients of the prediction block c^p with i, j = 0..3 as follows.

$$c_{ij}^s = c_{ij}^p + (((c_{ij}^r * LevelScale(QP_Y \% 6, i, j) * A_{ij}) << (QP_Y / 6)) >> 10) \tag{8-424}$$

where LevelScale(m, i, j) is specified in Equation 8-319, and where A_{ij} is specified as:

$$A_{ij} = \begin{cases} 16 & \text{for} \quad (i, j) \in \{(0,0), (0,2), (2,0), (2,2)\}, \\ 25 & \text{for} \quad (i, j) \in \{(1,1), (1,3), (3,1), (3,3)\}, \\ 20 & \text{otherwise;} \end{cases} \tag{8-425}$$

The function LevelScale2(m, i, j), used in the formulas below, is specified as:

$$\text{LevelScale2}(m, i, j) = \begin{cases} w_{m0} & \text{for} \quad (i, j) \in \{(0,0), (0,2), (2,0), (2,2)\}, \\ w_{m1} & \text{for} \quad (i, j) \in \{(1,1), (1,3), (3,1), (3,3)\}, \\ w_{m2} & \text{otherwise;} \end{cases} \tag{8-426}$$

where the first and second subscripts of w are row and column indices, respectively, of the matrix specified as:

$$w = \begin{bmatrix} 13107 & 5243 & 8066 \\ 11916 & 4660 & 7490 \\ 10082 & 4194 & 6554 \\ 9362 & 3647 & 5825 \\ 8192 & 3355 & 5243 \\ 7282 & 2893 & 4559 \end{bmatrix} \tag{8-427}$$

The resulting sum, c^s, is quantised with a quantisation parameter QS_Y and with i, j = 0..3 as follows.

$$c_{ij} = \text{Sign}(c_{ij}^s) * ((\text{Abs}(c_{ij}^s) * \text{LevelScale2}(QS_Y \% 6, i, j) + (1 << (14 + QS_Y / 6))) >> (15 + QS_Y / 6)) \tag{8-428}$$

The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c as the input and r as the output.

The 4x4 array u with elements u_{ij} is derived as follows.

$$u_{ij} = \text{Clip1}_Y(r_{ij}) \text{ with } i, j = 0..3 \tag{8-429}$$

The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with luma4x4BlkIdx and u as the inputs.

8.6.1.2 Chroma transform coefficient decoding process

Inputs to this process are Inter prediction chroma samples for the current macroblock from subclause 8.4 and the prediction residual transform coefficient levels, ChromaDCLevel and ChromaACLevel.

This process is invoked twice: once for the Cb component and once for the Cr component. The component is referred to by replacing C with Cb for the Cb component and C with Cr for the Cr component. Let iCbCr select the current chroma component.

For each 4x4 block of the current chroma component indexed using chroma4x4BlkIdx with chroma4x4BlkIdx equal to 0..3, the following applies.

– The position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx inside the macroblock is derived as follows.

$$x = \text{InverseRasterScan}(\text{chroma4x4BlkIdx}, 4, 4, 8, 0) \tag{8-430}$$

$$y = \text{InverseRasterScan}(\text{chroma4x4BlkIdx}, 4, 4, 8, 1) \tag{8-431}$$

– Let p be a 4x4 array of prediction samples with elements p_{ij} being derived as follows.

$$p_{ij} = pred_C[\, x + j, y + i \,] \quad \text{with } i, j = 0..3 \tag{8-432}$$

– The 4x4 array p is transformed producing transform coefficients c^p(chroma4x4BlkIdx) using Equation 8-423.

– The variable chromaList, which is a list of 16 entries, is derived. chromaList[0] is set equal to 0. chromaList[k] with index k = 1..15 are specified as follows.

$$\text{chromaList}[\, k \,] = \text{ChromaACLevel}[\, \text{iCbCr} \,][\, \text{chroma4x4BlkIdx} \,][\, k - 1 \,] \tag{8-433}$$

– The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with chromaList as the input and the 4x4 array c^r as the output.

– The prediction residual transform coefficients c^r are scaled using quantisation parameter QPC, and added to the transform coefficients of the prediction block c^p with i, j = 0..3 except for the combination i = 0, j = 0 as follows.

$$c_{ij}^s = c_{ij}^p(\, \text{chroma4x4BlkIdx} \,) + (((c_{ij}^r * \text{LevelScale}(QP_C \,\%\, 6, i, j) * A_{ij}) << (QP_C / 6)) >> 10) \tag{8-434}$$

– The resulting sum, c^s, is quantised with a quantisation parameter QS_C and with i, j = 0..3 except for the combination i = 0, j = 0 as follows. The derivation of c_{00}(chroma4x4BlkIdx) is described below in this subclause.

$$\begin{aligned} c_{ij}(\, \text{chroma4x4BlkIdx} \,) = {} & (\text{Sign}(c_{ij}^s) * (\text{Abs}(c_{ij}^s) * \text{LevelScale2}(QS_C \,\%\, 6, i, j) + \\ & (1 << (14 + QS_C / 6)))) >> (15 + QS_C / 6) \end{aligned} \tag{8-435}$$

– The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c(chroma4x4BlkIdx) as the input and r as the output.

– The 4x4 array u with elements u_{ij} is derived as follows.

$$u_{ij} = \text{Clip1}_C(r_{ij}) \text{ with } i, j = 0..3 \tag{8-436}$$

– The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with chroma4x4BlkIdx and u as the inputs.

The derivation of the DC transform coefficient level c_{00}(chroma4x4BlkIdx) is specified as follows. The DC transform coefficients of the 4 prediction chroma 4x4 blocks of the current component of the macroblock are assembled into a 2x2 matrix with elements c_{00}^p(chroma4x4BlkIdx) and a 2x2 transform is applied to the DC transform coefficients as follows

$$dc^p = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00}^p(0) & c_{00}^p(1) \\ c_{00}^p(2) & c_{00}^p(3) \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \tag{8-437}$$

The chroma DC prediction residual transform coefficient levels, ChromaDCLevel[iCbCr][k] with k = 0..3 are scaled using quantisation parameter QP, and added to the prediction DC transform coefficients as follows.

$$dc_{ij}^s = dc_{ij}^p + (((\text{ChromaDCLevel}[\, \text{iCbCr} \,][\, j * 2 + i \,] * \text{LevelScale}(QP_C \,\%\, 6, 0, 0) * A_{00}) << (QP_C / 6)) >> 9) \quad \text{with } i, j = 0, 1 \tag{8-438}$$

The 2x2 array dc^s, is quantised using the quantisation parameter QS_C as follows.

$$dc_{ij}^r = (\text{Sign}(dc_{ij}^s) * (\text{Abs}(dc_{ij}^s) * \text{LevelScale2}(QS_C \,\%\, 6, 0, 0) + (1 << (15 + QS_C / 6)))) >> (16 + QS_C / 6) \quad \text{with } i, j = 0, 1 \tag{8-439}$$

The 2x2 array f with elements f_{ij} and i, j = 0..1 is derived as follows.

$$f = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} dc_{00}^r & dc_{01}^r \\ dc_{10}^r & dc_{11}^r \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}. \tag{8-440}$$

Scaling of the elements f_{ij} of f is performed as follows.

$$c_{00}(j * 2 + i) = ((f_{ij} * \text{LevelScale}(QS_C \% 6, 0, 0)) << (QS_C / 6)) >> 5 \quad \text{with i, j = 0, 1} \tag{8-441}$$

8.6.2 SP and SI slice decoding process for switching pictures

This process is invoked, when decoding P macroblock types in SP slices in which sp_for_switch_flag is equal to 1 and when decoding SI macroblock type in SI slices.

Inputs to this process are the prediction residual transform coefficient levels and the prediction sample arrays $pred_L$, $pred_{Cb}$ and $pred_{Cr}$ for the current macroblock.

8.6.2.1 Luma transform coefficient decoding process

Inputs to this process are prediction luma samples $pred_L$ and the luma prediction residual transform coefficient levels, LumaLevel.

The 4x4 array p with elements p_{ij} with i, j = 0..3 is derived as in subclause 8.6.1.1, is transformed according to Equation 8-423 to produce transform coefficients c^p. These transform coefficients are then quantised with the quantisation parameter QS_Y, as follows:

$$c_{ij}^s = \text{Sign}(c_{ij}^p) * ((\text{Abs}(c_{ij}^p) * \text{LevelScale2}(QS_Y \% 6, i, j) + (1 << (14 + QS_Y / 6))) >> (15 + QS_Y / 6)) \quad \text{with i, j = 0..3} \tag{8-442}$$

The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with LumaLevel[luma4x4BlkIdx] as the input and the two-dimensional array c^r with elements c_{ij}^r as the output.

The 4x4 array c with elements c_{ij} with i, j = 0..3 is derived as follows.

$$c_{ij} = c_{ij}^r + c_{ij}^s \quad \text{with i, j = 0..3} \tag{8-443}$$

The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c as the input and r as the output.

The 4x4 array u with elements u_{ij} is derived as follows.

$$u_{ij} = \text{Clip1}_Y(r_{ij}) \text{ with i, j = 0..3} \tag{8-444}$$

The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with luma4x4BlkIdx and u as the inputs.

8.6.2.2 Chroma transform coefficient decoding process

Inputs to this process are predicted chroma samples for the current macroblock from subclause 8.4 and the prediction residual transform coefficient levels, ChromaDCLevel and ChromaACLevel.

This process is invoked twice: once for the Cb component and once for the Cr component. The component is referred to by replacing C with Cb for the Cb component and C with Cr for the Cr component. Let iCbCr select the current chroma component.

For each 4x4 block of the current chroma component indexed using chroma4x4BlkIdx with chroma4x4BlkIdx equal to 0..3, the following applies.

1. The 4x4 array p with elements p_{ij} with i, j = 0..3 is derived as in subclause 8.6.1.2, is transformed according to Equation 8-423 to produce transform coefficients c^p(chroma4x4BlkIdx). These transform coefficients are then quantised with the quantisation parameter QS_C, with i, j = 0..3 except for the combination i = 0, j = 0 as follows. The processing of c_{00}^p(chroma4x4BlkIdx) is described below in this subclause.

$$c_{ij}^s = (\text{Sign}(c_{ij}^p(\text{chroma4x4BlkIdx})) * (\text{Abs}(c_{ij}^p(\text{chroma4x4BlkIdx})) * \text{LevelScale2}(QS_C \% 6, i, j) + (1 << (14 + QS_C / 6)))) >> (15 + QS_C / 6) \tag{8-445}$$

– The variable chromaList, which is a list of 16 entries, is derived. chromaList[0] is set equal to 0. chromaList[k] with index k = 1..15 are specified as follows.

$$\text{chromaList}[k] = \text{ChromaACLevel}[\text{iCbCr}][\text{chroma4x4BlkIdx}][k - 1] \tag{8-446}$$

– The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with chromaList as the input and the two-dimensional array c^r(chroma4x4BlkIdx) with elements c_{ij}^r(chroma4x4BlkIdx) as the output.

– The 4x4 array c(chroma4x4BlkIdx) with elements c_{ij}(chroma4x4BlkIdx) with i, j = 0..3 except for the combination i = 0, j = 0 is derived as follows. The derivation of c_{00}(chroma4x4BlkIdx) is described below.

$$c_{ij}(\text{chroma4x4BlkIdx}) = c_{ij}^r(\text{chroma4x4BlkIdx}) + c_{ij}^s \tag{8-447}$$

– The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c(chroma4x4BlkIdx) as the input and r as the output.

– The 4x4 array u with elements u_{ij} is derived as follows.

$$u_{ij} = \text{Clip1}_C(r_{ij}) \text{ with } i, j = 0..3 \tag{8-448}$$

– The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with chroma4x4BlkIdx and u as the inputs.

The derivation of the DC transform coefficient level c_{00}(chroma4x4BlkIdx) is specified as follows. The DC transform coefficients of the 4 prediction 4x4 chroma blocks of the current component of the macroblock, c_{00}^p(chroma4x4BlkIdx), are assembled into a 2x2 matrix, and a 2x2 transform is applied to the DC transform coefficients of these blocks according to Equation 8-437 resulting in DC transform coefficients dc_{ij}^p.

These DC transform coefficients are then quantised with the quantisation parameter QS_C, as given by:

$$dc_{ij}^s = (\text{Sign}(dc_{ij}^p) * (\text{Abs}(dc_{ij}^p) * \text{LevelScale2}(QS_C \% 6, 0, 0) + (1 << (15 + QS_C / 6)))) >> (16 + QS_C / 6) \text{ with } i, j = 0, 1 \tag{8-449}$$

The parsed chroma DC prediction residual transform coefficients, ChromaDCLevel[iCbCr][k] with k = 0..3 are added to these quantised DC transform coefficients of the prediction block, as given by:

$$dc_{ij}^r = dc_{ij}^s + \text{ChromaDCLevel}[\text{iCbCr}][j * 2 + i] \text{ with } i, j = 0, 1 \tag{8-450}$$

The 2x2 array f with elements f_{ij} and i, j = 0..1 is derived using Equation 8-440.

The 2x2 array f with elements f_{ij} and i, j = 0..1 is copied as follows.

$$c_{00}(j * 2 + i) = f_{ij} \text{ with } i, j = 0, 1 \tag{8-451}$$

8.7 Deblocking filter process

A conditional filtering process is specified in this subclause that is an integral part of the decoding process which shall be applied by decoders conforming to the Baseline, Extended, Main, High, High 10, High 4:2:2, and High 4:4:4 Predictive profiles. For decoders conforming to the High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles, the filtering process specified in this subclause, or one similar to it, should be applied but is not required.

The conditional filtering process is applied to all NxN (where N = 4 or N = 8 for luma, N = 4 for chroma when ChromaArrayType is equal to 1 or 2, and N = 4 or N = 8 for chroma when ChromaArrayType is equal to 3) block edges of a picture, except edges at the boundary of the picture and any edges for which the deblocking filter process is disabled by disable_deblocking_filter_idc, as specified below. This filtering process is performed on a macroblock basis after the completion of the picture construction process prior to deblocking filter process (as specified in subclauses 8.5 and 8.6) for the entire decoded picture, with all macroblocks in a picture processed in order of increasing macroblock addresses.

NOTE 1 – Prior to the operation of the deblocking filter process for each macroblock, the deblocked samples of the macroblock or macroblock pair above (if any) and the macroblock or macroblock pair to the left (if any) of the current macroblock are always available because the deblocking filter process is performed after the completion of the picture construction process prior to deblocking filter process for the entire decoded picture. However, for purposes of determining which edges are to be filtered when disable_deblocking_filter_idc is equal to 2, macroblocks in different slices are considered not available during specified steps of the operation of the deblocking filter process.

The deblocking filter process is invoked for the luma and chroma components separately. For each macroblock and each component, vertical edges are filtered first, starting with the edge on the left-hand side of the macroblock proceeding through the edges towards the right-hand side of the macroblock in their geometrical order, and then horizontal edges are filtered, starting with the edge on the top of the macroblock proceeding through the edges towards the bottom of the macroblock in their geometrical order. Figure 8-10 shows edges of a macroblock which can be interpreted as luma or chroma edges.

When interpreting the edges in Figure 8-10 as luma edges, depending on the transform_size_8x8_flag, the following applies.

– If transform_size_8x8_flag is equal to 0, both types, the solid bold and dashed bold luma edges are filtered.

– Otherwise (transform_size_8x8_flag is equal to 1), only the solid bold luma edges are filtered.

When interpreting the edges in Figure 8-10 as chroma edges, depending on ChromaArrayType, the following applies.

– If ChromaArrayType is equal to 1 (4:2:0 format), only the solid bold chroma edges are filtered.

– Otherwise, if ChromaArrayType is equal to 2 (4:2:2 format), the solid bold vertical chroma edges are filtered and both types, the solid bold and dashed bold horizontal chroma edges are filtered.

– Otherwise, if ChromaArrayType is equal to 3 (4:4:4 format), the following applies.

  – If transform_size_8x8_flag is equal to 0, both types, the solid bold and dashed bold chroma edges are filtered.

  – Otherwise (transform_size_8x8_flag is equal to 1), only the solid bold chroma edges are filtered.

– Otherwise (ChromaArrayType is equal to 0), no chroma edges are filtered.

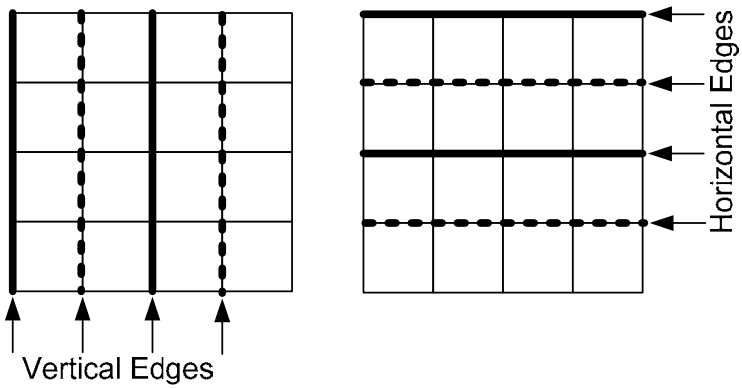


Figure 8-10 – Boundaries in a macroblock to be filtered

For the current macroblock address CurrMbAddr proceeding over values 0..PicSizeInMbs – 1, the following applies.

1. The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

2. The variables fieldModeMbFlag, filterInternalEdgesFlag, filterLeftMbEdgeFlag and filterTopMbEdgeFlag are derived as follows.

   – The variable fieldModeMbFlag is derived as follows.

     – If any of the following conditions is true, fieldModeMbFlag is set equal to 1.

       – field_pic_flag is equal to 1.

       – MbaffFrameFlag is equal to 1 and the macroblock CurrMbAddr is a field macroblock.

     – Otherwise, fieldModeMbFlag is set equal to 0.

– The variable filterInternalEdgesFlag is derived as follows.
  – If disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 1, the variable filterInternalEdgesFlag is set equal to 0;
  – Otherwise (disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is not equal to 1), the variable filterInternalEdgesFlag is set equal to 1.
– The variable filterLeftMbEdgeFlag is derived as follows.
  – If any of the following conditions is true, the variable filterLeftMbEdgeFlag is set equal to 0.
    – MbaffFrameFlag is equal to 0 and CurrMbAddr % PicWidthInMbs is equal to 0.
    – MbaffFrameFlag is equal to 1 and (CurrMbAddr >> 1) % PicWidthInMbs is equal to 0.
    – disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 1.
    – disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 2 and the macroblock mbAddrA is not available.
  – Otherwise, the variable filterLeftMbEdgeFlag is set equal to 1.
– The variable filterTopMbEdgeFlag is derived as follows.
  – If any of the following conditions is true, the variable filterTopMbEdgeFlag is set equal to 0.
    – MbaffFrameFlag is equal to 0 and CurrMbAddr is less than PicWidthInMbs.
    – MbaffFrameFlag is equal to 1, (CurrMbAddr >> 1) is less than PicWidthInMbs, and the macroblock CurrMbAddr is a field macroblock.
    – MbaffFrameFlag is equal to 1, (CurrMbAddr >> 1) is less than PicWidthInMbs, the macroblock CurrMbAddr is a frame macroblock, and CurrMbAddr % 2 is equal to 0.
    – disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 1.
    – disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 2 and the macroblock mbAddrB is not available.
  – Otherwise, the variable filterTopMbEdgeFlag is set equal to 1.

3. Given the variables fieldModeMbFlag, filterInternalEdgesFlag, filterLeftMbEdgeFlag and filterTopMbEdgeFlag the deblocking filtering is controlled as follows.
– When filterLeftMbEdgeFlag is equal to 1, the filtering of the left vertical luma edge is specified as follows.
  – The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (0, k)$ with k = 0..15 as input and S'_L as output.
– When filterInternalEdgesFlag is equal to 1, the filtering of the internal vertical luma edges is specified as follows.
  – When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (4, k)$ with k = 0..15 as input and S'_L as output.
  – The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (8, k)$ with k = 0..15 as input and S'_L as output.
  – When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (12, k)$ with k = 0..15 as input and S'_L as output.
– When filterTopMbEdgeFlag is equal to 1, the filtering of the top horizontal luma edge is specified as follows.
  – If MbaffFrameFlag is equal to 1, (CurrMbAddr % 2) is equal to 0, CurrMbAddr is greater than or equal to 2 * PicWidthInMbs, the macroblock CurrMbAddr is a frame macroblock, and the macroblock (CurrMbAddr - 2 * PicWidthInMbs + 1) is a field macroblock, the following applies.

- The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 0)$ with k = 0..15 as input and S'_L as output.
- The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 1)$ with k = 0..15 as input and S'_L as output.

– Otherwise, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 0)$ with k = 0..15 as input and S'_L as output.

– When filterInternalEdgesFlag is equal to 1, the filtering of the internal horizontal luma edges is specified as follows.

- When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 4)$ with k = 0..15 as input and S'_L as output.
- The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 8)$ with k = 0..15 as input and S'_L as output.
- When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 12)$ with k = 0..15 as input and S'_L as output.

– When ChromaArrayType is not equal to 0, for the filtering of both chroma components, with iCbCr = 0 for Cb and iCbCr = 1 for Cr, the following applies.

- When filterLeftMbEdgeFlag is equal to 1, the filtering of the left vertical chroma edge is specified as follows.
- The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (0, k)$ with k = 0..MbHeightC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
- When filterInternalEdgesFlag is equal to 1, the filtering of the internal vertical chroma edge is specified as follows.
  - When ChromaArrayType is not equal to 3 or transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (4, k)$ with k = 0..MbHeightC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
  - When ChromaArrayType is equal to 3, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (8, k)$ with k = 0..MbHeightC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
  - When ChromaArrayType is equal to 3 or transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (12, k)$ with k = 0..MbHeightC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
- When filterTopMbEdgeFlag is equal to 1, the filtering of the top horizontal chroma edge is specified as follows.
  - If MbaffFrameFlag is equal to 1, (CurrMbAddr % 2) is equal to 0, CurrMbAddr is greater than or equal to 2 * PicWidthInMbs, the macroblock CurrMbAddr is a frame macroblock, and the macroblock (CurrMbAddr – 2 * PicWidthInMbs + 1) is a field macroblock, the following applies.
    - The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 0)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 1)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– Otherwise, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 0)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– When filterInternalEdgesFlag is equal to 1, the filtering of the internal horizontal chroma edge is specified as follows.

– When ChromaArrayType is not equal to 3 or transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 4)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– When ChromaArrayType is not equal to 1, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 8)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– When ChromaArrayType is equal to 2, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 12)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– When ChromaArrayType is equal to 3 or transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 12)$ with k = 0..MbWidthC – 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

NOTE 2 – When field mode filtering (fieldModeFilteringFlag is equal to 1) is applied across the top horizontal edges of a frame macroblock, this vertical filtering across the top or bottom macroblock boundary may involve some samples that extend across an internal block edge that is also filtered internally in frame mode.

NOTE 3 – For example, in 4:2:0 chroma format when transform_size_8x8_flag is equal to 0, the following applies. 3 horizontal luma edges, 1 horizontal chroma edge for Cb, and 1 horizontal chroma edge for Cr are filtered that are internal to a macroblock. When field mode filtering (fieldModeFilteringFlag is equal to 1) is applied to the top edges of a frame macroblock, 2 horizontal luma, 2 horizontal chroma edges for Cb, and 2 horizontal chroma edges for Cr between the frame macroblock and the above macroblock pair are filtered using field mode filtering, for a total of up to 5 horizontal luma edges, 3 horizontal chroma edges for Cb, and 3 horizontal chroma edges for Cr filtered that are considered to be controlled by the frame macroblock. In all other cases, at most 4 horizontal luma, 2 horizontal chroma edges for Cb, and 2 horizontal chroma edges for Cr are filtered that are considered to be controlled by a particular macroblock.

Depending on separate_colour_plane_flag the following applies.

– If separate_colour_plane_flag is equal to 0, the arrays S'_L, S'_{Cb}, S'_{Cr} are assigned to the arrays S_L, S_{Cb}, S_{Cr} (which represent the decoded picture), respectively.

– Otherwise (separate_colour_plane_flag is equal to 1), the following applies.

– If colour_plane_id is equal to 0, the arrays S'_L is assigned to the array S_L (which represent the luma component of the decoded picture).

– Otherwise, if colour_plane_id is equal to 1, the arrays S'_L is assigned to the array S_{Cb} (which represents the Cb component of the decoded picture).

– Otherwise (colour_plane_id is equal to 2), the arrays S'_L is assigned to the array S_{Cr} (which represents the Cr component of the decoded picture).

8.7.1 Filtering process for block edges

Inputs to this process are chromaEdgeFlag, the chroma component index iCbCr (when chromaEdgeFlag is equal to 1), verticalEdgeFlag, fieldModeFilteringFlag, and a set of nE sample locations (xE_k, yE_k), with k = 0..nE - 1, expressed relative to the upper left corner of the macroblock CurrMbAddr. The set of sample locations (xE_k, yE_k) represent the

sample locations immediately to the right of a vertical edge (when verticalEdgeFlag is equal to 1) or immediately below a horizontal edge (when verticalEdgeFlag is equal to 0).

The variable nE is derived as follows.

- If chromaEdgeFlag is equal to 0, nE is set equal to 16.
- Otherwise (chromaEdgeFlag is equal to 1), nE is set equal to (verticalEdgeFlag = = 1) ? MbHeightC : MbWidthC.

Let s' be a variable specifying a luma or chroma sample array, be derived as follows.

- If chromaEdgeFlag is equal to 0, s' represents the luma sample array S'_L of the current picture.
- Otherwise, if chromaEdgeFlag is equal to 1 and iCbCr is equal to 0, s' represents the chroma sample array S'_{Cb} of the chroma component Cb of the current picture.
- Otherwise (chromaEdgeFlag is equal to 1 and iCbCr is equal to 1), s' represents the chroma sample array S'_{Cr} of the chroma component Cr of the current picture.

The variable dy is derived as follows.

- If fieldModeFilteringFlag is equal to 1 and MbaffFrameFlag is equal to 1, dy is set equal to 2.
- Otherwise (fieldModeFilteringFlag is equal to 0 or MbaffFrameFlag is equal to 0), dy is set equal to 1.

The position of the upper-left luma sample of the macroblock CurrMbAddr is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddr = CurrMbAddr as input and the output being assigned to (xI, yI).

The variables xP and yP are derived as follows.

- If chromaEdgeFlag is equal to 0, xP is set equal to xI and yP is set equal to yI.
- Otherwise (chromaEdgeFlag is equal to 1), xP is set equal to xI / SubWidthC and yP is set equal to (yI + SubHeightC – 1) / SubHeightC.

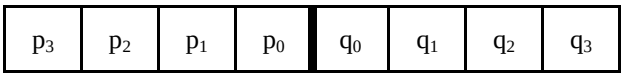


Figure 8-11 – Convention for describing samples across a 4x4 block horizontal or vertical boundary

For each sample location (xE_k, yE_k), k = 0 .. nE - 1, the following applies.

- The filtering process is applied to a set of eight samples across a 4x4 block horizontal or vertical edge denoted as p_i and q_i with i = 0..3 as shown in Figure 8-11 with the edge lying between p_0 and q_0. p_i and q_i with i = 0..3 are specified as follows.
  - If verticalEdgeFlag is equal to 1,

$$q_i = s'[\ xP + xE_k + i,\ yP + dy * yE_k\ ] \quad (8\text{-}452)$$

$$p_i = s'[\ xP + xE_k - i - 1,\ yP + dy * yE_k\ ] \quad (8\text{-}453)$$

  - Otherwise (verticalEdgeFlag is equal to 0),

$$q_i = s'[\ xP + xE_k,\ yP + dy * (\ yE_k + i\ ) - (yE_k \% 2\ )\ ] \quad (8\text{-}454)$$

$$p_i = s'[\ xP + xE_k,\ yP + dy * (\ yE_k - i - 1\ ) - (yE_k \% 2\ )\ ] \quad (8\text{-}455)$$

– The process specified in subclause 8.7.2 is invoked with the sample values p_i and q_i (i = 0..3), chromaEdgeFlag, verticalEdgeFlag, and fieldModeFilteringFlag as input, and the output is assigned to the filtered result sample values p'_i and q'_i with i = 0..2.

– The input sample values p_i and q_i with i = 0..2 are replaced by the corresponding filtered result sample values p'_i and q'_i with i = 0..2 inside the sample array s' as follows.

  – If verticalEdgeFlag is equal to 1,

$$s'[\ xP + xE_k + i,\ yP + dy * yE_k\ ] = q'_i \tag{8-456}$$

$$s'[\ xP + xE_k - i - 1,\ yP + dy * yE_k\ ] = p'_i \tag{8-457}$$

  – Otherwise (verticalEdgeFlag is equal to 0),

$$s'[\ xP + xE_k,\ yP + dy * (\ yE_k + i\ ) - (\ yE_k \% 2\ )\ ] = q'_i \tag{8-458}$$

$$s'[\ xP + xE_k,\ yP + dy * (\ yE_k - i - 1\ ) - (\ yE_k \% 2\ )\ ] = p'_i \tag{8-459}$$

8.7.2 Filtering process for a set of samples across a horizontal or vertical block edge

Inputs to this process are the input sample values p_i and q_i with i in the range of 0..3 of a single set of samples across an edge that is to be filtered, chromaEdgeFlag, verticalEdgeFlag, and fieldModeFilteringFlag.

Outputs of this process are the filtered result sample values p'_i and q'_i with i in the range of 0..2.

The content dependent boundary filtering strength variable bS is derived as follows.

– If chromaEdgeFlag is equal to 0, the derivation process for the content dependent boundary filtering strength specified in subclause 8.7.2.1 is invoked with p_0, q_0, and verticalEdgeFlag as input, and the output is assigned to bS.

– Otherwise (chromaEdgeFlag is equal to 1), the bS used for filtering a set of samples of a horizontal or vertical chroma edge is set equal to the value of bS for filtering the set of samples of a horizontal or vertical luma edge, respectively, that contains the luma sample at location (SubWidthC * x, SubHeightC * y) inside the luma array of the same field, where (x, y) is the location of the chroma sample q_0 inside the chroma array for that field.

Let filterOffsetA and filterOffsetB be the values of FilterOffsetA and FilterOffsetB as specified in subclause 7.4.3 for the slice that contains the macroblock containing sample q_0.

Let qP_p and qP_q be variables specifying quantisation parameter values for the macroblocks containing the samples p_0 and q_0, respectively. The variables qP_z (with z being replaced by p or q) are derived as follows.

– If chromaEdgeFlag is equal to 0, the following applies.

  – If the macroblock containing the sample z_0 is an I_PCM macroblock, qP_z is set to 0.

  – Otherwise (the macroblock containing the sample z_0 is not an I_PCM macroblock), qP_z is set to the value of QP_Y of the macroblock containing the sample z_0.

– Otherwise (chromaEdgeFlag is equal to 1), the following applies.

  – If the macroblock containing the sample z_0 is an I_PCM macroblock, qP_z is equal set to the value of QP_C that corresponds to a value of 0 for QP_Y as specified in subclause 8.5.8.

  – Otherwise (the macroblock containing the sample z_0 is not an I_PCM macroblock), qP_z is set equal to the value of QP_C that corresponds to the value QP_Y of the macroblock containing the sample z_0 as specified in subclause 8.5.8.

The process specified in subclause 8.7.2.2 is invoked with p_0, q_0, p_1, q_1, chromaEdgeFlag, bS, filterOffsetA, filterOffsetB, qP_p, and qP_q as inputs, and the outputs are assigned to filterSamplesFlag, indexA, α, and β.

The variable chromaStyleFiltering is set by

$$\text{chromaStyleFiltering} = \text{chromaEdgeFlag} \;\&\&\; (\ \text{ChromaArrayType} \;!=\; 3\ ) \tag{8-460}$$

Depending on the variable filterSamplesFlag, the following applies.

– If filterSamplesFlag is equal to 1, the following applies.
  – If bS is less than 4, the process specified in subclause 8.7.2.3 is invoked with p_i and q_i (i = 0..2), chromaEdgeFlag, chromaStyleFiltering, bS, β, and indexA given as input, and the output is assigned to p'_i and q'_i (i = 0..2).
  – Otherwise (bS is equal to 4), the process specified in subclause 8.7.2.4 is invoked with p_i and q_i (i = 0..3), chromaEdgeFlag, chromaStyleFiltering, α, and β given as input, and the output is assigned to p'_i and q'_i (i = 0..2).
– Otherwise (filterSamplesFlag is equal to 0), the filtered result samples p'_i and q'_i (i = 0..2) are replaced by the corresponding input samples p_i and q_i:

$$\text{for } i = 0..2, \quad p'_i = p_i \tag{8-461}$$

$$\text{for } i = 0..2, \quad q'_i = q_i \tag{8-462}$$

8.7.2.1 Derivation process for the luma content dependent boundary filtering strength

Inputs to this process are the input sample values p_0 and q_0 of a single set of samples across an edge that is to be filtered and verticalEdgeFlag.

Output of this process is the variable bS.

Let the variable mixedModeEdgeFlag be derived as follows.

– If MbaffFrameFlag is equal to 1 and the samples p_0 and q_0 are in different macroblock pairs, one of which is a field macroblock pair and the other is a frame macroblock pair, mixedModeEdgeFlag is set equal to 1
– Otherwise, mixedModeEdgeFlag is set equal to 0.

The variable bS is derived as follows.

– If the block edge is also a macroblock edge and any of the following conditions are true, a value of bS equal to 4 is the output:
  – the samples p_0 and q_0 are both in frame macroblocks and either or both of the samples p_0 or q_0 is in a macroblock coded using an Intra macroblock prediction mode.
  – the samples p_0 and q_0 are both in frame macroblocks and either or both of the samples p_0 or q_0 is in a macroblock that is in a slice with slice_type equal to SP or SI.
  – MbaffFrameFlag is equal to 1 or field_pic_flag is equal to 1, and verticalEdgeFlag is equal to 1, and either or both of the samples p_0 or q_0 is in a macroblock coded using an Intra macroblock prediction mode.
  – MbaffFrameFlag is equal to 1 or field_pic_flag is equal to 1, and verticalEdgeFlag is equal to 1, and either or both of the samples p_0 or q_0 is in a macroblock that is in a slice with slice_type equal to SP or SI.
– Otherwise, if any of the following conditions are true, a value of bS equal to 3 is the output:
  – mixedModeEdgeFlag is equal to 0 and either or both of the samples p_0 or q_0 is in a macroblock coded using an Intra macroblock prediction mode.
  – mixedModeEdgeFlag is equal to 0 and either or both of the samples p_0 or q_0 is in a macroblock that is in a slice with slice_type equal to SP or SI.
  – mixedModeEdgeFlag is equal to 1, verticalEdgeFlag is equal to 0, and either or both of the samples p_0 or q_0 is in a macroblock coded using an Intra macroblock prediction mode.
  – mixedModeEdgeFlag is equal to 1, verticalEdgeFlag is equal to 0, and either or both of the samples p_0 or q_0 is in a macroblock that is in a slice with slice_type equal to SP or SI.
– Otherwise, if the following condition is true, a value of bS equal to 2 is the output:
  – the luma block containing sample p_0 or the luma block containing sample q_0 contains non-zero transform coefficient levels.
– Otherwise, if any of the following conditions are true, a value of bS equal to 1 is the output:
  – mixedModeEdgeFlag is equal to 1.

– mixedModeEdgeFlag is equal to 0 and for the prediction of the macroblock/sub-macroblock partition containing the sample p_0 different reference pictures or a different number of motion vectors are used than for the prediction of the macroblock/sub-macroblock partition containing the sample q_0.

NOTE 1 – The determination of whether the reference pictures used for the two macroblock/sub-macroblock partitions are the same or different is based only on which pictures are referenced, without regard to whether a prediction is formed using an index into reference picture list 0 or an index into reference picture list 1, and also without regard to whether the index position within a reference picture list is different.

– mixedModeEdgeFlag is equal to 0 and one motion vector is used to predict the macroblock/sub-macroblock partition containing the sample p_0 and one motion vector is used to predict the macroblock/sub-macroblock partition containing the sample q_0 and the absolute difference between the horizontal or vertical component of the motion vectors used is greater than or equal to 4 in units of quarter luma frame samples.

– mixedModeEdgeFlag is equal to 0 and two motion vectors and two different reference pictures are used to predict the macroblock/sub-macroblock partition containing the sample p_0 and two motion vectors for the same two reference pictures are used to predict the macroblock/sub-macroblock partition containing the sample q_0 and the absolute difference between the horizontal or vertical component of the two motion vectors used in the prediction of the two macroblock/sub-macroblock partitions for the same reference picture is greater than or equal to 4 in units of quarter luma frame samples.

– mixedModeEdgeFlag is equal to 0 and two motion vectors for the same reference picture are used to predict the macroblock/sub-macroblock partition containing the sample p_0 and two motion vectors for the same reference picture are used to predict the macroblock/sub-macroblock partition containing the sample q_0 and both of the following conditions are true:

  – The absolute difference between the horizontal or vertical component of list 0 motion vectors used in the prediction of the two macroblock/sub-macroblock partitions is greater than or equal to 4 in quarter luma frame samples or the absolute difference between the horizontal or vertical component of the list 1 motion vectors used in the prediction of the two macroblock/sub-macroblock partitions is greater than or equal to 4 in units of quarter luma frame samples.

  – The absolute difference between the horizontal or vertical component of list 0 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample p_0 and the list 1 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample q_0 is greater than or equal to 4 in units of quarter luma frame samples or the absolute difference between the horizontal or vertical component of the list 1 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample p_0 and list 0 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample q_0 is greater than or equal to 4 in units of quarter luma frame samples.

    NOTE 2 – A vertical difference of 4 in units of quarter luma frame samples is a difference of 2 in units of quarter luma field samples

– Otherwise, a value of bS equal to 0 is the output.

8.7.2.2 Derivation process for the thresholds for each block edge

Inputs to this process are

– the input sample values p_0, q_0, p_1 and q_1 of a single set of samples across an edge that is to be filtered,

– the variables chromaEdgeFlag and bS, for the set of input samples, as specified in 8.7.2,

– the variables filterOffsetA, filterOffsetB, qP_p, and qP_q.

Outputs of this process are the variable filterSamplesFlag, which indicates whether the input samples are filtered, the value of indexA, and the values of the threshold variables α and β.

Let qP_{av} be a variable specifying an average quantisation parameter. It is derived as follows.

$$qP_{av} = (qP_p + qP_q + 1) >> 1 \quad (8\text{-}463)$$

NOTE – In SP and SI slices, qP_{av} is derived in the same way as in other slice types. QS_Y from Equation 7-29 is not used in the deblocking filter.

Let indexA be a variable that is used to access the α table (Table 8-16) as well as the t_{C0} table (Table 8-17), which is used in filtering of edges with bS less than 4 as specified in subclause 8.7.2.3, and let indexB be a variable that is used to access the β table (Table 8-16). The variables indexA and indexB are derived as follows.

$$indexA = Clip3(0, 51, qP_{av} + filterOffsetA) \quad (8\text{-}464)$$

$$indexB = Clip3(0, 51, qP_{av} + filterOffsetB) \quad (8\text{-}465)$$

The variables α' and β' depending on the values of indexA and indexB are specified in Table 8-16. Depending on chromaEdgeFlag, the corresponding threshold variables α and β are derived as follows.

– If chromaEdgeFlag is equal to 0,

$$\alpha = \alpha' * (1 << (BitDepth_Y - 8)) \quad (8\text{-}466)$$

$$\beta = \beta' * (1 << (BitDepth_Y - 8)) \quad (8\text{-}467)$$

– Otherwise (chromaEdgeFlag is equal to 1),

$$\alpha = \alpha' * (1 << (BitDepth_C - 8)) \quad (8\text{-}468)$$

$$\beta = \beta' * (1 << (BitDepth_C - 8)) \quad (8\text{-}469)$$

The variable filterSamplesFlag is derived by

$$filterSamplesFlag = (bS != 0 \ \&\& \ Abs(p_0 - q_0) < \alpha \ \&\& \ Abs(p_1 - p_0) < \beta \ \&\& \ Abs(q_1 - q_0) < \beta) \quad (8\text{-}470)$$

Table 8-16 – Derivation of offset dependent threshold variables α' and β' from indexA and indexB

	indexA (for α') or indexB (for β')																									
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
α'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	5	6	7	8	9	10	12	13
β'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	3	3	3	3	4	4	4

Table 8-16 (concluded) – Derivation of indexA and indexB from offset dependent threshold variables α' and β'

	indexA (for α') or indexB (for β')																									
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
α'	15	17	20	22	25	28	32	36	40	45	50	56	63	71	80	90	101	113	127	144	162	182	203	226	255	255
β'	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18

8.7.2.3 Filtering process for edges with bS less than 4

Inputs to this process are the input sample values p_i and q_i (i = 0..2) of a single set of samples across an edge that is to be filtered, chromaEdgeFlag, chromaStyleFiltering, bS, β, and indexA, for the set of input samples, as specified in 8.7.2.

Outputs of this process are the filtered result sample values p'_i and q'_i (i = 0..2) for the set of input sample values.

Let Clip1( ) be a function that is replaced by $Clip1_Y( )$ when chromaStyleFiltering is equal to 0 and by $Clip1_C( )$ when chromaStyleFIltering is equal to 1.

The filtered result samples p'_0 and q'_0 are derived by

$$\Delta = Clip3(-t_C, t_C, ((((q_0 - p_0) << 2) + (p_1 - q_1) + 4) >> 3)) \quad (8\text{-}471)$$

$$p'_0 = Clip1(p_0 + \Delta) \quad (8\text{-}472)$$

$$q'_0 = \text{Clip1}(q_0 - \Delta) \quad (8\text{-}473)$$

where the threshold t_C is determined as follows.

– If chromaStyleFiltering is equal to 0,

$$t_C = t_{C0} + ((a_p < \beta) ? 1 : 0) + ((a_q < \beta) ? 1 : 0) \quad (8\text{-}474)$$

– Otherwise (chromaStyleFiltering is equal to 1),

$$t_C = t_{C0} + 1 \quad (8\text{-}475)$$

Depending on the values of indexA and bS the variable t'_{C0} is specified in Table 8-17. Depending on chromaEdgeFlag, the corresponding threshold variable t_{C0} is derived as follows.

– If chromaEdgeFlag is equal to 0,

$$t_{C0} = t'_{C0} * (1 << (\text{BitDepth}_Y - 8)) \quad (8\text{-}476)$$

– Otherwise (chromaEdgeFlag is equal to 1),

$$t_{C0} = t'_{C0} * (1 << (\text{BitDepth}_C - 8)) \quad (8\text{-}477)$$

Let a_p and a_q be two threshold variables specified by

$$a_p = \text{Abs}(p_2 - p_0) \quad (8\text{-}478)$$

$$a_q = \text{Abs}(q_2 - q_0) \quad (8\text{-}479)$$

The filtered result sample p'_1 is derived as follows

– If chromaStyleFiltering is equal to 0 and a_p is less than β,

$$p'_1 = p_1 + \text{Clip3}(-t_{C0}, t_{C0}, (p_2 + ((p_0 + q_0 + 1) >> 1) - (p_1 << 1)) >> 1) \quad (8\text{-}480)$$

– Otherwise (chromaStyleFiltering is equal to 1 or a_p is greater than or equal to β),

$$p'_1 = p_1 \quad (8\text{-}481)$$

The filtered result sample q'_1 is derived as follows

– If chromaStyleFiltering is equal to 0 and a_q is less than β,

$$q'_1 = q_1 + \text{Clip3}(-t_{C0}, t_{C0}, (q_2 + ((p_0 + q_0 + 1) >> 1) - (q_1 << 1)) >> 1) \quad (8\text{-}482)$$

– Otherwise (chromaStyleFiltering is equal to 1 or a_q is greater than or equal to β),

$$q'_1 = q_1 \quad (8\text{-}483)$$

The filtered result samples p'_2 and q'_2 are always set equal to the input samples p_2 and q_2:

$$p'_2 = p_2 \quad (8\text{-}484)$$

$$q'_2 = q_2 \quad (8\text{-}485)$$

Table 8-17 – Value of variable t'_{C0} as a function of indexA and bS

	indexA																									
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
bS = 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
bS = 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
bS = 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1

Table 8-17 (concluded) – Value of variable t'_{C0} as a function of indexA and bS

	indexA																									
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
bS = 1	1	1	1	1	1	1	1	2	2	2	2	3	3	3	4	4	4	5	6	6	7	8	9	10	11	13
bS = 2	1	1	1	1	1	2	2	2	2	3	3	3	4	4	5	5	6	7	8	8	10	11	12	13	15	17
bS = 3	1	2	2	2	2	3	3	3	4	4	4	5	6	6	7	8	9	10	11	13	14	16	18	20	23	25

8.7.2.4 Filtering process for edges for bS equal to 4

Inputs to this process are the input sample values p_i and q_i (i = 0..3) of a single set of samples across an edge that is to be filtered, chromaEdgeFlag, chromaStyleFiltering, and the values of the threshold variables α and β for the set of samples, as specified in subclause 8.7.2.

Outputs of this process are the filtered result sample values p'_i and q'_i (i = 0..2) for the set of input sample values.

Let a_p and a_q be two threshold variables as specified in Equations 8-478 and 8-479, respectively, in subclause 8.7.2.3.

The filtered result samples p'_i (i = 0..2) are derived as follows.

– If chromaStyleFiltering is equal to 0 and the following condition holds,

$$a_p < \beta \;\&\&\; Abs(p_0 - q_0) < ((\alpha >> 2) + 2) \tag{8-486}$$

then the variables p'_0, p'_1, and p'_2 are derived by

$$p'_0 = (p_2 + 2*p_1 + 2*p_0 + 2*q_0 + q_1 + 4) >> 3 \tag{8-487}$$

$$p'_1 = (p_2 + p_1 + p_0 + q_0 + 2) >> 2 \tag{8-488}$$

$$p'_2 = (2*p_3 + 3*p_2 + p_1 + p_0 + q_0 + 4) >> 3 \tag{8-489}$$

– Otherwise (chromaStyleFiltering is equal to 1 or the condition in Equation 8-486 does not hold), the variables p'_0, p'_1, and p'_2 are derived by

$$p'_0 = (2*p_1 + p_0 + q_1 + 2) >> 2 \tag{8-490}$$

$$p'_1 = p_1 \tag{8-491}$$

$$p'_2 = p_2 \tag{8-492}$$

The filtered result samples q'_i (i = 0..2) are derived as follows.

– If chromaStyleFiltering is equal to 0 and the following condition holds,

$$a_q < \beta \;\&\&\; Abs(p_0 – q_0) < ((\alpha >> 2) + 2) \quad (8\text{-}493)$$

then the variables q'_0, q'_1, and q'_2 are derived by

$$q'_0 = (p_1 + 2*p_0 + 2*q_0 + 2*q_1 + q_2 + 4) >> 3 \quad (8\text{-}494)$$

$$q'_1 = (p_0 + q_0 + q_1 + q_2 + 2) >> 2 \quad (8\text{-}495)$$

$$q'_2 = (2*q_3 + 3*q_2 + q_1 + q_0 + p_0 + 4) >> 3 \quad (8\text{-}496)$$

– Otherwise (chromaStyleFiltering is equal to 1 or the condition in Equation 8-493 does not hold), the variables q'_0, q'_1, and q'_2 are derived by

$$q'_0 = (2*q_1 + q_0 + p_1 + 2) >> 2 \quad (8\text{-}497)$$

$$q'_1 = q_1 \quad (8\text{-}498)$$

$$q'_2 = q_2 \quad (8\text{-}499)$$

9 Parsing process

Inputs to this process are bits from the RBSP.

Outputs of this process are syntax element values.

This process is invoked when the descriptor of a syntax element in the syntax tables in subclause 7.3 is equal to ue(v), me(v), se(v), te(v) (see subclause 9.1), ce(v) (see subclause 9.2), or ae(v) (see subclause 9.3).

9.1 Parsing process for Exp-Golomb codes

This process is invoked when the descriptor of a syntax element in the syntax tables in subclause 7.3 is equal to ue(v), me(v), se(v), or te(v). For syntax elements in subclauses 7.3.4 and 7.3.5, this process is invoked only when entropy_coding_mode_flag is equal to 0.

Inputs to this process are bits from the RBSP.

Outputs of this process are syntax element values.

Syntax elements coded as ue(v), me(v), or se(v) are Exp-Golomb-coded. Syntax elements coded as te(v) are truncated Exp-Golomb-coded. The parsing process for these syntax elements begins with reading the bits starting at the current location in the bitstream up to and including the first non-zero bit, and counting the number of leading bits that are equal to 0. This process is specified as follows:

```
leadingZeroBits = -1;
for( b = 0; !b; leadingZeroBits++ )
    b = read_bits( 1 )
```

The variable codeNum is then assigned as follows:

$$codeNum = 2^{leadingZeroBits} – 1 + read\_bits(leadingZeroBits)$$

where the value returned from read_bits(leadingZeroBits) is interpreted as a binary representation of an unsigned integer with most significant bit written first.

Table 9-1 illustrates the structure of the Exp-Golomb code by separating the bit string into “prefix” and “suffix” bits. The “prefix” bits are those bits that are parsed in the above pseudo-code for the computation of leadingZeroBits, and are shown as either 0 or 1 in the bit string column of Table 9-1. The “suffix” bits are those bits that are parsed in the

computation of codeNum and are shown as x_i in Table 9-1, with i being in the range 0 to leadingZeroBits - 1, inclusive. Each x_i can take on values 0 or 1.

Table 9-1 – Bit strings with "prefix" and "suffix" bits and assignment to codeNum ranges (informative)

Bit string form	Range of codeNum
1	0
0 1 x_0	1-2
0 0 1 x_1 x_0	3-6
0 0 0 1 x_2 x_1 x_0	7-14
0 0 0 0 1 x_3 x_2 x_1 x_0	15-30
0 0 0 0 0 1 x_4 x_3 x_2 x_1 x_0	31-62
…	…

Table 9-2 illustrates explicitly the assignment of bit strings to codeNum values.

Table 9-2 – Exp-Golomb bit strings and codeNum in explicit form and used as ue(v) (informative)

Bit string	codeNum
1	0
0 1 0	1
0 1 1	2
0 0 1 0 0	3
0 0 1 0 1	4
0 0 1 1 0	5
0 0 1 1 1	6
0 0 0 1 0 0 0	7
0 0 0 1 0 0 1	8
0 0 0 1 0 1 0	9
…	…

Depending on the descriptor, the value of a syntax element is derived as follows.

– If the syntax element is coded as ue(v), the value of the syntax element is equal to codeNum.

– Otherwise, if the syntax element is coded as se(v), the value of the syntax element is derived by invoking the mapping process for signed Exp-Golomb codes as specified in subclause 9.1.1 with codeNum as the input.

– Otherwise, if the syntax element is coded as me(v), the value of the syntax element is derived by invoking the mapping process for coded block pattern as specified in subclause 9.1.2 with codeNum as the input.

– Otherwise (the syntax element is coded as te(v)), the range of possible values for the syntax element is determined first. The range of this syntax element may be between 0 and x, with x being greater than or equal to 1 and the range is used in the derivation of the value of the syntax element value as follows

  – If x is greater than 1, codeNum and the value of the syntax element is derived in the same way as for syntax elements coded as ue(v)

– Otherwise (x is equal to 1), the parsing process for codeNum which is equal to the value of the syntax element is given by a process equivalent to:

```
b = read_bits( 1 )
codeNum = !b
```

9.1.1 Mapping process for signed Exp-Golomb codes

Input to this process is codeNum as specified in subclause 9.1.

Output of this process is a value of a syntax element coded as se(v).

The syntax element is assigned to the codeNum by ordering the syntax element by its absolute value in increasing order and representing the positive value for a given absolute value with the lower codeNum. Table 9-3 provides the assignment rule.

Table 9-3 – Assignment of syntax element to codeNum for signed Exp-Golomb coded syntax elements se(v)

codeNum	syntax element value
0	0
1	1
2	–1
3	2
4	–2
5	3
6	–3
k	$(-1)^{k+1}$ Ceil(k÷2)

9.1.2 Mapping process for coded block pattern

Input to this process is codeNum as specified in subclause 9.1.

Output of this process is a value of the syntax element coded_block_pattern coded as me(v).

Table 9-4 shows the assignment of coded_block_pattern to codeNum depending on whether the macroblock prediction mode is equal to Intra_4x4, Intra_8x8 or Inter.

Table 9-4 – Assignment of codeNum to values of coded_block_pattern for macroblock prediction modes

(a) ChromaArrayType is equal to 1 or 2

codeNum	coded_block_pattern	
	Intra_4x4, Intra_8x8	Inter
0	47	0
1	31	16
2	15	1
3	0	2
4	23	4
5	27	8
6	29	32

(a) ChromaArrayType is equal to 1 or 2

codeNum	coded_block_pattern	
	Intra_4x4, Intra_8x8	Inter
7	30	3
8	7	5
9	11	10
10	13	12
11	14	15
12	39	47
13	43	7
14	45	11
15	46	13
16	16	14
17	3	6
18	5	9
19	10	31
20	12	35
21	19	37
22	21	42
23	26	44
24	28	33
25	35	34
26	37	36
27	42	40
28	44	39
29	1	43
30	2	45
31	4	46
32	8	17
33	17	18
34	18	20
35	20	24
36	24	19
37	6	21
38	9	26

(a) ChromaArrayType is equal to 1 or 2

codeNum	coded_block_pattern	
	Intra_4x4, Intra_8x8	Inter
39	22	28
40	25	23
41	32	27
42	33	29
43	34	30
44	36	22
45	40	25
46	38	38
47	41	41

(b) ChromaArrayType is equal to 0 or 3

codeNum	coded_block_pattern	
	Intra_4x4, Intra_8x8	Inter
0	15	0
1	0	1
2	7	2
3	11	4
4	13	8
5	14	3
6	3	5
7	5	10
8	10	12
9	12	15
10	1	7
11	2	11
12	4	13
13	8	14
14	6	6
15	9	9

9.2 CAVLC parsing process for transform coefficient levels

This process is invoked when parsing syntax elements with descriptor equal to ce(v) in subclause 7.3.5.3.2 and when entropy_coding_mode_flag is equal to 0.

Inputs to this process are bits from slice data, a maximum number of non-zero transform coefficient levels maxNumCoeff, the luma block index luma4x4BlkIdx or the chroma block index chroma4x4BlkIdx, cb4x4BlkIdx or cr4x4BlkIdx of the current block of transform coefficient levels.

Output of this process is the list coeffLevel containing transform coefficient levels of the luma block with block index luma4x4BlkIdx or the chroma block with block index chroma4x4BlkIdx, cb4x4BlkIdx or cr4x4BlkIdx.

The process is specified in the following ordered steps:

1. All transform coefficient levels, with indices from 0 to maxNumCoeff - 1, in the list coeffLevel are set equal to 0.
2. The total number of non-zero transform coefficient levels TotalCoeff(coeff_token) and the number of trailing one transform coefficient levels TrailingOnes(coeff_token) are derived by parsing coeff_token (see subclause 9.2.1) as follows.
   - If the number of non-zero transform coefficient levels TotalCoeff(coeff_token) is equal to 0, the list coeffLevel containing 0 values is returned and no further step is carried out.
   - Otherwise, the following steps are carried out.
     a. The non-zero transform coefficient levels are derived by parsing trailing_ones_sign_flag, level_prefix, and level_suffix (see subclause 9.2.2).
     b. The runs of zero transform coefficient levels before each non-zero transform coefficient level are derived by parsing total_zeros and run_before (see subclause 9.2.3).
     c. The level and run information are combined into the list coeffLevel (see subclause 9.2.4).

9.2.1 Parsing process for total number of transform coefficient levels and trailing ones

Inputs to this process are bits from slice data, a maximum number of non-zero transform coefficient levels maxNumCoeff, the luma block index luma4x4BlkIdx or the chroma block index chroma4x4BlkIdx, cb4x4BlkIdx or cr4x4BlkIdx of the current block of transform coefficient levels.

Outputs of this process are TotalCoeff(coeff_token), TrailingOnes(coeff_token), and the variable nC.

The syntax element coeff_token is decoded using one of the six VLCs specified in the six right-most columns of Table 9-5. Each VLC specifies both TotalCoeff(coeff_token) and TrailingOnes(coeff_token) for a given codeword coeff_token. VLC selection is dependent upon a variable nC that is derived as follows.

– If the CAVLC parsing process is invoked for ChromaDCLevel, nC is derived as follows.
  – If ChromaArrayType is equal to 1, nC is set equal to -1,
  – Otherwise (ChromaArrayType is equal to 2), nC is set equal to -2.
– Otherwise, the following applies.
  – When the CAVLC parsing process is invoked for Intra16x16DCLevel, luma4x4BlkIdx is set equal to 0.
  – When the CAVLC parsing process is invoked for CbIntra16x16DCLevel, cb4x4BlkIdx is set equal to 0.
  – When the CAVLC parsing process is invoked for CrIntra16x16DCLevel, cr4x4BlkIdx is set equal to 0.
  – The variables blkA and blkB are derived as follows.
    – If the CAVLC parsing process is invoked for Intra16x16DCLevel, Intra16x16ACLevel, or LumaLevel, the process specified in subclause 6.4.10.4 is invoked with luma4x4BlkIdx as the input, and the output is assigned to mbAddrA, mbAddrB, luma4x4BlkIdxA, and luma4x4BlkIdxB. The 4x4 luma block specified by mbAddrA\luma4x4BlkIdxA is assigned to blkA, and the 4x4 luma block specified by mbAddrB\luma4x4BlkIdxB is assigned to blkB.
    – Otherwise, if the CAVLC parsing process is invoked for CbIntra16x16DCLevel, CbIntra16x16ACLevel, or CbLevel, the process specified in subclause 6.4.10.6 is invoked with cb4x4BlkIdx as the input, and the output is assigned to mbAddrA, mbAddrB, cb4x4BlkIdxA, and cb4x4BlkIdxB. The 4x4 Cb block specified by mbAddrA\cb4x4BlkIdxA is assigned to blkA, and the 4x4 Cb block specified by mbAddrB\cb4x4BlkIdxB is assigned to blkB.

– Otherwise, if the CAVLC parsing process is invoked for CrIntra16x16DCLevel, CrIntra16x16ACLevel, or CrLevel, the process specified in subclause 6.4.10.6 is invoked with cr4x4BlkIdx as the input, and the output is assigned to mbAddrA, mbAddrB, cr4x4BlkIdxA, and cr4x4BlkIdxB. The 4x4 Cr block specified by mbAddrA\cr4x4BlkIdxA is assigned to blkA, and the 4x4 Cr block specified by mbAddrB\cr4x4BlkIdxB is assigned to blkB.

– Otherwise (the CAVLC parsing process is invoked for ChromaACLevel), the process specified in subclause 6.4.10.5 is invoked with chroma4x4BlkIdx as input, and the output is assigned to mbAddrA, mbAddrB, chroma4x4BlkIdxA, and chroma4x4BlkIdxB. The 4x4 chroma block specified by mbAddrA\iCbCr\chroma4x4BlkIdxA is assigned to blkA, and the 4x4 chroma block specified by mbAddrB\iCbCr\chroma4x4BlkIdxB is assigned to blkB.

– Let nA and nB be the number of non-zero transform coefficient levels (given by TotalCoeff(coeff_token)) in the block of transform coefficient levels blkA located to the left of the current block and the block of transform coefficient levels blkB located above the current block, respectively.

– With N replaced by A and B, in mbAddrN, blkN, and nN the following applies.

  – If any of the following conditions is true, nN is set equal to 0.

    – mbAddrN is not available.

    – The current macroblock is coded using an Intra prediction mode, constrained_intra_pred_flag is equal to 1 and mbAddrN is coded using Inter prediction and slice data partitioning is in use (nal_unit_type is in the range of 2 to 4, inclusive).

    – The macroblock mbAddrN has mb_type equal to P_Skip or B_Skip.

    – All AC residual transform coefficient levels of the neighbouring block blkN are equal to 0 due to the corresponding bit of CodedBlockPatternLuma or CodedBlockPatternChroma being equal to 0.

  – Otherwise, if mbAddrN is an I_PCM macroblock, nN is set equal to 16.

  – Otherwise, nN is set equal to the value TotalCoeff(coeff_token) of the neighbouring block blkN.

    NOTE 1 – The values nA and nB that are derived using TotalCoeff(coeff_token) do not include the DC transform coefficient levels in Intra_16x16 macroblocks or DC transform coefficient levels in chroma blocks, because these transform coefficient levels are decoded separately. When the block above or to the left belongs to an Intra_16x16 macroblock, or is a chroma block, nA and nB is the number of decoded non-zero AC transform coefficient levels.

    NOTE 2 – When parsing for Intra16x16DCLevel, CbIntra16x16DCLevel, or CrIntra16x16DCLevel, the values nA and nB are based on the number of non-zero transform coefficient levels in adjacent 4x4 blocks and not on the number of non-zero DC transform coefficient levels in adjacent 16x16 blocks.

– Given the values of nA and nB, the variable nC is derived as follows.

  – If both mbAddrA and mbAddrB are available, the variable nC is set equal to (nA + nB + 1) >> 1.

  – Otherwise (mbAddrA is not available or mbAddrB is not available), the variable nC is set equal to nA + nB.

The value of TotalCoeff(coeff_token) resulting from decoding coeff_token shall be in the range of 0 to maxNumCoeff, inclusive.

Table 9-5 – coeff_token mapping to TotalCoeff(coeff_token) and TrailingOnes(coeff_token)

TrailingOnes (coeff_token)	TotalCoeff (coeff_token)	0 <= nC < 2	2 <= nC < 4	4 <= nC < 8	8 <= nC	nC = = -1	nC = = -2
0	0	1	11	1111	0000 11	01	1
0	1	0001 01	0010 11	0011 11	0000 00	0001 11	0001 111
1	1	01	10	1110	0000 01	1	01
0	2	0000 0111	0001 11	0010 11	0001 00	0001 00	0001 110
1	2	0001 00	0011 1	0111 1	0001 01	0001 10	0001 101
2	2	001	011	1101	0001 10	001	001
0	3	0000 0011 1	0000 111	0010 00	0010 00	0000 11	0000 0011 1
1	3	0000 0110	0010 10	0110 0	0010 01	0000 011	0001 100
2	3	0000 101	0010 01	0111 0	0010 10	0000 010	0001 011
3	3	0001 1	0101	1100	0010 11	0001 01	0000 1
0	4	0000 0001 11	0000 0111	0001 111	0011 00	0000 10	0000 0011 0
1	4	0000 0011 0	0001 10	0101 0	0011 01	0000 0011	0000 0010 1
2	4	0000 0101	0001 01	0101 1	0011 10	0000 0010	0001 010
3	4	0000 11	0100	1011	0011 11	0000 000	0000 01
0	5	0000 0000 111	0000 0100	0001 011	0100 00	-	0000 0001 11
1	5	0000 0001 10	0000 110	0100 0	0100 01	-	0000 0001 10
2	5	0000 0010 1	0000 101	0100 1	0100 10	-	0000 0010 0
3	5	0000 100	0011 0	1010	0100 11	-	0001 001
0	6	0000 0000 0111 1	0000 0011 1	0001 001	0101 00	-	0000 0000 111
1	6	0000 0000 110	0000 0110	0011 10	0101 01	-	0000 0000 110
2	6	0000 0001 01	0000 0101	0011 01	0101 10	-	0000 0001 01
3	6	0000 0100	0010 00	1001	0101 11	-	0001 000
0	7	0000 0000 0101 1	0000 0001 111	0001 000	0110 00	-	0000 0000 0111
1	7	0000 0000 0111 0	0000 0011 0	0010 10	0110 01	-	0000 0000 0110
2	7	0000 0000 101	0000 0010 1	0010 01	0110 10	-	0000 0000 101
3	7	0000 0010 0	0001 00	1000	0110 11	-	0000 0001 00
0	8	0000 0000 0100 0	0000 0001 011	0000 1111	0111 00	-	0000 0000 0011 1
1	8	0000 0000 0101 0	0000 0001 110	0001 110	0111 01	-	0000 0000 0101
2	8	0000 0000 0110 1	0000 0001 101	0001 101	0111 10	-	0000 0000 0100
3	8	0000 0001 00	0000 100	0110 1	0111 11	-	0000 0000 100
0	9	0000 0000 0011 11	0000 0000 1111	0000 1011	1000 00	-	
1	9	0000 0000 0011 10	0000 0001 010	0000 1110	1000 01	-	
2	9	0000 0000 0100 1	0000 0001 001	0001 010	1000 10	-	
3	9	0000 0000 100	0000 0010 0	0011 00	1000 11	-	

Table 9-5 – coeff_token mapping to TotalCoeff(coeff_token) and TrailingOnes(coeff_token)

TrailingOnes (coeff_token)	TotalCoeff (coeff_token)	0 <= nC < 2	2 <= nC < 4	4 <= nC < 8	8 <= nC	nC = = -1	nC = = -2
0	10	0000 0000 0010 11	0000 0000 1011	0000 0111 1	1001 00	-	
1	10	0000 0000 0010 10	0000 0000 1110	0000 1010	1001 01	-	
2	10	0000 0000 0011 01	0000 0000 1101	0000 1101	1001 10	-	
3	10	0000 0000 0110 0	0000 0001 100	0001 100	1001 11	-	
0	11	0000 0000 0001 111	0000 0000 1000	0000 0101 1	1010 00	-	
1	11	0000 0000 0001 110	0000 0000 1010	0000 0111 0	1010 01	-	
2	11	0000 0000 0010 01	0000 0000 1001	0000 1001	1010 10	-	
3	11	0000 0000 0011 00	0000 0001 000	0000 1100	1010 11	-	
0	12	0000 0000 0001 011	0000 0000 0111 1	0000 0100 0	1011 00	-	
1	12	0000 0000 0001 010	0000 0000 0111 0	0000 0101 0	1011 01	-	
2	12	0000 0000 0001 101	0000 0000 0110 1	0000 0110 1	1011 10	-	
3	12	0000 0000 0010 00	0000 0000 1100	0000 1000	1011 11	-	
0	13	0000 0000 0000 1111	0000 0000 0101 1	0000 0011 01	1100 00	-	
1	13	0000 0000 0000 001	0000 0000 0101 0	0000 0011 1	1100 01	-	
2	13	0000 0000 0001 001	0000 0000 0100 1	0000 0100 1	1100 10	-	
3	13	0000 0000 0001 100	0000 0000 0110 0	0000 0110 0	1100 11	-	
0	14	0000 0000 0000 1011	0000 0000 0011 1	0000 0010 01	1101 00	-	
1	14	0000 0000 0000 1110	0000 0000 0010 11	0000 0011 00	1101 01	-	
2	14	0000 0000 0000 1101	0000 0000 0011 0	0000 0010 11	1101 10	-	
3	14	0000 0000 0001 000	0000 0000 0100 0	0000 0010 10	1101 11	-	
0	15	0000 0000 0000 0111	0000 0000 0010 01	0000 0001 01	1110 00	-	
1	15	0000 0000 0000 1010	0000 0000 0010 00	0000 0010 00	1110 01	-	
2	15	0000 0000 0000 1001	0000 0000 0010 10	0000 0001 11	1110 10	-	
3	15	0000 0000 0000 1100	0000 0000 0000 1	0000 0001 10	1110 11	-	
0	16	0000 0000 0000 0100	0000 0000 0001 11	0000 0000 01	1111 00	-	
1	16	0000 0000 0000 0110	0000 0000 0001 10	0000 0001 00	1111 01	-	
2	16	0000 0000 0000 0101	0000 0000 0001 01	0000 0000 11	1111 10	-	
3	16	0000 0000 0000 1000	0000 0000 0001 00	0000 0000 10	1111 11	-	

9.2.2 Parsing process for level information

Inputs to this process are bits from slice data, the number of non-zero transform coefficient levels TotalCoeff(coeff_token), and the number of trailing one transform coefficient levels TrailingOnes(coeff_token).

Output of this process is a list with name level containing transform coefficient levels.

Initially an index i is set equal to 0. Then the following procedure is iteratively applied TrailingOnes(coeff_token) times to decode the trailing one transform coefficient levels (if any):

– A 1-bit syntax element trailing_ones_sign_flag is decoded and evaluated as follows.
  – If trailing_ones_sign_flag is equal to 0, the value +1 is assigned to level[i].
  – Otherwise (trailing_ones_sign_flag is equal to 1), the value -1 is assigned to level[i].
– The index i is incremented by 1.

Following the decoding of the trailing one transform coefficient levels, a variable suffixLength is initialised as follows.

– If TotalCoeff(coeff_token) is greater than 10 and TrailingOnes(coeff_token) is less than 3, suffixLength is set equal to 1.
– Otherwise (TotalCoeff(coeff_token) is less than or equal to 10 or TrailingOnes(coeff_token) is equal to 3), suffixLength is set equal to 0.

The following procedure is then applied iteratively (TotalCoeff(coeff_token) – TrailingOnes(coeff_token)) times to decode the remaining levels (if any):

– The syntax element level_prefix is decoded as specified in subclause 9.2.2.1.
– The variable levelSuffixSize is set equal to the variable suffixLength with the exception of the following two cases.
– When level_prefix is equal to 14 and suffixLength is equal to 0, levelSuffixSize is set equal to 4.
– When level_prefix is greater than or equal to 15, levelSuffixSize is set equal to level_prefix - 3.
– The syntax element level_suffix is decoded as follows.
  – If levelSuffixSize is greater than 0, the syntax element level_suffix is decoded as unsigned integer representation u(v) with levelSuffixSize bits.
  – Otherwise (levelSuffixSize is equal to 0), the syntax element level_suffix is inferred to be equal to 0.
– A variable levelCode is set equal to (Min(15, level_prefix) << suffixLength) + level_suffix.
– When level_prefix is greater than or equal to 15 and suffixLength is equal to 0, levelCode is incremented by 15.
– When level_prefix is greater than or equal to 16, levelCode is incremented by (1<<(level_prefix – 3)) – 4096.
– When the index i is equal to TrailingOnes(coeff_token) and TrailingOnes(coeff_token) is less than 3, levelCode is incremented by 2.
– The variable level[i] is derived as follows.
  – If levelCode is an even number, the value (levelCode + 2) >> 1 is assigned to level[i].
  – Otherwise (levelCode is an odd number), the value (-levelCode – 1) >> 1 is assigned to level[i].
– When suffixLength is equal to 0, suffixLength is set equal to 1.
– When the absolute value of level[i] is greater than (3 << (suffixLength – 1)) and suffixLength is less than 6, suffixLength is incremented by 1.
– The index i is incremented by 1.

9.2.2.1 Parsing process for level_prefix

Inputs to this process are bits from slice data.

Output of this process is level_prefix.

The parsing process for this syntax element consists in reading the bits starting at the current location in the bitstream up to and including the first non-zero bit, and counting the number of leading bits that are equal to 0. This process is specified as follows:

```
leadingZeroBits = -1
for( b = 0; !b; leadingZeroBits++ )
    b = read_bits( 1 )
level_prefix = leadingZeroBits
```

Table 9-6 illustrates the codeword table for level_prefix.

Table 9-6 – Codeword table for level_prefix (informative)

level_prefix	bit string
0	1
1	01
2	001
3	0001
4	0000 1
5	0000 01
6	0000 001
7	0000 0001
8	0000 0000 1
9	0000 0000 01
10	0000 0000 001
11	0000 0000 0001
12	0000 0000 0000 1
13	0000 0000 0000 01
14	0000 0000 0000 001
15	0000 0000 0000 0001
…	…

9.2.3 Parsing process for run information

Inputs to this process are bits from slice data, the number of non-zero transform coefficient levels TotalCoeff(coeff_token), and the maximum number of non-zero transform coefficient levels maxNumCoeff.

Output of this process is a list of runs of zero transform coefficient levels preceding non-zero transform coefficient levels called run.

Initially, an index i is set equal to 0.

The variable zerosLeft is derived as follows.

– If the number of non-zero transform coefficient levels TotalCoeff(coeff_token) is equal to the maximum number of non-zero transform coefficient levels maxNumCoeff, a variable zerosLeft is set equal to 0.

– Otherwise (the number of non-zero transform coefficient levels TotalCoeff(coeff_token) is less than the maximum number of non-zero transform coefficient levels maxNumCoeff), total_zeros is decoded and zerosLeft is set equal to its value.

Let the variable tzVlcIndex be equal to TotalCoeff(coeff_token).

The VLC used to decode total_zeros is derived as follows:

If maxNumCoeff is equal to 4, one of the VLCs specified in Table 9-9 (a) is used.

– Otherwise, if maxNumCoeff is equal to 8, one of the VLCs specified in Table 9-9 (b) is used.

– Otherwise (maxNumCoeff is not equal to 4 and not equal to 8), VLCs from Table 9-7 and 9-8 are used.

The following procedure is then applied iteratively (TotalCoeff(coeff_token) – 1) times:

– The variable run[i] is derived as follows.

  – If zerosLeft is greater than zero, a value run_before is decoded based on Table 9-10 and zerosLeft. run[i] is set equal to run_before.

– Otherwise (zerosLeft is equal to 0), run[i] is set equal to 0.

– The value of run[i] is subtracted from zerosLeft and the result assigned to zerosLeft. The result of the subtraction shall be greater than or equal to 0.

– The index i is incremented by 1.

Finally the value of zerosLeft is assigned to run[i].

Table 9-7 – total_zeros tables for 4x4 blocks with tzVlcIndex 1 to 7

total_zeros	tzVlcIndex						
	1	2	3	4	5	6	7
0	1	111	0101	0001 1	0101	0000 01	0000 01
1	011	110	111	111	0100	0000 1	0000 1
2	010	101	110	0101	0011	111	101
3	0011	100	101	0100	111	110	100
4	0010	011	0100	110	110	101	011
5	0001 1	0101	0011	101	101	100	11
6	0001 0	0100	100	100	100	011	010
7	0000 11	0011	011	0011	011	010	0001
8	0000 10	0010	0010	011	0010	0001	001
9	0000 011	0001 1	0001 1	0010	0000 1	001	0000 00
10	0000 010	0001 0	0001 0	0001 0	0001	0000 00	
11	0000 0011	0000 11	0000 01	0000 1	0000 0		
12	0000 0010	0000 10	0000 1	0000 0			
13	0000 0001 1	0000 01	0000 00				
14	0000 0001 0	0000 00					
15	0000 0000 1						

Table 9-8 – total_zeros tables for 4x4 blocks with tzVlcIndex 8 to 15

total_zeros	tzVlcIndex							
	8	9	10	11	12	13	14	15
0	0000 01	0000 01	0000 1	0000	0000	000	00	0
1	0001	0000 00	0000 0	0001	0001	001	01	1
2	0000 1	0001	001	001	01	1	1	
3	011	11	11	010	1	01		
4	11	10	10	1	001			
5	10	001	01	011				
6	010	01	0001					
7	001	0000 1						
8	0000 00							

Table 9-9 – total_zeros tables for chroma DC 2x2 and 2x4 blocks

(a) Chroma DC 2x2 block (4:2:0 chroma sampling)

total_zeros	tzVlcIndex		
	1	2	3
0	1	1	1
1	01	01	0
2	001	00	
3	000		

(b) Chroma DC 2x4 block (4:2:2 chroma sampling)

total_zeros	tzVlcIndex						
	1	2	3	4	5	6	7
0	1	000	000	110	00	00	0
1	010	01	001	00	01	01	1
2	011	001	01	01	10	1	
3	0010	100	10	10	11		
4	0011	101	110	111			
5	0001	110	111				
6	0000 1	111					
7	0000 0						

Table 9-10 – Tables for run_before

run_before	zerosLeft						
	1	2	3	4	5	6	>6
0	1	1	11	11	11	11	111
1	0	01	10	10	10	000	110
2	-	00	01	01	011	001	101
3	-	-	00	001	010	011	100
4	-	-	-	000	001	010	011
5	-	-	-	-	000	101	010
6	-	-	-	-	-	100	001
7	-	-	-	-	-	-	0001
8		-	-	-	-	-	00001
9	-	-	-	-	-	-	000001
10	-	-	-	-	-	-	0000001
11	-	-	-	-	-	-	00000001
12	-	-	-	-	-	-	000000001
13	-	-	-	-	-	-	0000000001
14	-	-	-	-	-	-	00000000001

9.2.4 Combining level and run information

Input to this process are a list of transform coefficient levels called level, a list of runs called run, and the number of non-zero transform coefficient levels TotalCoeff(coeff_token).

Output of this process is an list coeffLevel of transform coefficient levels.

A variable coeffNum is set equal to -1 and an index i is set equal to (TotalCoeff(coeff_token) – 1). The following procedure is iteratively applied TotalCoeff(coeff_token) times:

– coeffNum is incremented by run[i] + 1.

– coeffLevel[coeffNum] is set equal to level[i].

– The index i is decremented by 1.

9.3 CABAC parsing process for slice data

This process is invoked when parsing syntax elements with descriptor ae(v) in subclauses 7.3.4 and 7.3.5 when entropy_coding_mode_flag is equal to 1.

Inputs to this process are a request for a value of a syntax element and values of prior parsed syntax elements.

Output of this process is the value of the syntax element.

When starting the parsing of the slice data of a slice in subclause 7.3.4, the initialisation process of the CABAC parsing process is invoked as specified in subclause 9.3.1.

The parsing of syntax elements proceeds as follows:

For each requested value of a syntax element a binarization is derived as described in subclause 9.3.2.

The binarization for the syntax element and the sequence of parsed bins determines the decoding process flow as described in subclause 9.3.3.

For each bin of the binarization of the syntax element, which is indexed by the variable binIdx, a context index ctxIdx is derived as specified in subclause 9.3.3.1.

For each ctxIdx the arithmetic decoding process is invoked as specified in subclause 9.3.3.2.

The resulting sequence (b_0 .. b_{binIdx}) of parsed bins is compared to the set of bin strings given by the binarization process after decoding of each bin. When the sequence matches a bin string in the given set, the corresponding value is assigned to the syntax element.

In case the request for a value of a syntax element is processed for the syntax element mb_type and the decoded value of mb_type is equal to I_PCM, the decoding engine is initialised after the decoding of any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data as specified in subclause 9.3.1.2.

The whole CABAC parsing process is illustrated in the flowchart of Figure 9-1 with the abbreviation SE for syntax element.

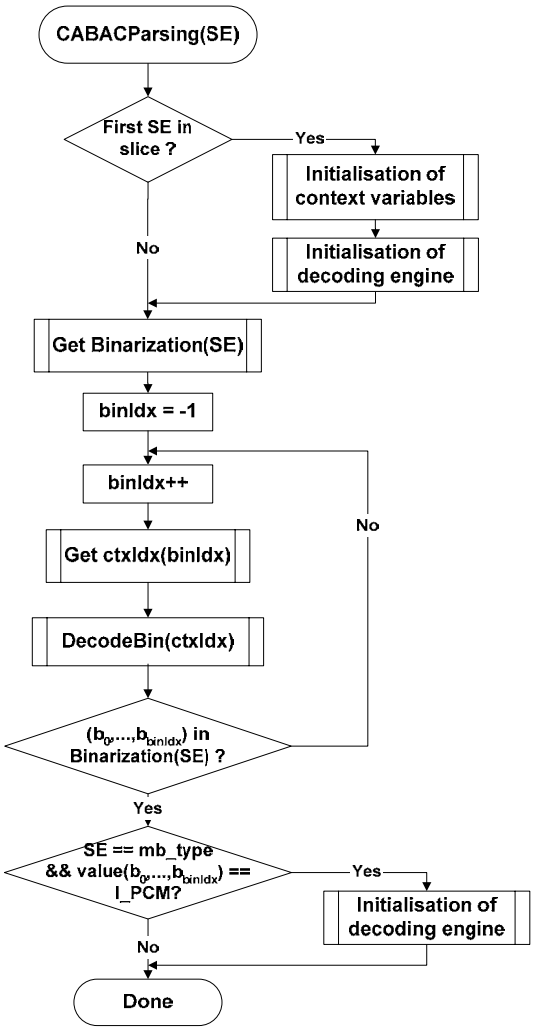


Figure 9-1 – Illustration of CABAC parsing process for a syntax element SE (informative)

9.3.1 Initialisation process

Outputs of this process are initialised CABAC internal variables.

The processes in subclauses 9.3.1.1 and 9.3.1.2 are invoked when starting the parsing of the slice data of a slice in subclause 7.3.4.

The process in subclause 9.3.1.2 is also invoked after decoding any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data for a macroblock of type I_PCM.

9.3.1.1 Initialisation process for context variables

Outputs of this process are the initialised CABAC context variables indexed by ctxIdx.

Table 9-12 to Table 9-33 contain the values of the variables n and m used in the initialisation of context variables that are assigned to all syntax elements in subclauses 7.3.4 and 7.3.5 except for the end-of-slice flag.

For each context variable, the two variables pStateIdx and valMPS are initialised.

NOTE 1 – The variable pStateIdx corresponds to a probability state index and the variable valMPS corresponds to the value of the most probable symbol as further described in subclause 9.3.3.2.

The two values assigned to pStateIdx and valMPS for the initialisation are derived from $SliceQP_Y$, which is derived in Equation 7-28. Given the two table entries (m, n),

1. preCtxState = Clip3(1, 126, ((m * Clip3(0, 51, $SliceQP_Y$)) >> 4) + n)
2. if(preCtxState <= 63) {

        pStateIdx = 63 - preCtxState

        valMPS = 0

    } else {

        pStateIdx = preCtxState - 64

        valMPS = 1

    }

In Table 9-11, the ctxIdx for which initialisation is needed for each of the slice types are listed. Also listed is the table number that includes the values of m and n needed for the initialisation. For P, SP and B slice type, the initialisation depends also on the value of the cabac_init_idc syntax element. Note that the syntax element names do not affect the initialisation process.

Table 9-11 – Association of ctxIdx and syntax elements for each slice type in the initialisation process

	Syntax element	Table	Slice type			
			SI	I	P, SP	B
slice_data( )	mb_skip_flag	Table 9-13 Table 9-14			11-13	24-26
	mb_field_decoding_flag	Table 9-18	70-72	70-72	70-72	70-72
macroblock_layer( )	mb_type	Table 9-12 Table 9-13 Table 9-14	0-10	3-10	14-20	27-35
	transform_size_8x8_flag	Table 9-16	na	399-401	399-401	399-401
	coded_block_pattern (luma)	Table 9-18	73-76	73-76	73-76	73-76
	coded_block_pattern (chroma)	Table 9-18	77-84	77-84	77-84	77-84
	mb_qp_delta	Table 9-17	60-63	60-63	60-63	60-63
mb_pred( )	prev_intra4x4_pred_mode_flag	Table 9-17	68	68	68	68
	rem_intra4x4_pred_mode	Table 9-17	69	69	69	69
	prev_intra8x8_pred_mode_flag	Table 9-17	na	68	68	68
	rem_intra8x8_pred_mode	Table 9-17	na	69	69	69
	intra_chroma_pred_mode	Table 9-17	64-67	64-67	64-67	64-67

Table 9-11 – Association of ctxIdx and syntax elements for each slice type in the initialisation process

	Syntax element	Table	Slice type			
			SI	I	P, SP	B
mb_pred( ) and sub_mb_pred( )	ref_idx_l0	Table 9-16			54-59	54-59
	ref_idx_l1	Table 9-16				54-59
	mvd_l0[ ][ ][0]	Table 9-15			40-46	40-46
	mvd_l1[ ][ ][0]	Table 9-15				40-46
	mvd_l0[ ][ ][1]	Table 9-15			47-53	47-53
	mvd_l1[ ][ ][1]	Table 9-15				47-53
sub_mb_pred( )	sub_mb_type	Table 9-13 Table 9-14			21-23	36-39
residual_block_cabac( )	coded_block_flag	Table 9-18 Table 9-25 Table 9-33	85-104 460-483	85-104 460-483 1012-1023	85-104 460-483 1012-1023	85-104 460-483 1012-1023
	significant_coeff_flag[ ]	Table 9-19 Table 9-22 Table 9-24 Table 9-24 Table 9-26 Table 9-30 Table 9-28 Table 9-29	105-165 277-337	105-165 277-337 402-416 436-450 484-571 776-863 660-689 718-747	105-165 277-337 402-416 436-450 484-571 776-863 660-689 718-747	105-165 277-337 402-416 436-450 484-571 776-863 660-689 718-747
	last_significant_coeff_flag[ ]	Table 9-20 Table 9-23 Table 9-24 Table 9-24 Table 9-27 Table 9-31 Table 9-28 Table 9-29	166-226 338-398	166-226 338-398 417-425 451-459 572-659 864-951 690-707 748-765	166-226 338-398 417-425 451-459 572-659 864-951 690-707 748-765	166-226 338-398 417-425 451-459 572-659 864-951 690-707 748-765
	coeff_abs_level_minus1[ ]	Table 9-21 Table 9-24 Table 9-32 Table 9-28 Table 9-29	227-275	227-275 426-435 952-1011 708-717 766-775	227-275 426-435 952-1011 708-717 766-775	227-275 426-435 952-1011 708-717 766-775

NOTE 2 – ctxIdx equal to 276 is associated with the end_of_slice_flag and the bin of mb_type, which specifies the I_PCM macroblock type. The decoding process specified in subclause 9.3.3.2.4 applies to ctxIdx equal to 276. This decoding process, however, may also be implemented by using the decoding process specified in subclause 9.3.3.2.1. In this case, the initial values associated with ctxIdx equal to 276 are specified to be pStateIdx = 63 and valMPS = 0, where pStateIdx = 63 represents a non-adapting probability state.

Table 9-12 – Values of variables m and n for ctxIdx from 0 to 10

Initialisation variables	ctxIdx										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
m	20	2	3	20	2	3	-28	-23	-6	-1	7
n	-15	54	74	-15	54	74	127	104	53	54	51

Table 9-13 – Values of variables m and n for ctxIdx from 11 to 23

Value of cabac_init_idc	Initialisation variables	ctxIdx												
		11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
0	**m**	23	23	21	1	0	-37	5	-13	-11	1	12	-4	17
	n	33	2	0	9	49	118	57	78	65	62	49	73	50
1	**m**	22	34	16	-2	4	-29	2	-6	-13	5	9	-3	10
	n	25	0	0	9	41	118	65	71	79	52	50	70	54
2	**m**	29	25	14	-10	-3	-27	26	-4	-24	5	6	-17	14
	n	16	0	0	51	62	99	16	85	102	57	57	73	57

Table 9-14 – Values of variables m and n for ctxIdx from 24 to 39

Value of cabac_init_idc	Initialisation variables	ctxIdx															
		24	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
0	**m**	18	9	29	26	16	9	-46	-20	1	-13	-11	1	-6	-17	-6	9
	n	64	43	0	67	90	104	127	104	67	78	65	62	86	95	61	45
1	**m**	26	19	40	57	41	26	-45	-15	-4	-6	-13	5	6	-13	0	8
	n	34	22	0	2	36	69	127	101	76	71	79	52	69	90	52	43
2	**m**	20	20	29	54	37	12	-32	-22	-2	-4	-24	5	-6	-14	-6	4
	n	40	10	0	0	42	97	127	117	74	85	102	57	93	88	44	55

Table 9-15 – Values of variables m and n for ctxIdx from 40 to 53

Value of cabac_init_idc	Initialisation variables	ctxIdx													
		40	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
0	**m**	-3	-6	-11	6	7	-5	2	0	-3	-10	5	4	-3	0
	n	69	81	96	55	67	86	88	58	76	94	54	69	81	88
1	**m**	-2	-5	-10	2	2	-3	-3	1	-3	-6	0	-3	-7	-5
	n	69	82	96	59	75	87	100	56	74	85	59	81	86	95
2	**m**	-11	-15	-21	19	20	4	6	1	-5	-13	5	6	-3	-1
	n	89	103	116	57	58	84	96	63	85	106	63	75	90	101

Table 9-16 – Values of variables m and n for ctxIdx from 54 to 59, and 399 to 401

Value of cabac_init_idc	Initialisation variables	ctxIdx								
		54	**55**	**56**	**57**	**58**	**59**	**399**	**400**	**401**
I slices	**m**	na	na	na	na	na	na	31	31	25
	n	na	na	na	na	na	na	21	31	50
0	**m**	-7	-5	-4	-5	-7	1	12	11	14
	n	67	74	74	80	72	58	40	51	59
1	**m**	-1	-1	1	-2	-5	0	25	21	21
	n	66	77	70	86	72	61	32	49	54
2	**m**	3	-4	-2	-12	-7	1	21	19	17
	n	55	79	75	97	50	60	33	50	61

Table 9-17 – Values of variables m and n for ctxIdx from 60 to 69

Initialisation variables	ctxIdx									
	60	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**
m	0	0	0	0	-9	4	0	-7	13	3
n	41	63	63	63	83	86	97	72	41	62

Table 9-18 – Values of variables m and n for ctxIdx from 70 to 104

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
70	0	11	0	45	13	15	7	34	**88**	-11	115	-13	108	-4	92	5	78
71	1	55	-4	78	7	51	-9	88	**89**	-12	63	-3	46	0	39	-6	55
72	0	69	-3	96	2	80	-20	127	**90**	-2	68	-1	65	0	65	4	61
73	-17	127	-27	126	-39	127	-36	127	**91**	-15	84	-1	57	-15	84	-14	83
74	-13	102	-28	98	-18	91	-17	91	**92**	-13	104	-9	93	-35	127	-37	127
75	0	82	-25	101	-17	96	-14	95	**93**	-3	70	-3	74	-2	73	-5	79
76	-7	74	-23	67	-26	81	-25	84	**94**	-8	93	-9	92	-12	104	-11	104
77	-21	107	-28	82	-35	98	-25	86	**95**	-10	90	-8	87	-9	91	-11	91
78	-27	127	-20	94	-24	102	-12	89	**96**	-30	127	-23	126	-31	127	-30	127
79	-31	127	-16	83	-23	97	-17	91	**97**	-1	74	5	54	3	55	0	65
80	-24	127	-22	110	-27	119	-31	127	**98**	-6	97	6	60	7	56	-2	79
81	-18	95	-21	91	-24	99	-14	76	**99**	-7	91	6	59	7	55	0	72
82	-27	127	-18	102	-21	110	-18	103	**100**	-20	127	6	69	8	61	-4	92
83	-21	114	-13	93	-18	102	-13	90	**101**	-4	56	-1	48	-3	53	-6	56
84	-30	127	-29	127	-36	127	-37	127	**102**	-5	82	0	68	0	68	3	68
85	-17	123	-7	92	0	80	11	80	**103**	-7	76	-4	69	-7	74	-8	71
86	-12	115	-5	89	-5	89	5	76	**104**	-22	125	-8	88	-9	88	-13	98
87	-16	122	-7	96	-7	94	2	84									

Table 9-19 – Values of variables m and n for ctxIdx from 105 to 165

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
105	-7	93	-2	85	-13	103	-4	86	**136**	-13	101	5	53	0	58	-5	75
106	-11	87	-6	78	-13	91	-12	88	**137**	-13	91	-2	61	-1	60	-8	80
107	-3	77	-1	75	-9	89	-5	82	**138**	-12	94	0	56	-3	61	-21	83
108	-5	71	-7	77	-14	92	-3	72	**139**	-10	88	0	56	-8	67	-21	64
109	-4	63	2	54	-8	76	-4	67	**140**	-16	84	-13	63	-25	84	-13	31
110	-4	68	5	50	-12	87	-8	72	**141**	-10	86	-5	60	-14	74	-25	64
111	-12	84	-3	68	-23	110	-16	89	**142**	-7	83	-1	62	-5	65	-29	94
112	-7	62	1	50	-24	105	-9	69	**143**	-13	87	4	57	5	52	9	75
113	-7	65	6	42	-10	78	-1	59	**144**	-19	94	-6	69	2	57	17	63
114	8	61	-4	81	-20	112	5	66	**145**	1	70	4	57	0	61	-8	74
115	5	56	1	63	-17	99	4	57	**146**	0	72	14	39	-9	69	-5	35
116	-2	66	-4	70	-78	127	-4	71	**147**	-5	74	4	51	-11	70	-2	27
117	1	64	0	67	-70	127	-2	71	**148**	18	59	13	68	18	55	13	91
118	0	61	2	57	-50	127	2	58	**149**	-8	102	3	64	-4	71	3	65
119	-2	78	-2	76	-46	127	-1	74	**150**	-15	100	1	61	0	58	-7	69
120	1	50	11	35	-4	66	-4	44	**151**	0	95	9	63	7	61	8	77
121	7	52	4	64	-5	78	-1	69	**152**	-4	75	7	50	9	41	-10	66
122	10	35	1	61	-4	71	0	62	**153**	2	72	16	39	18	25	3	62
123	0	44	11	35	-8	72	-7	51	**154**	-11	75	5	44	9	32	-3	68
124	11	38	18	25	2	59	-4	47	**155**	-3	71	4	52	5	43	-20	81
125	1	45	12	24	-1	55	-6	42	**156**	15	46	11	48	9	47	0	30
126	0	46	13	29	-7	70	-3	41	**157**	-13	69	-5	60	0	44	1	7
127	5	44	13	36	-6	75	-6	53	**158**	0	62	-1	59	0	51	-3	23
128	31	17	-10	93	-8	89	8	76	**159**	0	65	0	59	2	46	-21	74
129	1	51	-7	73	-34	119	-9	78	**160**	21	37	22	33	19	38	16	66
130	7	50	-2	73	-3	75	-11	83	**161**	-15	72	5	44	-4	66	-23	124
131	28	19	13	46	32	20	9	52	**162**	9	57	14	43	15	38	17	37
132	16	33	9	49	30	22	0	67	**163**	16	54	-1	78	12	42	44	-18
133	14	62	-7	100	-44	127	-5	90	**164**	0	62	0	60	9	34	50	-34
134	-13	108	9	53	0	54	1	67	**165**	12	72	9	69	0	89	-22	127
135	-15	100	2	53	-5	61	-15	72									

Table 9-20 – Values of variables m and n for ctxIdx from 166 to 226

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
166	24	0	11	28	4	45	4	39	**197**	26	-17	28	3	36	-28	28	-3
167	15	9	2	40	10	28	0	42	**198**	30	-25	28	4	38	-28	24	10
168	8	25	3	44	10	31	7	34	**199**	28	-20	32	0	38	-27	27	0
169	13	18	0	49	33	-11	11	29	**200**	33	-23	34	-1	34	-18	34	-14
170	15	9	0	46	52	-43	8	31	**201**	37	-27	30	6	35	-16	52	-44
171	13	19	2	44	18	15	6	37	**202**	33	-23	30	6	34	-14	39	-24
172	10	37	2	51	28	0	7	42	**203**	40	-28	32	9	32	-8	19	17
173	12	18	0	47	35	-22	3	40	**204**	38	-17	31	19	37	-6	31	25
174	6	29	4	39	38	-25	8	33	**205**	33	-11	26	27	35	0	36	29
175	20	33	2	62	34	0	13	43	**206**	40	-15	26	30	30	10	24	33
176	15	30	6	46	39	-18	13	36	**207**	41	-6	37	20	28	18	34	15
177	4	45	0	54	32	-12	4	47	**208**	38	1	28	34	26	25	30	20
178	1	58	3	54	102	-94	3	55	**209**	41	17	17	70	29	41	22	73
179	0	62	2	58	0	0	2	58	**210**	30	-6	1	67	0	75	20	34
180	7	61	4	63	56	-15	6	60	**211**	27	3	5	59	2	72	19	31
181	12	38	6	51	33	-4	8	44	**212**	26	22	9	67	8	77	27	44
182	11	45	6	57	29	10	11	44	**213**	37	-16	16	30	14	35	19	16
183	15	39	7	53	37	-5	14	42	**214**	35	-4	18	32	18	31	15	36
184	11	42	6	52	51	-29	7	48	**215**	38	-8	18	35	17	35	15	36
185	13	44	6	55	39	-9	4	56	**216**	38	-3	22	29	21	30	21	28
186	16	45	11	45	52	-34	4	52	**217**	37	3	24	31	17	45	25	21
187	12	41	14	36	69	-58	13	37	**218**	38	5	23	38	20	42	30	20
188	10	49	8	53	67	-63	9	49	**219**	42	0	18	43	18	45	31	12
189	30	34	-1	82	44	-5	19	58	**220**	35	16	20	41	27	26	27	16
190	18	42	7	55	32	7	10	48	**221**	39	22	11	63	16	54	24	42
191	10	55	-3	78	55	-29	12	45	**222**	14	48	9	59	7	66	0	93
192	17	51	15	46	32	1	0	69	**223**	27	37	9	64	16	56	14	56
193	17	46	22	31	0	0	20	33	**224**	21	60	-1	94	11	73	15	57
194	0	89	-1	84	27	36	8	63	**225**	12	68	-2	89	10	67	26	38
195	26	-19	25	7	33	-25	35	-18	**226**	2	97	-9	108	-10	116	-24	127
196	22	-17	30	-7	34	-30	33	-25									

Table 9-21 – Values of variables m and n for ctxIdx from 227 to 275

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
227	-3	71	-6	76	-23	112	-24	115	**252**	-12	73	-6	55	-16	72	-14	75
228	-6	42	-2	44	-15	71	-22	82	**253**	-8	76	0	58	-7	69	-10	79
229	-5	50	0	45	-7	61	-9	62	**254**	-7	80	0	64	-4	69	-9	83
230	-3	54	0	52	0	53	0	53	**255**	-9	88	-3	74	-5	74	-12	92
231	-2	62	-3	64	-5	66	0	59	**256**	-17	110	-10	90	-9	86	-18	108
232	0	58	-2	59	-11	77	-14	85	**257**	-11	97	0	70	2	66	-4	79
233	1	63	-4	70	-9	80	-13	89	**258**	-20	84	-4	29	-9	34	-22	69
234	-2	72	-4	75	-9	84	-13	94	**259**	-11	79	5	31	1	32	-16	75
235	-1	74	-8	82	-10	87	-11	92	**260**	-6	73	7	42	11	31	-2	58
236	-9	91	-17	102	-34	127	-29	127	**261**	-4	74	1	59	5	52	1	58
237	-5	67	-9	77	-21	101	-21	100	**262**	-13	86	-2	58	-2	55	-13	78
238	-5	27	3	24	-3	39	-14	57	**263**	-13	96	-3	72	-2	67	-9	83
239	-3	39	0	42	-5	53	-12	67	**264**	-11	97	-3	81	0	73	-4	81
240	-2	44	0	48	-7	61	-11	71	**265**	-19	117	-11	97	-8	89	-13	99
241	0	46	0	55	-11	75	-10	77	**266**	-8	78	0	58	3	52	-13	81
242	-16	64	-6	59	-15	77	-21	85	**267**	-5	33	8	5	7	4	-6	38
243	-8	68	-7	71	-17	91	-16	88	**268**	-4	48	10	14	10	8	-13	62
244	-10	78	-12	83	-25	107	-23	104	**269**	-2	53	14	18	17	8	-6	58
245	-6	77	-11	87	-25	111	-15	98	**270**	-3	62	13	27	16	19	-2	59
246	-10	86	-30	119	-28	122	-37	127	**271**	-13	71	2	40	3	37	-16	73
247	-12	92	1	58	-11	76	-10	82	**272**	-10	79	0	58	-1	61	-10	76
248	-15	55	-3	29	-10	44	-8	48	**273**	-12	86	-3	70	-5	73	-13	86
249	-10	60	-1	36	-10	52	-8	61	**274**	-13	90	-6	79	-1	70	-9	83
250	-6	62	1	38	-10	57	-8	66	**275**	-14	97	-8	85	-4	78	-10	87
251	-4	65	2	43	-9	58	-7	70									

Table 9-22 – Values of variables m and n for ctxIdx from 277 to 337

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
277	-6	93	-13	106	-21	126	-22	127	**308**	-16	96	-1	51	-16	77	-10	67
278	-6	84	-16	106	-23	124	-25	127	**309**	-7	88	7	49	-2	64	1	68
279	-8	79	-10	87	-20	110	-25	120	**310**	-8	85	8	52	2	61	0	77
280	0	66	-21	114	-26	126	-27	127	**311**	-7	85	9	41	-6	67	2	64
281	-1	71	-18	110	-25	124	-19	114	**312**	-9	85	6	47	-3	64	0	68
282	0	62	-14	98	-17	105	-23	117	**313**	-13	88	2	55	2	57	-5	78
283	-2	60	-22	110	-27	121	-25	118	**314**	4	66	13	41	-3	65	7	55
284	-2	59	-21	106	-27	117	-26	117	**315**	-3	77	10	44	-3	66	5	59
285	-5	75	-18	103	-17	102	-24	113	**316**	-3	76	6	50	0	62	2	65
286	-3	62	-21	107	-26	117	-28	118	**317**	-6	76	5	53	9	51	14	54
287	-4	58	-23	108	-27	116	-31	120	**318**	10	58	13	49	-1	66	15	44
288	-9	66	-26	112	-33	122	-37	124	**319**	-1	76	4	63	-2	71	5	60
289	-1	79	-10	96	-10	95	-10	94	**320**	-1	83	6	64	-2	75	2	70
290	0	71	-12	95	-14	100	-15	102	**321**	-7	99	-2	69	-1	70	-2	76
291	3	68	-5	91	-8	95	-10	99	**322**	-14	95	-2	59	-9	72	-18	86
292	10	44	-9	93	-17	111	-13	106	**323**	2	95	6	70	14	60	12	70
293	-7	62	-22	94	-28	114	-50	127	**324**	0	76	10	44	16	37	5	64
294	15	36	-5	86	-6	89	-5	92	**325**	-5	74	9	31	0	47	-12	70
295	14	40	9	67	-2	80	17	57	**326**	0	70	12	43	18	35	11	55
296	16	27	-4	80	-4	82	-5	86	**327**	-11	75	3	53	11	37	5	56
297	12	29	-10	85	-9	85	-13	94	**328**	1	68	14	34	12	41	0	69
298	1	44	-1	70	-8	81	-12	91	**329**	0	65	10	38	10	41	2	65
299	20	36	7	60	-1	72	-2	77	**330**	-14	73	-3	52	2	48	-6	74
300	18	32	9	58	5	64	0	71	**331**	3	62	13	40	12	41	5	54
301	5	42	5	61	1	67	-1	73	**332**	4	62	17	32	13	41	7	54
302	1	48	12	50	9	56	4	64	**333**	-1	68	7	44	0	59	-6	76
303	10	62	15	50	0	69	-7	81	**334**	-13	75	7	38	3	50	-11	82
304	17	46	18	49	1	69	5	64	**335**	11	55	13	50	19	40	-2	77
305	9	64	17	54	7	69	15	57	**336**	5	64	10	57	3	66	-2	77
306	-12	104	10	41	-7	69	1	67	**337**	12	70	26	43	18	50	25	42
307	-11	97	7	46	-6	67	0	68									

Table 9-23 – Values of variables m and n for ctxIdx from 338 to 398

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
338	15	6	14	11	19	-6	17	-13	**369**	32	-26	31	-4	40	-37	37	-17
339	6	19	11	14	18	-6	16	-9	**370**	37	-30	27	6	38	-30	32	1
340	7	16	9	11	14	0	17	-12	**371**	44	-32	34	8	46	-33	34	15
341	12	14	18	11	26	-12	27	-21	**372**	34	-18	30	10	42	-30	29	15
342	18	13	21	9	31	-16	37	-30	**373**	34	-15	24	22	40	-24	24	25
343	13	11	23	-2	33	-25	41	-40	**374**	40	-15	33	19	49	-29	34	22
344	13	15	32	-15	33	-22	42	-41	**375**	33	-7	22	32	38	-12	31	16
345	15	16	32	-15	37	-28	48	-47	**376**	35	-5	26	31	40	-10	35	18
346	12	23	34	-21	39	-30	39	-32	**377**	33	0	21	41	38	-3	31	28
347	13	23	39	-23	42	-30	46	-40	**378**	38	2	26	44	46	-5	33	41
348	15	20	42	-33	47	-42	52	-51	**379**	33	13	23	47	31	20	36	28
349	14	26	41	-31	45	-36	46	-41	**380**	23	35	16	65	29	30	27	47
350	14	44	46	-28	49	-34	52	-39	**381**	13	58	14	71	25	44	21	62
351	17	40	38	-12	41	-17	43	-19	**382**	29	-3	8	60	12	48	18	31
352	17	47	21	29	32	9	32	11	**383**	26	0	6	63	11	49	19	26
353	24	17	45	-24	69	-71	61	-55	**384**	22	30	17	65	26	45	36	24
354	21	21	53	-45	63	-63	56	-46	**385**	31	-7	21	24	22	22	24	23
355	25	22	48	-26	66	-64	62	-50	**386**	35	-15	23	20	23	22	27	16
356	31	27	65	-43	77	-74	81	-67	**387**	34	-3	26	23	27	21	24	30
357	22	29	43	-19	54	-39	45	-20	**388**	34	3	27	32	33	20	31	29
358	19	35	39	-10	52	-35	35	-2	**389**	36	-1	28	23	26	28	22	41
359	14	50	30	9	41	-10	28	15	**390**	34	5	28	24	30	24	22	42
360	10	57	18	26	36	0	34	1	**391**	32	11	23	40	27	34	16	60
361	7	63	20	27	40	-1	39	1	**392**	35	5	24	32	18	42	15	52
362	-2	77	0	57	30	14	30	17	**393**	34	12	28	29	25	39	14	60
363	-4	82	-14	82	28	26	20	38	**394**	39	11	23	42	18	50	3	78
364	-3	94	-5	75	23	37	18	45	**395**	30	29	19	57	12	70	-16	123
365	9	69	-19	97	12	55	15	54	**396**	34	26	22	53	21	54	21	53
366	-12	109	-35	125	11	65	0	79	**397**	29	39	22	61	14	71	22	56
367	36	-35	27	0	37	-33	36	-16	**398**	19	66	11	86	11	83	25	61
368	36	-34	28	0	39	-36	37	-14									

Table 9-24 – Values of variables m and n for ctxIdx from 402 to 459

ctxIdx	I slices		Value of cabac_init_idc						ctxIdx	I slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
402	-17	120	-4	79	-5	85	-3	78	**431**	-2	55	-12	56	-9	57	-12	59
403	-20	112	-7	71	-6	81	-8	74	**432**	0	61	-6	60	-6	63	-8	63
404	-18	114	-5	69	-10	77	-9	72	**433**	1	64	-5	62	-4	65	-9	67
405	-11	85	-9	70	-7	81	-10	72	**434**	0	68	-8	66	-4	67	-6	68
406	-15	92	-8	66	-17	80	-18	75	**435**	-9	92	-8	76	-7	82	-10	79
407	-14	89	-10	68	-18	73	-12	71	**436**	-14	106	-5	85	-3	81	-3	78
408	-26	71	-19	73	-4	74	-11	63	**437**	-13	97	-6	81	-3	76	-8	74
409	-15	81	-12	69	-10	83	-5	70	**438**	-15	90	-10	77	-7	72	-9	72
410	-14	80	-16	70	-9	71	-17	75	**439**	-12	90	-7	81	-6	78	-10	72
411	0	68	-15	67	-9	67	-14	72	**440**	-18	88	-17	80	-12	72	-18	75
412	-14	70	-20	62	-1	61	-16	67	**441**	-10	73	-18	73	-14	68	-12	71
413	-24	56	-19	70	-8	66	-8	53	**442**	-9	79	-4	74	-3	70	-11	63
414	-23	68	-16	66	-14	66	-14	59	**443**	-14	86	-10	83	-6	76	-5	70
415	-24	50	-22	65	0	59	-9	52	**444**	-10	73	-9	71	-5	66	-17	75
416	-11	74	-20	63	2	59	-11	68	**445**	-10	70	-9	67	-5	62	-14	72
417	23	-13	9	-2	17	-10	9	-2	**446**	-10	69	-1	61	0	57	-16	67
418	26	-13	26	-9	32	-13	30	-10	**447**	-5	66	-8	66	-4	61	-8	53
419	40	-15	33	-9	42	-9	31	-4	**448**	-9	64	-14	66	-9	60	-14	59
420	49	-14	39	-7	49	-5	33	-1	**449**	-5	58	0	59	1	54	-9	52
421	44	3	41	-2	53	0	33	7	**450**	2	59	2	59	2	58	-11	68
422	45	6	45	3	64	3	31	12	**451**	21	-10	21	-13	17	-10	9	-2
423	44	34	49	9	68	10	37	23	**452**	24	-11	33	-14	32	-13	30	-10
424	33	54	45	27	66	27	31	38	**453**	28	-8	39	-7	42	-9	31	-4
425	19	82	36	59	47	57	20	64	**454**	28	-1	46	-2	49	-5	33	-1
426	-3	75	-6	66	-5	71	-9	71	**455**	29	3	51	2	53	0	33	7
427	-1	23	-7	35	0	24	-7	37	**456**	29	9	60	6	64	3	31	12
428	1	34	-7	42	-1	36	-8	44	**457**	35	20	61	17	68	10	37	23
429	1	43	-8	45	-2	42	-11	49	**458**	29	36	55	34	66	27	31	38
430	0	54	-5	48	-2	52	-10	56	**459**	14	67	42	62	47	57	20	64

Table 9-25 – Values of variables m and n for ctxIdx from 460 to 483

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
460	-17	123	-7	92	0	80	11	80	**472**	-17	123	-7	92	0	80	11	80
461	-12	115	-5	89	-5	89	5	76	**473**	-12	115	-5	89	-5	89	5	76
462	-16	122	-7	96	-7	94	2	84	**474**	-16	122	-7	96	-7	94	2	84
463	-11	115	-13	108	-4	92	5	78	**475**	-11	115	-13	108	-4	92	5	78
464	-12	63	-3	46	0	39	-6	55	**476**	-12	63	-3	46	0	39	-6	55
465	-2	68	-1	65	0	65	4	61	**477**	-2	68	-1	65	0	65	4	61
466	-15	84	-1	57	-15	84	-14	83	**478**	-15	84	-1	57	-15	84	-14	83
467	-13	104	-9	93	-35	127	-37	127	**479**	-13	104	-9	93	-35	127	-37	127
468	-3	70	-3	74	-2	73	-5	79	**480**	-3	70	-3	74	-2	73	-5	79
469	-8	93	-9	92	-12	104	-11	104	**481**	-8	93	-9	92	-12	104	-11	104
470	-10	90	-8	87	-9	91	-11	91	**482**	-10	90	-8	87	-9	91	-11	91
471	-30	127	-23	126	-31	127	-30	127	**483**	-30	127	-23	126	-31	127	-30	127

Table 9-26 – Values of variables m and n for ctxIdx from 484 to 571

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
484	-7	93	-2	85	-13	103	-4	86	**528**	-7	93	-2	85	-13	103	-4	86
485	-11	87	-6	78	-13	91	-12	88	**529**	-11	87	-6	78	-13	91	-12	88
486	-3	77	-1	75	-9	89	-5	82	**530**	-3	77	-1	75	-9	89	-5	82
487	-5	71	-7	77	-14	92	-3	72	**531**	-5	71	-7	77	-14	92	-3	72
488	-4	63	2	54	-8	76	-4	67	**532**	-4	63	2	54	-8	76	-4	67
489	-4	68	5	50	-12	87	-8	72	**533**	-4	68	5	50	-12	87	-8	72
490	-12	84	-3	68	-23	110	-16	89	**534**	-12	84	-3	68	-23	110	-16	89
491	-7	62	1	50	-24	105	-9	69	**535**	-7	62	1	50	-24	105	-9	69
492	-7	65	6	42	-10	78	-1	59	**536**	-7	65	6	42	-10	78	-1	59
493	8	61	-4	81	-20	112	5	66	**537**	8	61	-4	81	-20	112	5	66
494	5	56	1	63	-17	99	4	57	**538**	5	56	1	63	-17	99	4	57
495	-2	66	-4	70	-78	127	-4	71	**539**	-2	66	-4	70	-78	127	-4	71
496	1	64	0	67	-70	127	-2	71	**540**	1	64	0	67	-70	127	-2	71
497	0	61	2	57	-50	127	2	58	**641**	0	61	2	57	-50	127	2	58
498	-2	78	-2	76	-46	127	-1	74	**542**	-2	78	-2	76	-46	127	-1	74

Table 9-26 – Values of variables m and n for ctxIdx from 484 to 571

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
499	1	50	11	35	-4	66	-4	44	**543**	1	50	11	35	-4	66	-4	44
500	7	52	4	64	-5	78	-1	69	**544**	7	52	4	64	-5	78	-1	69
501	10	35	1	61	-4	71	0	62	**545**	10	35	1	61	-4	71	0	62
502	0	44	11	35	-8	72	-7	51	**546**	0	44	11	35	-8	72	-7	51
503	11	38	18	25	2	59	-4	47	**547**	11	38	18	25	2	59	-4	47
504	1	45	12	24	-1	55	-6	42	**548**	1	45	12	24	-1	55	-6	42
505	0	46	13	29	-7	70	-3	41	**549**	0	46	13	29	-7	70	-3	41
506	5	44	13	36	-6	75	-6	53	**550**	5	44	13	36	-6	75	-6	53
507	31	17	-10	93	-8	89	8	76	**551**	31	17	-10	93	-8	89	8	76
508	1	51	-7	73	-34	119	-9	78	**552**	1	51	-7	73	-34	119	-9	78
509	7	50	-2	73	-3	75	-11	83	**553**	7	50	-2	73	-3	75	-11	83
510	28	19	13	46	32	20	9	52	**554**	28	19	13	46	32	20	9	52
511	16	33	9	49	30	22	0	67	**555**	16	33	9	49	30	22	0	67
512	14	62	-7	100	-44	127	-5	90	**556**	14	62	-7	100	-44	127	-5	90
513	-13	108	9	53	0	54	1	67	**557**	-13	108	9	53	0	54	1	67
514	-15	100	2	53	-5	61	-15	72	**558**	-15	100	2	53	-5	61	-15	72
515	-13	101	5	53	0	58	-5	75	**559**	-13	101	5	53	0	58	-5	75
516	-13	91	-2	61	-1	60	-8	80	**560**	-13	91	-2	61	-1	60	-8	80
517	-12	94	0	56	-3	61	-21	83	**561**	-12	94	0	56	-3	61	-21	83
518	-10	88	0	56	-8	67	-21	64	**562**	-10	88	0	56	-8	67	-21	64
519	-16	84	-13	63	-25	84	-13	31	**563**	-16	84	-13	63	-25	84	-13	31
520	-10	86	-5	60	-14	74	-25	64	**564**	-10	86	-5	60	-14	74	-25	64
521	-7	83	-1	62	-5	65	-29	94	**565**	-7	83	-1	62	-5	65	-29	94
522	-13	87	4	57	5	52	9	75	**566**	-13	87	4	57	5	52	9	75
523	-19	94	-6	69	2	57	17	63	**567**	-19	94	-6	69	2	57	17	63
524	1	70	4	57	0	61	-8	74	**568**	1	70	4	57	0	61	-8	74
525	0	72	14	39	-9	69	-5	35	**569**	0	72	14	39	-9	69	-5	35
526	-5	74	4	51	-11	70	-2	27	**570**	-5	74	4	51	-11	70	-2	27
527	18	59	13	68	18	55	13	91	**571**	18	59	13	68	18	55	13	91

Table 9-27 – Values of variables m and n for ctxIdx from 572 to 659

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
572	24	0	11	28	4	45	4	39	**616**	24	0	11	28	4	45	4	39
573	15	9	2	40	10	28	0	42	**617**	15	9	2	40	10	28	0	42
574	8	25	3	44	10	31	7	34	**618**	8	25	3	44	10	31	7	34
575	13	18	0	49	33	-11	11	29	**619**	13	18	0	49	33	-11	11	29
576	15	9	0	46	52	-43	8	31	**620**	15	9	0	46	52	-43	8	31
577	13	19	2	44	18	15	6	37	**621**	13	19	2	44	18	15	6	37
578	10	37	2	51	28	0	7	42	**622**	10	37	2	51	28	0	7	42
579	12	18	0	47	35	-22	3	40	**623**	12	18	0	47	35	-22	3	40
580	6	29	4	39	38	-25	8	33	**624**	6	29	4	39	38	-25	8	33
581	20	33	2	62	34	0	13	43	**625**	20	33	2	62	34	0	13	43
582	15	30	6	46	39	-18	13	36	**626**	15	30	6	46	39	-18	13	36
583	4	45	0	54	32	-12	4	47	**627**	4	45	0	54	32	-12	4	47
584	1	58	3	54	102	-94	3	55	**628**	1	58	3	54	102	-94	3	55
585	0	62	2	58	0	0	2	58	**629**	0	62	2	58	0	0	2	58
586	7	61	4	63	56	-15	6	60	**630**	7	61	4	63	56	-15	6	60
587	12	38	6	51	33	-4	8	44	**631**	12	38	6	51	33	-4	8	44
588	11	45	6	57	29	10	11	44	**632**	11	45	6	57	29	10	11	44
589	15	39	7	53	37	-5	14	42	**633**	15	39	7	53	37	-5	14	42
590	11	42	6	52	51	-29	7	48	**634**	11	42	6	52	51	-29	7	48
591	13	44	6	55	39	-9	4	56	**635**	13	44	6	55	39	-9	4	56
592	16	45	11	45	52	-34	4	52	**636**	16	45	11	45	52	-34	4	52
593	12	41	14	36	69	-58	13	37	**637**	12	41	14	36	69	-58	13	37
594	10	49	8	53	67	-63	9	49	**638**	10	49	8	53	67	-63	9	49
595	30	34	-1	82	44	-5	19	58	**639**	30	34	-1	82	44	-5	19	58
596	18	42	7	55	32	7	10	48	**640**	18	42	7	55	32	7	10	48
597	10	55	-3	78	55	-29	12	45	**641**	10	55	-3	78	55	-29	12	45
598	17	51	15	46	32	1	0	69	**642**	17	51	15	46	32	1	0	69
599	17	46	22	31	0	0	20	33	**643**	17	46	22	31	0	0	20	33
600	0	89	-1	84	27	36	8	63	**644**	0	89	-1	84	27	36	8	63
601	26	-19	25	7	33	-25	35	-18	**645**	26	-19	25	7	33	-25	35	-18
602	22	-17	30	-7	34	-30	33	-25	**646**	22	-17	30	-7	34	-30	33	-25

Table 9-27 – Values of variables m and n for ctxIdx from 572 to 659

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
603	26	-17	28	3	36	-28	28	-3	**647**	26	-17	28	3	36	-28	28	-3
604	30	-25	28	4	38	-28	24	10	**648**	30	-25	28	4	38	-28	24	10
605	28	-20	32	0	38	-27	27	0	**649**	28	-20	32	0	38	-27	27	0
606	33	-23	34	-1	34	-18	34	-14	**650**	33	-23	34	-1	34	-18	34	-14
607	37	-27	30	6	35	-16	52	-44	**651**	37	-27	30	6	35	-16	52	-44
608	33	-23	30	6	34	-14	39	-24	**652**	33	-23	30	6	34	-14	39	-24
609	40	-28	32	9	32	-8	19	17	**653**	40	-28	32	9	32	-8	19	17
610	38	-17	31	19	37	-6	31	25	**654**	38	-17	31	19	37	-6	31	25
611	33	-11	26	27	35	0	36	29	**655**	33	-11	26	27	35	0	36	29
612	40	-15	26	30	30	10	24	33	**656**	40	-15	26	30	30	10	24	33
613	41	-6	37	20	28	18	34	15	**657**	41	-6	37	20	28	18	34	15
614	38	1	28	34	26	25	30	20	**658**	38	1	28	34	26	25	30	20
615	41	17	17	70	29	41	22	73	**659**	41	17	17	70	29	41	22	73

Table 9-28– Values of variables m and n for ctxIdx from 660 to 717

ctxIdx	I slices		Value of cabac_init_idc						ctxIdx	I slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
660	-17	120	-4	79	-5	85	-3	78	**689**	2	59	2	59	2	58	-11	68
661	-20	112	-7	71	-6	81	-8	74	**690**	23	-13	9	-2	17	-10	9	-2
662	-18	114	-5	69	-10	77	-9	72	**691**	26	-13	26	-9	32	-13	30	-10
663	-11	85	-9	70	-7	81	-10	72	**692**	40	-15	33	-9	42	-9	31	-4
664	-15	92	-8	66	-17	80	-18	75	**693**	49	-14	39	-7	49	-5	33	-1
665	-14	89	-10	68	-18	73	-12	71	**694**	44	3	41	-2	53	0	33	7
666	-26	71	-19	73	-4	74	-11	63	**695**	45	6	45	3	64	3	31	12
667	-15	81	-12	69	-10	83	-5	70	**696**	44	34	49	9	68	10	37	23
668	-14	80	-16	70	-9	71	-17	75	**697**	33	54	45	27	66	27	31	38
669	0	68	-15	67	-9	67	-14	72	**698**	19	82	36	59	47	57	20	64
670	-14	70	-20	62	-1	61	-16	67	**699**	21	-10	21	-13	17	-10	9	-2
671	-24	56	-19	70	-8	66	-8	53	**700**	24	-11	33	-14	32	-13	30	-10
672	-23	68	-16	66	-14	66	-14	59	**701**	28	-8	39	-7	42	-9	31	-4
673	-24	50	-22	65	0	59	-9	52	**702**	28	-1	46	-2	49	-5	33	-1
674	-11	74	-20	63	2	59	-11	68	**703**	29	3	51	2	53	0	33	7
675	-14	106	-5	85	-3	81	-3	78	**704**	29	9	60	6	64	3	31	12
676	-13	97	-6	81	-3	76	-8	74	**705**	35	20	61	17	68	10	37	23
677	-15	90	-10	77	-7	72	-9	72	**706**	29	36	55	34	66	27	31	38
678	-12	90	-7	81	-6	78	-10	72	**707**	14	67	42	62	47	57	20	64
679	-18	88	-17	80	-12	72	-18	75	**708**	-3	75	-6	66	-5	71	-9	71
680	-10	73	-18	73	-14	68	-12	71	**709**	-1	23	-7	35	0	24	-7	37
681	-9	79	-4	74	-3	70	-11	63	**710**	1	34	-7	42	-1	36	-8	44
682	-14	86	-10	83	-6	76	-5	70	**711**	1	43	-8	45	-2	42	-11	49
683	-10	73	-9	71	-5	66	-17	75	**712**	0	54	-5	48	-2	52	-10	56
684	-10	70	-9	67	-5	62	-14	72	**713**	-2	55	-12	56	-9	57	-12	59
685	-10	69	-1	61	0	57	-16	67	**714**	0	61	-6	60	-6	63	-8	63
686	-5	66	-8	66	-4	61	-8	53	**715**	1	64	-5	62	-4	65	-9	67
687	-9	64	-14	66	-9	60	-14	59	**716**	0	68	-8	66	-4	67	-6	68
688	-5	58	0	59	1	54	-9	52	**717**	-9	92	-8	76	-7	82	-10	79

Table 9-29– Values of variables m and n for ctxIdx from 718 to 775

ctxIdx	I slices		Value of cabac_init_idc						ctxIdx	I slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
718	-17	120	-4	79	-5	85	-3	78	**747**	2	59	2	59	2	58	-11	68
719	-20	112	-7	71	-6	81	-8	74	**748**	23	-13	9	-2	17	-10	9	-2
720	-18	114	-5	69	-10	77	-9	72	**749**	26	-13	26	-9	32	-13	30	-10
721	-11	85	-9	70	-7	81	-10	72	**750**	40	-15	33	-9	42	-9	31	-4
722	-15	92	-8	66	-17	80	-18	75	**751**	49	-14	39	-7	49	-5	33	-1
723	-14	89	-10	68	-18	73	-12	71	**752**	44	3	41	-2	53	0	33	7
724	-26	71	-19	73	-4	74	-11	63	**753**	45	6	45	3	64	3	31	12
725	-15	81	-12	69	-10	83	-5	70	**754**	44	34	49	9	68	10	37	23
726	-14	80	-16	70	-9	71	-17	75	**755**	33	54	45	27	66	27	31	38
727	0	68	-15	67	-9	67	-14	72	**756**	19	82	36	59	47	57	20	64
728	-14	70	-20	62	-1	61	-16	67	**757**	21	-10	21	-13	17	-10	9	-2
729	-24	56	-19	70	-8	66	-8	53	**758**	24	-11	33	-14	32	-13	30	-10
730	-23	68	-16	66	-14	66	-14	59	**759**	28	-8	39	-7	42	-9	31	-4
731	-24	50	-22	65	0	59	-9	52	**760**	28	-1	46	-2	49	-5	33	-1
732	-11	74	-20	63	2	59	-11	68	**761**	29	3	51	2	53	0	33	7
733	-14	106	-5	85	-3	81	-3	78	**762**	29	9	60	6	64	3	31	12
734	-13	97	-6	81	-3	76	-8	74	**763**	35	20	61	17	68	10	37	23
735	-15	90	-10	77	-7	72	-9	72	**764**	29	36	55	34	66	27	31	38
736	-12	90	-7	81	-6	78	-10	72	**765**	14	67	42	62	47	57	20	64
737	-18	88	-17	80	-12	72	-18	75	**766**	-3	75	-6	66	-5	71	-9	71
738	-10	73	-18	73	-14	68	-12	71	**767**	-1	23	-7	35	0	24	-7	37
739	-9	79	-4	74	-3	70	-11	63	**768**	1	34	-7	42	-1	36	-8	44
740	-14	86	-10	83	-6	76	-5	70	**769**	1	43	-8	45	-2	42	-11	49
741	-10	73	-9	71	-5	66	-17	75	**770**	0	54	-5	48	-2	52	-10	56
742	-10	70	-9	67	-5	62	-14	72	**771**	-2	55	-12	56	-9	57	-12	59
743	-10	69	-1	61	0	57	-16	67	**772**	0	61	-6	60	-6	63	-8	63
744	-5	66	-8	66	-4	61	-8	53	**773**	1	64	-5	62	-4	65	-9	67
745	-9	64	-14	66	-9	60	-14	59	**774**	0	68	-8	66	-4	67	-6	68
746	-5	58	0	59	1	54	-9	52	**775**	-9	92	-8	76	-7	82	-10	79

Table 9-30 – Values of variables m and n for ctxIdx from 776 to 863

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
776	-6	93	-13	106	-21	126	-22	127	**820**	-6	93	-13	106	-21	126	-22	127
777	-6	84	-16	106	-23	124	-25	127	**821**	-6	84	-16	106	-23	124	-25	127
778	-8	79	-10	87	-20	110	-25	120	**822**	-8	79	-10	87	-20	110	-25	120
779	0	66	-21	114	-26	126	-27	127	**823**	0	66	-21	114	-26	126	-27	127
780	-1	71	-18	110	-25	124	-19	114	**824**	-1	71	-18	110	-25	124	-19	114
781	0	62	-14	98	-17	105	-23	117	**825**	0	62	-14	98	-17	105	-23	117
782	-2	60	-22	110	-27	121	-25	118	**826**	-2	60	-22	110	-27	121	-25	118
783	-2	59	-21	106	-27	117	-26	117	**827**	-2	59	-21	106	-27	117	-26	117
784	-5	75	-18	103	-17	102	-24	113	**828**	-5	75	-18	103	-17	102	-24	113
785	-3	62	-21	107	-26	117	-28	118	**829**	-3	62	-21	107	-26	117	-28	118
786	-4	58	-23	108	-27	116	-31	120	**830**	-4	58	-23	108	-27	116	-31	120
787	-9	66	-26	112	-33	122	-37	124	**831**	-9	66	-26	112	-33	122	-37	124
788	-1	79	-10	96	-10	95	-10	94	**832**	-1	79	-10	96	-10	95	-10	94
789	0	71	-12	95	-14	100	-15	102	**833**	0	71	-12	95	-14	100	-15	102
790	3	68	-5	91	-8	95	-10	99	**834**	3	68	-5	91	-8	95	-10	99
791	10	44	-9	93	-17	111	-13	106	**835**	10	44	-9	93	-17	111	-13	106
792	-7	62	-22	94	-28	114	-50	127	**836**	-7	62	-22	94	-28	114	-50	127
793	15	36	-5	86	-6	89	-5	92	**837**	15	36	-5	86	-6	89	-5	92
794	14	40	9	67	-2	80	17	57	**838**	14	40	9	67	-2	80	17	57
795	16	27	-4	80	-4	82	-5	86	**839**	16	27	-4	80	-4	82	-5	86
796	12	29	-10	85	-9	85	-13	94	**840**	12	29	-10	85	-9	85	-13	94
797	1	44	-1	70	-8	81	-12	91	**841**	1	44	-1	70	-8	81	-12	91
798	20	36	7	60	-1	72	-2	77	**842**	20	36	7	60	-1	72	-2	77
799	18	32	9	58	5	64	0	71	**843**	18	32	9	58	5	64	0	71
800	5	42	5	61	1	67	-1	73	**844**	5	42	5	61	1	67	-1	73
801	1	48	12	50	9	56	4	64	**845**	1	48	12	50	9	56	4	64
802	10	62	15	50	0	69	-7	81	**846**	10	62	15	50	0	69	-7	81
803	17	46	18	49	1	69	5	64	**847**	17	46	18	49	1	69	5	64
804	9	64	17	54	7	69	15	57	**848**	9	64	17	54	7	69	15	57
805	-12	104	10	41	-7	69	1	67	**849**	-12	104	10	41	-7	69	1	67
806	-11	97	7	46	-6	67	0	68	**850**	-11	97	7	46	-6	67	0	68

Table 9-30 – Values of variables m and n for ctxIdx from 776 to 863

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
807	-16	96	-1	51	-16	77	-10	67	**851**	-16	96	-1	51	-16	77	-10	67
808	-7	88	7	49	-2	64	1	68	**852**	-7	88	7	49	-2	64	1	68
809	-8	85	8	52	2	61	0	77	**853**	-8	85	8	52	2	61	0	77
810	-7	85	9	41	-6	67	2	64	**854**	-7	85	9	41	-6	67	2	64
811	-9	85	6	47	-3	64	0	68	**855**	-9	85	6	47	-3	64	0	68
812	-13	88	2	55	2	57	-5	78	**856**	-13	88	2	55	2	57	-5	78
813	4	66	13	41	-3	65	7	55	**857**	4	66	13	41	-3	65	7	55
814	-3	77	10	44	-3	66	5	59	**858**	-3	77	10	44	-3	66	5	59
815	-3	76	6	50	0	62	2	65	**859**	-3	76	6	50	0	62	2	65
816	-6	76	5	53	9	51	14	54	**860**	-6	76	5	53	9	51	14	54
817	10	58	13	49	-1	66	15	44	**861**	10	58	13	49	-1	66	15	44
818	-1	76	4	63	-2	71	5	60	**862**	-1	76	4	63	-2	71	5	60
819	-1	83	6	64	-2	75	2	70	**863**	-1	83	6	64	-2	75	2	70

Table 9-31 – Values of variables m and n for ctxIdx from 864 to 951

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
864	15	6	14	11	19	-6	17	-13	**908**	15	6	14	11	19	-6	17	-13
865	6	19	11	14	18	-6	16	-9	**909**	6	19	11	14	18	-6	16	-9
866	7	16	9	11	14	0	17	-12	**910**	7	16	9	11	14	0	17	-12
867	12	14	18	11	26	-12	27	-21	**911**	12	14	18	11	26	-12	27	-21
868	18	13	21	9	31	-16	37	-30	**912**	18	13	21	9	31	-16	37	-30
869	13	11	23	-2	33	-25	41	-40	**913**	13	11	23	-2	33	-25	41	-40
870	13	15	32	-15	33	-22	42	-41	**914**	13	15	32	-15	33	-22	42	-41
871	15	16	32	-15	37	-28	48	-47	**915**	15	16	32	-15	37	-28	48	-47
872	12	23	34	-21	39	-30	39	-32	**916**	12	23	34	-21	39	-30	39	-32
873	13	23	39	-23	42	-30	46	-40	**917**	13	23	39	-23	42	-30	46	-40
874	15	20	42	-33	47	-42	52	-51	**918**	15	20	42	-33	47	-42	52	-51
875	14	26	41	-31	45	-36	46	-41	**919**	14	26	41	-31	45	-36	46	-41
876	14	44	46	-28	49	-34	52	-39	**920**	14	44	46	-28	49	-34	52	-39
877	17	40	38	-12	41	-17	43	-19	**921**	17	40	38	-12	41	-17	43	-19
878	17	47	21	29	32	9	32	11	**922**	17	47	21	29	32	9	32	11
879	24	17	45	-24	69	-71	61	-55	**923**	24	17	45	-24	69	-71	61	-55
880	21	21	53	-45	63	-63	56	-46	**924**	21	21	53	-45	63	-63	56	-46
881	25	22	48	-26	66	-64	62	-50	**925**	25	22	48	-26	66	-64	62	-50
882	31	27	65	-43	77	-74	81	-67	**926**	31	27	65	-43	77	-74	81	-67
883	22	29	43	-19	54	-39	45	-20	**927**	22	29	43	-19	54	-39	45	-20
884	19	35	39	-10	52	-35	35	-2	**928**	19	35	39	-10	52	-35	35	-2
885	14	50	30	9	41	-10	28	15	**929**	14	50	30	9	41	-10	28	15
886	10	57	18	26	36	0	34	1	**930**	10	57	18	26	36	0	34	1
887	7	63	20	27	40	-1	39	1	**931**	7	63	20	27	40	-1	39	1
888	-2	77	0	57	30	14	30	17	**932**	-2	77	0	57	30	14	30	17
889	-4	82	-14	82	28	26	20	38	**933**	-4	82	-14	82	28	26	20	38
890	-3	94	-5	75	23	37	18	45	**934**	-3	94	-5	75	23	37	18	45
891	9	69	-19	97	12	55	15	54	**935**	9	69	-19	97	12	55	15	54
892	-12	109	-35	125	11	65	0	79	**936**	-12	109	-35	125	11	65	0	79
893	36	-35	27	0	37	-33	36	-16	**937**	36	-35	27	0	37	-33	36	-16
894	36	-34	28	0	39	-36	37	-14	**938**	36	-34	28	0	39	-36	37	-14

Table 9-31 – Values of variables m and n for ctxIdx from 864 to 951

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
895	32	-26	31	-4	40	-37	37	-17	**939**	32	-26	31	-4	40	-37	37	-17
896	37	-30	27	6	38	-30	32	1	**940**	37	-30	27	6	38	-30	32	1
897	44	-32	34	8	46	-33	34	15	**941**	44	-32	34	8	46	-33	34	15
898	34	-18	30	10	42	-30	29	15	**942**	34	-18	30	10	42	-30	29	15
899	34	-15	24	22	40	-24	24	25	**943**	34	-15	24	22	40	-24	24	25
900	40	-15	33	19	49	-29	34	22	**944**	40	-15	33	19	49	-29	34	22
901	33	-7	22	32	38	-12	31	16	**945**	33	-7	22	32	38	-12	31	16
902	35	-5	26	31	40	-10	35	18	**946**	35	-5	26	31	40	-10	35	18
903	33	0	21	41	38	-3	31	28	**947**	33	0	21	41	38	-3	31	28
904	38	2	26	44	46	-5	33	41	**948**	38	2	26	44	46	-5	33	41
905	33	13	23	47	31	20	36	28	**949**	33	13	23	47	31	20	36	28
906	23	35	16	65	29	30	27	47	**950**	23	35	16	65	29	30	27	47
907	13	58	14	71	25	44	21	62	**951**	13	58	14	71	25	44	21	62

Table 9-32 – Values of variables m and n for ctxIdx from 952 to 1011

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
952	-3	71	-6	76	-23	112	-24	115	**982**	-3	71	-6	76	-23	112	-24	115
953	-6	42	-2	44	-15	71	-22	82	**983**	-6	42	-2	44	-15	71	-22	82
954	-5	50	0	45	-7	61	-9	62	**984**	-5	50	0	45	-7	61	-9	62
955	-3	54	0	52	0	53	0	53	**985**	-3	54	0	52	0	53	0	53
956	-2	62	-3	64	-5	66	0	59	**986**	-2	62	-3	64	-5	66	0	59
957	0	58	-2	59	-11	77	-14	85	**987**	0	58	-2	59	-11	77	-14	85
958	1	63	-4	70	-9	80	-13	89	**988**	1	63	-4	70	-9	80	-13	89
959	-2	72	-4	75	-9	84	-13	94	**989**	-2	72	-4	75	-9	84	-13	94
960	-1	74	-8	82	-10	87	-11	92	**990**	-1	74	-8	82	-10	87	-11	92
961	-9	91	-17	102	-34	127	-29	127	**991**	-9	91	-17	102	-34	127	-29	127
962	-5	67	-9	77	-21	101	-21	100	**992**	-5	67	-9	77	-21	101	-21	100
963	-5	27	3	24	-3	39	-14	57	**993**	-5	27	3	24	-3	39	-14	57
964	-3	39	0	42	-5	53	-12	67	**994**	-3	39	0	42	-5	53	-12	67
965	-2	44	0	48	-7	61	-11	71	**995**	-2	44	0	48	-7	61	-11	71
966	0	46	0	55	-11	75	-10	77	**996**	0	46	0	55	-11	75	-10	77
967	-16	64	-6	59	-15	77	-21	85	**997**	-16	64	-6	59	-15	77	-21	85
968	-8	68	-7	71	-17	91	-16	88	**998**	-8	68	-7	71	-17	91	-16	88
969	-10	78	-12	83	-25	107	-23	104	**999**	-10	78	-12	83	-25	107	-23	104
970	-6	77	-11	87	-25	111	-15	98	**1000**	-6	77	-11	87	-25	111	-15	98
971	-10	86	-30	119	-28	122	-37	127	**1001**	-10	86	-30	119	-28	122	-37	127
972	-12	92	1	58	-11	76	-10	82	**1002**	-12	92	1	58	-11	76	-10	82
973	-15	55	-3	29	-10	44	-8	48	**1003**	-15	55	-3	29	-10	44	-8	48
974	-10	60	-1	36	-10	52	-8	61	**1004**	-10	60	-1	36	-10	52	-8	61
975	-6	62	1	38	-10	57	-8	66	**1005**	-6	62	1	38	-10	57	-8	66
976	-4	65	2	43	-9	58	-7	70	**1006**	-4	65	2	43	-9	58	-7	70
977	-12	73	-6	55	-16	72	-14	75	**1007**	-12	73	-6	55	-16	72	-14	75
978	-8	76	0	58	-7	69	-10	79	**1008**	-8	76	0	58	-7	69	-10	79
979	-7	80	0	64	-4	69	-9	83	**1009**	-7	80	0	64	-4	69	-9	83
980	-9	88	-3	74	-5	74	-12	92	**1010**	-9	88	-3	74	-5	74	-12	92
981	-17	110	-10	90	-9	86	-18	108	**1011**	-17	110	-10	90	-9	86	-18	108

Table 9-33 – Values of variables m and n for ctxIdx from 1012 to 1023

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	N	m	n
1012	-3	70	-3	74	-2	73	-5	79	**1018**	-10	90	-8	87	-9	91	-11	91
1013	-8	93	-9	92	-12	104	-11	104	**1019**	-30	127	-23	126	-31	127	-30	127
1014	-10	90	-8	87	-9	91	-11	91	**1020**	-3	70	-3	74	-2	73	-5	79
1015	-30	127	-23	126	-31	127	-30	127	**1021**	-8	93	-9	92	-12	104	-11	104
1016	-3	70	-3	74	-2	73	-5	79	**1022**	-10	90	-8	87	-9	91	-11	91
1017	-8	93	-9	92	-12	104	-11	104	**1023**	-30	127	-23	126	-31	127	-30	127

9.3.1.2 Initialisation process for the arithmetic decoding engine

This process is invoked before decoding the first macroblock of a slice or after the decoding of any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data for a macroblock of type I_PCM.

Outputs of this process are the initialised decoding engine registers codIRange and codIOffset both in 16 bit register precision.

The status of the arithmetic decoding engine is represented by the variables codIRange and codIOffset. In the initialisation procedure of the arithmetic decoding process, codIRange is set equal to 0x01FE and codIOffset is set equal to the value returned from read_bits(9) interpreted as a 9 bit binary representation of an unsigned integer with most significant bit written first.

The bitstream shall not contain data that results in a value of codIOffset being equal to 0x01FE or 0x01FF.

NOTE – The description of the arithmetic decoding engine in this Recommendation | International Standard utilizes 16 bit register precision. However, the minimum register precision for the variables codIRange and codIOffset is 9 bits.

9.3.2 Binarization process

Input to this process is a request for a syntax element.

Output of this process is the binarization of the syntax element, maxBinIdxCtx, ctxIdxOffset, and bypassFlag.

Table 9-34 specifies the type of binarization process, maxBinIdxCtx, and ctxIdxOffset associated with each syntax element.

The specification of the unary (U) binarization process, the truncated unary (TU) binarization process, the concatenated unary / k-th order Exp-Golomb (UEGk) binarization process, and the fixed-length (FL) binarization process are given in subclauses 9.3.2.1 to 9.3.2.4, respectively. Other binarizations are specified in subclauses 9.3.2.5 to 9.3.2.7.

Except for I slices, the binarizations for the syntax element mb_type as specified in subclause 9.3.2.5 consist of bin strings given by a concatenation of prefix and suffix bit strings. The UEGk binarization as specified in 9.3.2.3, which is used for the binarization of the syntax elements mvd_lX (X = 0, 1) and coeff_abs_level_minus1, and the binarization of the coded_block_pattern also consist of a concatenation of prefix and suffix bit strings. For these binarization processes, the prefix and the suffix bit string are separately indexed using the binIdx variable as specified further in subclause 9.3.3. The two sets of prefix bit strings and suffix bit strings are referred to as the binarization prefix part and the binarization suffix part, respectively.

Associated with each binarization or binarization part of a syntax element is a specific value of the context index offset (ctxIdxOffset) variable and a specific value of the maxBinIdxCtx variable as given in Table 9-34. When two values for each of these variables are specified for one syntax element in Table 9-34, the value in the upper row is related to the prefix part while the value in the lower row is related to the suffix part of the binarization of the corresponding syntax element.

The use of the DecodeBypass process and the variable bypassFlag is derived as follows.

– If no value is assigned to ctxIdxOffset for the corresponding binarization or binarization part in Table 9-34 labelled as “na”, all bins of the bit strings of the corresponding binarization or of the binarization prefix/suffix part are decoded by invoking the DecodeBypass process as specified in subclause 9.3.3.2.3. In such a case, bypassFlag is

set equal to 1, where bypassFlag is used to indicate that for parsing the value of the bin from the bitstream the DecodeBypass process is applied.

– Otherwise, for each possible value of binIdx up to the specified value of maxBinIdxCtx given in Table 9-34, a specific value of the variable ctxIdx is further specified in subclause 9.3.3. bypassFlag is set equal to 0.

The possible values of the context index ctxIdx are in the range 0 to 1023, inclusive. The value assigned to ctxIdxOffset specifies the lower value of the range of ctxIdx assigned to the corresponding binarization or binarization part of a syntax element.

ctxIdx = ctxIdxOffset = 276 is assigned to the syntax element end_of_slice_flag and the bin of mb_type, which specifies the I_PCM macroblock type as further specified in subclause 9.3.3.1. For parsing the value of the corresponding bin from the bitstream, the arithmetic decoding process for decisions before termination (DecodeTerminate) as specified in subclause 9.3.3.2.4 is applied.

NOTE – The bins of mb_type in I slices and the bins of the suffix for mb_type in SI slices that correspond to the same value of binIdx share the same ctxIdx. The last bin of the prefix of mb_type and the first bin of the suffix of mb_type in P, SP, and B slices may share the same ctxIdx.

Table 9-34 – Syntax elements and associated types of binarization, maxBinIdxCtx, and ctxIdxOffset

Syntax element	Type of binarization	maxBinIdxCtx	ctxIdxOffset
mb_type (SI slices only)	prefix and suffix as specified in subclause 9.3.2.5	prefix: 0 suffix: 6	prefix: 0 suffix: 3
mb_type (I slices only)	as specified in subclause 9.3.2.5	6	3
mb_skip_flag (P, SP slices only)	FL, cMax=1	0	11
mb_type (P, SP slices only)	prefix and suffix as specified in subclause 9.3.2.5	prefix: 2 suffix: 5	prefix: 14 suffix: 17
sub_mb_type (P, SP slices only)	as specified in subclause 9.3.2.5	2	21
mb_skip_flag (B slices only)	FL, cMax=1	0	24
mb_type (B slices only)	prefix and suffix as specified in subclause 9.3.2.5	prefix: 3 suffix: 5	prefix: 27 suffix: 32
sub_mb_type (B slices only)	as specified in subclause 9.3.2.5	3	36
mvd_l0[ ][ ][0], mvd_l1[ ][ ][0]	prefix and suffix as given by UEG3 with signedValFlag=1, uCoff=9	prefix: 4 suffix: na	prefix: 40 suffix: na (uses DecodeBypass)
mvd_l0[ ][ ][1], mvd_l1[ ][ ][1]		prefix: 4 suffix: na	prefix: 47 suffix: na (uses DecodeBypass)
ref_idx_l0, ref_idx_l1	U	2	54
mb_qp_delta	as specified in subclause 9.3.2.7	2	60
intra_chroma_pred_mode	TU, cMax=3	1	64
prev_intra4x4_pred_mode_flag, prev_intra8x8_pred_mode_flag	FL, cMax=1	0	68
rem_intra4x4_pred_mode, rem_intra8x8_pred_mode	FL, cMax=7	0	69
mb_field_decoding_flag	FL, cMax=1	0	70
coded_block_pattern	prefix and suffix as specified in subclause 9.3.2.6	prefix: 3 suffix: 1	prefix: 73 suffix: 77

Table 9-34 – Syntax elements and associated types of binarization, maxBinIdxCtx, and ctxIdxOffset

Syntax element	Type of binarization	maxBinIdxCtx	ctxIdxOffset
coded_block_flag	FL, cMax=1	0	85
significant_coeff_flag (frame coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	105
last_significant_coeff_flag (frame coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	166
coeff_abs_level_minus1 (blocks with ctxBlockCat < 5)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 227 suffix: na, (uses DecodeBypass)
coeff_sign_flag	FL, cMax=1	0	na, (uses DecodeBypass)
end_of_slice_flag	FL, cMax=1	0	276
significant_coeff_flag (field coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	277
last_significant_coeff_flag (field coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	338
transform_size_8x8_flag	FL, cMax=1	0	399
significant_coeff_flag (frame coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	402
last_significant_coeff_flag (frame coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	417
coeff_abs_level_minus1 (blocks with ctxBlockCat = = 5)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 426 suffix: na, (uses DecodeBypass)
significant_coeff_flag (field coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	436
last_significant_coeff_flag (field coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	451
coded_block_flag (5 < ctxBlockCat < 9)	FL, cMax=1	0	460
coded_block_flag (9 < ctxBlockCat < 13)	FL, cMax=1	0	472
coded_block_flag (ctxBlockCat = = 5, 9, or 13)	FL, cMax=1	0	1012
significant_coeff_flag (frame coded blocks with 5 < ctxBlockCat < 9)	FL, cMax=1	0	484
significant_coeff_flag (frame coded blocks with 9 < ctxBlockCat < 13)	FL, cMax=1	0	528
last_significant_coeff_flag (frame coded blocks with 5 < ctxBlockCat < 9)	FL, cMax=1	0	572
last_significant_coeff_flag (frame coded blocks with 9 < ctxBlockCat < 13)	FL, cMax=1	0	616
coeff_abs_level_minus1 (blocks with 5 < ctxBlockCat < 9)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 952 suffix: na, (uses DecodeBypass)
coeff_abs_level_minus1 (blocks with 9 < ctxBlockCat < 13)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 982 suffix: na, (uses DecodeBypass)

Table 9-34 – Syntax elements and associated types of binarization, maxBinIdxCtx, and ctxIdxOffset

Syntax element	Type of binarization	maxBinIdxCtx	ctxIdxOffset
significant_coeff_flag (field coded blocks with 5 < ctxBlockCat < 9)	FL, cMax=1	0	776
significant_coeff_flag (field coded blocks with 9 < ctxBlockCat < 13)	FL, cMax=1	0	820
last_significant_coeff_flag (field coded blocks with 5 < ctxBlockCat < 9)	FL, cMax=1	0	864
last_significant_coeff_flag (field coded blocks with 9 < ctxBlockCat < 13)	FL, cMax=1	0	908
significant_coeff_flag (frame coded blocks with ctxBlockCat = = 9)	FL, cMax=1	0	660
significant_coeff_flag (frame coded blocks with ctxBlockCat = = 13)	FL, cMax=1	0	718
last_significant_coeff_flag (frame coded blocks with ctxBlockCat = = 9)	FL, cMax=1	0	690
last_significant_coeff_flag (frame coded blocks with ctxBlockCat = = 13)	FL, cMax=1	0	748
coeff_abs_level_minus1 (blocks with ctxBlockCat = = 9)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 708 suffix: na, (uses DecodeBypass)
coeff_abs_level_minus1 (blocks with ctxBlockCat = = 13)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 766 suffix: na, (uses DecodeBypass)
significant_coeff_flag (field coded blocks with ctxBlockCat = = 9)	FL, cMax=1	0	675
significant_coeff_flag (field coded blocks with ctxBlockCat = = 13)	FL, cMax=1	0	733
last_significant_coeff_flag (field coded blocks with ctxBlockCat = = 9)	FL, cMax=1	0	699
last_significant_coeff_flag (field coded blocks with ctxBlockCat = = 13)	FL, cMax=1	0	757

9.3.2.1 Unary (U) binarization process

Input to this process is a request for a U binarization for a syntax element.

Output of this process is the U binarization of the syntax element.

The bin string of a syntax element having (unsigned integer) value synElVal is a bit string of length synElVal + 1 indexed by BinIdx. The bins for binIdx less than synElVal are equal to 1. The bin with binIdx equal to synElVal is equal to 0.

Table 9-35 illustrates the bin strings of the unary binarization for a syntax element.

Table 9-35 – Bin string of the unary binarization (informative)

Value of syntax element	Bin string					
0 (I_NxN)	0					
1	1	0				
2	1	1	0			
3	1	1	1	0		
4	1	1	1	1	0	
5	1	1	1	1	1	0
…						
binIdx	0	1	2	3	4	5

9.3.2.2 Truncated unary (TU) binarization process

Input to this process is a request for a TU binarization for a syntax element and cMax.

Output of this process is the TU binarization of the syntax element.

For syntax element (unsigned integer) values less than cMax, the U binarization process as specified in subclause 9.3.2.1 is invoked. For the syntax element value equal to cMax the bin string is a bit string of length cMax with all bins being equal to 1.

NOTE – TU binarization is always invoked with a cMax value equal to the largest possible value of the syntax element being decoded.

9.3.2.3 Concatenated unary/ k-th order Exp-Golomb (UEGk) binarization process

Input to this process is a request for a UEGk binarization for a syntax element, signedValFlag and uCoff.

Output of this process is the UEGk binarization of the syntax element.

A UEGk bin string is a concatenation of a prefix bit string and a suffix bit string. The prefix of the binarization is specified by invoking the TU binarization process for the prefix part Min(uCoff, Abs(synElVal)) of a syntax element value synElVal as specified in subclause 9.3.2.2 with cMax = uCoff, where uCoff > 0.

The UEGk bin string is derived as follows.

- If one of the following is true, the bin string of a syntax element having value synElVal consists only of a prefix bit string,
    - signedValFlag is equal to 0 and the prefix bit string is not equal to the bit string of length uCoff with all bits equal to 1.
    - signedValFlag is equal to 1 and the prefix bit string is equal to the bit string that consists of a single bit with value equal to 0.
- Otherwise, the bin string of the UEGk suffix part of a syntax element value synElVal is specified by a process equivalent to the following pseudo-code:

```
if( Abs( synElVal )  >=  uCoff ) {
    sufS = Abs( synElVal ) − uCoff
    stopLoop = 0
    do {
        if( sufS  >=  ( 1 << k ) ) {
            put( 1 )
            sufS = sufS − ( 1<<k )
            k++
        } else {
            put( 0 )
            while( k− − )
                put( ( sufS >> k )  &  0x01 )
            stopLoop = 1
```

```
        }
    } while( !stopLoop )
}
if( signedValFlag && synElVal != 0)
    if( synElVal > 0 )
        put( 0 )
    else
        put( 1 )
```

NOTE – The specification for the k-th order Exp-Golomb (EGk) code uses 1's and 0's in reverse meaning for the unary part of the Exp-Golomb code of 0-th order as specified in subclause 9.1.

9.3.2.4 Fixed-length (FL) binarization process

Input to this process is a request for a FL binarization for a syntax element and cMax.

Output of this process is the FL binarization of the syntax element.

FL binarization is constructed by using a fixedLength-bit unsigned integer bin string of the syntax element value, where fixedLength = Ceil(Log2(cMax + 1)). The indexing of bins for the FL binarization is such that the binIdx = 0 relates to the least significant bit with increasing values of binIdx towards the most significant bit.

9.3.2.5 Binarization process for macroblock type and sub-macroblock type

Input to this process is a request for a binarization for syntax elements mb_type or sub_mb_type.

Output of this process is the binarization of the syntax element.

The binarization scheme for decoding of macroblock type in I slices is specified in Table 9-36.

For macroblock types in SI slices, the binarization consists of bin strings specified as a concatenation of a prefix and a suffix bit string as follows.

The prefix bit string consists of a single bit, which is specified by b_0 = ((mb_type == SI) ? 0 : 1). For the syntax element value for which b_0 is equal to 0, the bin string only consists of the prefix bit string. For the syntax element value for which b_0 is equal to 1, the binarization is given by concatenating the prefix b_0 and the suffix bit string as specified in Table 9-36 for macroblock type in I slices indexed by subtracting 1 from the value of mb_type in SI slices.

Table 9-36 – Binarization for macroblock types in I slices

Value (name) of mb_type	Bin string						
0 (I_4x4)	0						
1 (I_16x16_0_0_0)	1	0	0	0	0	0	
2 (I_16x16_1_0_0)	1	0	0	0	0	1	
3 (I_16x16_2_0_0)	1	0	0	0	1	0	
4 (I_16x16_3_0_0)	1	0	0	0	1	1	
5 (I_16x16_0_1_0)	1	0	0	1	0	0	0
6 (I_16x16_1_1_0)	1	0	0	1	0	0	1
7 (I_16x16_2_1_0)	1	0	0	1	0	1	0
8 (I_16x16_3_1_0)	1	0	0	1	0	1	1
9 (I_16x16_0_2_0)	1	0	0	1	1	0	0
10 (I_16x16_1_2_0)	1	0	0	1	1	0	1
11 (I_16x16_2_2_0)	1	0	0	1	1	1	0
12 (I_16x16_3_2_0)	1	0	0	1	1	1	1
13 (I_16x16_0_0_1)	1	0	1	0	0	0	
14 (I_16x16_1_0_1)	1	0	1	0	0	1	
15 (I_16x16_2_0_1)	1	0	1	0	1	0	
16 (I_16x16_3_0_1)	1	0	1	0	1	1	
17 (I_16x16_0_1_1)	1	0	1	1	0	0	0
18 (I_16x16_1_1_1)	1	0	1	1	0	0	1
19 (I_16x16_2_1_1)	1	0	1	1	0	1	0
20 (I_16x16_3_1_1)	1	0	1	1	0	1	1
21 (I_16x16_0_2_1)	1	0	1	1	1	0	0
22 (I_16x16_1_2_1)	1	0	1	1	1	0	1
23 (I_16x16_2_2_1)	1	0	1	1	1	1	0
24 (I_16x16_3_2_1)	1	0	1	1	1	1	1
25 (I_PCM)	1	1					
binIdx	0	1	2	3	4	5	6

The binarization schemes for P macroblock types in P and SP slices and for B macroblocks in B slices are specified in Table 9-37.

The bin string for I macroblock types in P and SP slices corresponding to mb_type values 5 to 30 consists of a concatenation of a prefix, which consists of a single bit with value equal to 1 as specified in Table 9-37 and a suffix as specified in Table 9-36, indexed by subtracting 5 from the value of mb_type.

mb_type equal to 4 (P_8x8ref0) is not allowed.

For I macroblock types in B slices (mb_type values 23 to 48) the binarization consists of bin strings specified as a concatenation of a prefix bit string as specified in Table 9-37 and suffix bit strings as specified in Table 9-36, indexed by subtracting 23 from the value of mb_type.

Table 9-37 – Binarization for macroblock types in P, SP, and B slices

Slice type	Value (name) of mb_type	Bin string						
P, SP slice	0 (P_L0_16x16)	0	0	0				
	1 (P_L0_L0_16x8)	0	1	1				
	2 (P_L0_L0_8x16)	0	1	0				
	3 (P_8x8)	0	0	1				
	4 (P_8x8ref0)	na						
	5 to 30 (Intra, prefix only)	1						
B slice	0 (B_Direct_16x16)	0						
	1 (B_L0_16x16)	1	0	0				
	2 (B_L1_16x16)	1	0	1				
	3 (B_Bi_16x16)	1	1	0	0	0	0	
	4 (B_L0_L0_16x8)	1	1	0	0	0	1	
	5 (B_L0_L0_8x16)	1	1	0	0	1	0	
	6 (B_L1_L1_16x8)	1	1	0	0	1	1	
	7 (B_L1_L1_8x16)	1	1	0	1	0	0	
	8 (B_L0_L1_16x8)	1	1	0	1	0	1	
	9 (B_L0_L1_8x16)	1	1	0	1	1	0	
	10 (B_L1_L0_16x8)	1	1	0	1	1	1	
	11 (B_L1_L0_8x16)	1	1	1	1	1	0	
	12 (B_L0_Bi_16x8)	1	1	1	0	0	0	0
	13 (B_L0_Bi_8x16)	1	1	1	0	0	0	1
	14 (B_L1_Bi_16x8)	1	1	1	0	0	1	0
	15 (B_L1_Bi_8x16)	1	1	1	0	0	1	1
	16 (B_Bi_L0_16x8)	1	1	1	0	1	0	0
	17 (B_Bi_L0_8x16)	1	1	1	0	1	0	1
	18 (B_Bi_L1_16x8)	1	1	1	0	1	1	0
	19 (B_Bi_L1_8x16)	1	1	1	0	1	1	1
	20 (B_Bi_Bi_16x8)	1	1	1	1	0	0	0
	21 (B_Bi_Bi_8x16)	1	1	1	1	0	0	1
	22 (B_8x8)	1	1	1	1	1	1	
	23 to 48 (Intra, prefix only)	1	1	1	1	0	1	
binIdx		0	1	2	3	4	5	6

For P, SP, and B slices the specification of the binarization for sub_mb_type is given in Table 9-38.

Table 9-38 – Binarization for sub-macroblock types in P, SP, and B slices

Slice type	Value (name) of sub_mb_type	Bin string					
P, SP slice	0 (P_L0_8x8)	1					
	1 (P_L0_8x4)	0	0				
	2 (P_L0_4x8)	0	1	1			
	3 (P_L0_4x4)	0	1	0			
B slice	0 (B_Direct_8x8)	0					
	1 (B_L0_8x8)	1	0	0			
	2 (B_L1_8x8)	1	0	1			
	3 (B_Bi_8x8)	1	1	0	0	0	
	4 (B_L0_8x4)	1	1	0	0	1	
	5 (B_L0_4x8)	1	1	0	1	0	
	6 (B_L1_8x4)	1	1	0	1	1	
	7 (B_L1_4x8)	1	1	1	0	0	0
	8 (B_Bi_8x4)	1	1	1	0	0	1
	9 (B_Bi_4x8)	1	1	1	0	1	0
	10 (B_L0_4x4)	1	1	1	0	1	1
	11 (B_L1_4x4)	1	1	1	1	0	
	12 (B_Bi_4x4)	1	1	1	1	1	
binIdx		0	1	2	3	4	5

9.3.2.6 Binarization process for coded block pattern

Input to this process is a request for a binarization for the syntax element coded_block_pattern.

Output of this process is the binarization of the syntax element.

The binarization of coded_block_pattern consists of a prefix part and (when present) a suffix part. The prefix part of the binarization is given by the FL binarization of CodedBlockPatternLuma with cMax = 15. When ChromaArrayType is not equal to 0 or 3, the suffix part is present and consists of the TU binarization of CodedBlockPatternChroma with cMax = 2. The relationship between the value of the syntax element coded_block_pattern and the values of CodedBlockPatternLuma and CodedBlockPatternChroma is given as specified in subclause 7.4.5.

9.3.2.7 Binarization process for mb_qp_delta

Input to this process is a request for a binarization for the syntax element mb_qp_delta.

Output of this process is the binarization of the syntax element.

The bin string of mb_qp_delta is derived by the U binarization of the mapped value of the syntax element mb_qp_delta, where the assignment rule between the signed value of mb_qp_delta and its mapped value is given as specified in Table 9-3.

9.3.3 Decoding process flow

Input to this process is a binarization of the requested syntax element, maxBinIdxCtx, bypassFlag and ctxIdxOffset as specified in subclause 9.3.2.

Output of this process is the value of the syntax element.

This process specifies how each bit of a bit string is parsed for each syntax element.

After parsing each bit, the resulting bit string is compared to all bin strings of the binarization of the syntax element and the following applies.

– If the bit string is equal to one of the bin strings, the corresponding value of the syntax element is the output.

– Otherwise (the bit string is not equal to one of the bin strings), the next bit is parsed.

While parsing each bin, the variable binIdx is incremented by 1 starting with binIdx being set equal to 0 for the first bin.

When the binarization of the corresponding syntax element consists of a prefix and a suffix binarization part,, the variable binIdx is set equal to 0 for the first bin of each part of the bin string (prefix part or suffix part). In this case, after parsing the prefix bit string, the parsing process of the suffix bit string related to the binarizations specified in subclauses 9.3.2.3 and 9.3.2.5 is invoked depending on the resulting prefix bit string as specified in subclauses 9.3.2.3 and 9.3.2.5. Note that for the binarization of the syntax element coded_block_pattern, the suffix bit string is present regardless of the prefix bit string of length 4 as specified in subclause 9.3.2.6.

Depending on the variable bypassFlag, the following applies.

– If bypassFlag is equal to 1, the bypass decoding process as specified in subclause 9.3.3.2.3 is applied for parsing the value of the bins from the bitstream.

– Otherwise (bypassFlag is equal to 0), the parsing of each bin is specified by the following two ordered steps:

1. Given binIdx, maxBinIdxCtx and ctxIdxOffset, ctxIdx is derived as specified in subclause 9.3.3.1.

2. Given ctxIdx, the value of the bin from the bitstream as specified in subclause 9.3.3.2 is decoded.

9.3.3.1 Derivation process for ctxIdx

Inputs to this process are binIdx, maxBinIdxCtx and ctxIdxOffset.

Output of this process is ctxIdx.

Table 9-39 shows the assignment of ctxIdx increments (ctxIdxInc) to binIdx for all ctxIdxOffset values except those related to the syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1.

The ctxIdx to be used with a specific binIdx is specified by first determining the ctxIdxOffset associated with the given bin string or part thereof. The ctxIdx is determined as follows.

– If the ctxIdxOffset is listed in Table 9-39, the ctxIdx for a binIdx is the sum of ctxIdxOffset and ctxIdxInc, which is found in Table 9-39. When more than one value is listed in Table 9-39 for a binIdx, the assignment process for ctxIdxInc for that binIdx is further specified in the subclauses given in parenthesis of the corresponding table entry.

– Otherwise (ctxIdxOffset is not listed in Table 9-39), the ctxIdx is specified to be the sum of the following terms: ctxIdxOffset and ctxIdxBlockCatOffset(ctxBlockCat) as specified in Table 9-40 and ctxIdxInc(ctxBlockCat). Subclause 9.3.3.1.3 specifies which ctxBlockCat is used. Subclause 9.3.3.1.1.9 specifies the assignment of ctxIdxInc(ctxBlockCat) for coded_block_flag, and subclause 9.3.3.1.3 specifies the assignment of ctxIdxInc(ctxBlockCat) for significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1.

All bins with binIdx greater than maxBinIdxCtx are parsed using the value of ctxIdx being assigned to binIdx equal to maxBinIdxCtx.

All entries in Table 9-39 labelled with “na” correspond to values of binIdx that do not occur for the corresponding ctxIdxOffset.

ctxIdx = 276 is assigned to the binIdx of mb_type indicating the I_PCM mode. For parsing the value of the corresponding bins from the bitstream, the arithmetic decoding process for decisions before termination as specified in subclause 9.3.3.2.4 is applied.

Table 9-39 – Assignment of ctxIdxInc to binIdx for all ctxIdxOffset values except those related to the syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1

ctxIdxOffset	binIdx						
	0	**1**	**2**	**3**	**4**	**5**	**>= 6**
0	0,1,2 (subclause 9.3.3.1.1.3)	na	na	na	na	na	na
3	0,1,2 (subclause 9.3.3.1.1.3)	ctxIdx=276	3	4	5,6 (subclause 9.3.3.1.2)	6,7 (subclause 9.3.3.1.2)	7
11	0,1,2 (subclause 9.3.3.1.1.1)	na	na	na	na	na	na
14	0	1	2,3 (subclause 9.3.3.1.2)	na	na	na	na
17	0	ctxIdx=276	1	2	2,3 (subclause 9.3.3.1.2)	3	3
21	0	1	2	na	na	na	na
24	0,1,2 (subclause 9.3.3.1.1.1)	na	na	na	na	na	na
27	0,1,2 (subclause 9.3.3.1.1.3)	3	4,5 (subclause 9.3.3.1.2)	5	5	5	5
32	0	ctxIdx=276	1	2	2,3 (subclause 9.3.3.1.2)	3	3
36	0	1	2,3 (subclause 9.3.3.1.2)	3	3	3	na
40	0,1,2 (subclause 9.3.3.1.1.7)	3	4	5	6	6	6
47	0,1,2 (subclause 9.3.3.1.1.7)	3	4	5	6	6	6
54	0,1,2,3 (subclause 9.3.3.1.1.6)	4	5	5	5	5	5
60	0,1 (subclause 9.3.3.1.1.5)	2	3	3	3	3	3
64	0,1,2 (subclause 9.3.3.1.1.8)	3	3	na	na	na	na
68	0	na	na	na	na	na	na
69	0	0	0	na	na	na	na
70	0,1,2 (subclause 9.3.3.1.1.2)	na	na	na	na	na	na
73	0,1,2,3 (subclause 9.3.3.1.1.4)	0,1,2,3 (subclause 9.3.3.1.1.4)	0,1,2,3 (subclause 9.3.3.1.1.4)	0,1,2,3 (subclause 9.3.3.1.1.4)	na	na	na
77	0,1,2,3 (subclause 9.3.3.1.1.4)	4,5,6,7 (subclause 9.3.3.1.1.4)	na	na	na	na	na
276	0	na	na	na	na	na	na
399	0,1,2 (subclause 9.3.3.1.1.10)	na	na	na	na	na	na

Table 9-40 shows the values of ctxIdxBlockCatOffset depending on ctxBlockCat for the syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1. The specification of ctxBlockCat is given in Table 9-42.

Table 9-40 – Assignment of ctxIdxBlockCatOffset to ctxBlockCat for syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1

Syntax element	ctxBlockCat (as specified in Table 9-42)													
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
coded_block_flag	0	4	8	12	16	0	0	4	8	4	0	4	8	8
significant_coeff_flag	0	15	29	44	47	0	0	15	29	0	0	15	29	0
last_significant_coeff_flag	0	15	29	44	47	0	0	15	29	0	0	15	29	0
coeff_abs_level_minus1	0	10	20	30	39	0	0	10	20	0	0	10	20	0

9.3.3.1.1 Assignment process of ctxIdxInc using neighbouring syntax elements

Subclause 9.3.3.1.1.1 specifies the derivation process of ctxIdxInc for the syntax element mb_skip_flag.

Subclause 9.3.3.1.1.2 specifies the derivation process of ctxIdxInc for the syntax element mb_field_decoding_flag.

Subclause 9.3.3.1.1.3 specifies the derivation process of ctxIdxInc for the syntax element mb_type.

Subclause 9.3.3.1.1.4 specifies the derivation process of ctxIdxInc for the syntax element coded_block_pattern.

Subclause 9.3.3.1.1.5 specifies the derivation process of ctxIdxInc for the syntax element mb_qp_delta.

Subclause 9.3.3.1.1.6 specifies the derivation process of ctxIdxInc for the syntax elements ref_idx_l0 and ref_idx_l1.

Subclause 9.3.3.1.1.7 specifies the derivation process of ctxIdxInc for the syntax elements mvd_l0 and mvd_l1.

Subclause 9.3.3.1.1.8 specifies the derivation process of ctxIdxInc for the syntax element intra_chroma_pred_mode.

Subclause 9.3.3.1.1.9 specifies the derivation process of ctxIdxInc for the syntax element coded_block_flag.

Subclause 9.3.3.1.1.10 specifies the derivation process of ctxIdxInc for the syntax element transform_size_8x8_flag.

9.3.3.1.1.1 Derivation process of ctxIdxInc for the syntax element mb_skip_flag

Output of this process is ctxIdxInc.

When MbaffFrameFlag is equal to 1 and mb_field_decoding_flag has not been decoded (yet) for the current macroblock pair with top macroblock address 2 * (CurrMbAddr / 2), the inference rule for the syntax element mb_field_decoding_flag as specified in subclause 7.4.4 is applied.

The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If mbAddrN is not available or mb_skip_flag for the macroblock mbAddrN is equal to 1, condTermFlagN is set equal to 0.

– Otherwise (mbAddrN is available and mb_skip_flag for the macroblock mbAddrN is equal to 0), condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad (9\text{-}1)$$

9.3.3.1.1.2 Derivation process of ctxIdxInc for the syntax element mb_field_decoding_flag

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblock addresses and their availability in MBAFF frames as specified in subclause 6.4.9 is invoked and the output is assigned to mbAddrA and mbAddrB.

When both macroblocks mbAddrN and mbAddrN + 1 have mb_type equal to P_Skip or B_Skip, the inference rule for the syntax element mb_field_decoding_flag as specified in subclause 7.4.4 is applied for the macroblock mbAddrN.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0,
  – mbAddrN is not available,
  – the macroblock mbAddrN is a frame macroblock.
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad (9\text{-}2)$$

9.3.3.1.1.3 Derivation process of ctxIdxInc for the syntax element mb_type

Input to this process is ctxIdxOffset.

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0,
  – mbAddrN is not available,
  – ctxIdxOffset is equal to 0 and mb_type for the macroblock mbAddrN is equal to SI,
  – ctxIdxOffset is equal to 3 and mb_type for the macroblock mbAddrN is equal to I_NxN,
  – ctxIdxOffset is equal to 27 and mb_type for the macroblock mbAddrN is equal to P_Skip, B_Skip, or B_Direct_16x16.
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived as

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad (9\text{-}3)$$

9.3.3.1.1.4 Derivation process of ctxIdxInc for the syntax element coded_block_pattern

Inputs to this process are ctxIdxOffset and binIdx.

Output of this process is ctxIdxInc.

Depending on the value of the variable ctxIdxOffset, the following applies.

– If ctxIdxOffset is equal to 73, the following applies,
  – The derivation process for neighbouring 8x8 luma blocks specified in subclause 6.4.10.2 is invoked with luma8x8BlkIdx = binIdx as input and the output is assigned to mbAddrA, mbAddrB, luma8x8BlkIdxA, and luma8x8BlkIdxB.
  – Let the variable condTermFlagN (with N being either A or B) be derived as follows.
    – If any of the following conditions are true, condTermFlagN is set equal to 0,
      – mbAddrN is not available,
      – mb_type for the macroblock mbAddrN is equal to I_PCM,
      – the macroblock mbAddrN is not the current macroblock CurrMbAddr and the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, and

((CodedBlockPatternLuma >> luma8x8BlkIdxN) & 1) is not equal to 0 for the value of CodedBlockPatternLuma for the macroblock mbAddrN.

– the macroblock mbAddrN is the current macroblock CurrMbAddr and the prior decoded bin value b_k of coded_block_pattern with k = luma8x8BlkIdxN is not equal to 0.

– Otherwise, condTermFlagN is set equal to 1.

– The variable ctxIdxInc is derived as

$$ctxIdxInc = condTermFlagA + 2 * condTermFlagB \quad (9\text{-}4)$$

– Otherwise (ctxIdxOffset is equal to 77), the following applies.

– The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

– Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If mbAddrN is available and mb_type for the macroblock mbAddrN is equal to I_PCM, condTermFlagN is set equal to 1,

– Otherwise, if any of the following conditions is true, condTermFlagN is set equal to 0,

– mbAddrN is not available or the macroblock mbAddrN has mb_type equal to P_Skip or B_Skip,

– binIdx is equal to 0 and CodedBlockPatternChroma for the macroblock mbAddrN is equal to 0,

– binIdx is equal to 1 and CodedBlockPatternChroma for the macroblock mbAddrN is not equal to 2.

– Otherwise, condTermFlagN is set equal to 1.

– The variable ctxIdxInc is derived as

$$ctxIdxInc = condTermFlagA + 2 * condTermFlagB + ((binIdx == 1) ? 4 : 0) \quad (9\text{-}5)$$

NOTE – When a macroblock uses an Intra_16x16 prediction mode, the values of CodedBlockPatternLuma and CodedBlockPatternChroma for the macroblock are derived from mb_type as specified in Table 7-11.

9.3.3.1.1.5 Derivation process of ctxIdxInc for the syntax element mb_qp_delta

Output of this process is ctxIdxInc.

Let prevMbAddr be the macroblock address of the macroblock that precedes the current macroblock in decoding order. When the current macroblock is the first macroblock of a slice, prevMbAddr is marked as not available.

Let the variable ctxIdxInc be derived as follows.

– If any of the following conditions is true, ctxIdxInc is set equal to 0,

– prevMbAddr is not available or the macroblock prevMbAddr has mb_type equal to P_Skip or B_Skip,

– mb_type of the macroblock prevMbAddr is equal to I_PCM,

– The macroblock prevMbAddr is not coded in Intra_16x16 prediction mode and both CodedBlockPatternLuma and CodedBlockPatternChroma for the macroblock prevMbAddr are equal to 0,

– mb_qp_delta for the macroblock prevMbAddr is equal to 0,

– Otherwise, ctxIdxInc is set equal to 1.

9.3.3.1.1.6 Derivation process of ctxIdxInc for the syntax elements ref_idx_l0 and ref_idx_l1

Input to this process is mbPartIdx.

Output of this process is ctxIdxInc.

The interpretation of ref_idx_lX and Pred_LX within this subclause is specified as follows.

– If this process is invoked for the derivation of ref_idx_l0, ref_idx_lX is interpreted as ref_idx_l0 and Pred_LX is interpreted as Pred_L0.

– Otherwise (this process is invoked for the derivation of ref_idx_l1), ref_idx_lX is interpreted as ref_idx_l1 and Pred_LX is interpreted as Pred_L1.

The derivation process for neighbouring partitions specified in subclause 6.4.10.7 is invoked with mbPartIdx, currSubMbType, and subMbPartIdx = 0 as input and the output is assigned to mbAddrA\mbPartIdxA and mbAddrB\mbPartIdxB.

With ref_idx_lX[mbPartIdxN] (with N being either A or B) specifying the syntax element for the macroblock mbAddrN, let the variable refIdxZeroFlagN be derived as follows.

– If MbaffFrameFlag is equal to 1, the current macroblock is a frame macroblock, and the macroblock mbAddrN is a field macroblock

$$refIdxZeroFlagN = ((ref\_idx\_lX[mbPartIdxN] > 1) ? 0 : 1) \quad (9\text{-}6)$$

– Otherwise,

$$refIdxZeroFlagN = ((ref\_idx\_lX[mbPartIdxN] > 0) ? 0 : 1) \quad (9\text{-}7)$$

Let the variable predModeEqualFlagN be specified as follows.

– If the macroblock mbAddrN has mb_type equal to P_8x8 or B_8x8, the following applies.
  – If SubMbPredMode(sub_mb_type[mbPartIdxN]) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where sub_mb_type specifies the syntax element for the macroblock mbAddrN.
  – Otherwise, predModeEqualFlagN is set equal to 1.
– Otherwise, the following applies.
  – If MbPartPredMode(mb_type, mbPartIdxN) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where mb_type specifies the syntax element for the macroblock mbAddrN.
  – Otherwise, predModeEqualFlagN is set equal to 1.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0,
  – mbAddrN is not available,
  – the macroblock mbAddrN has mb_type equal to P_Skip or B_Skip,
  – the macroblock mbAddrN is coded in Intra prediction mode,
  – predModeEqualFlagN is equal to 0,
  – refIdxZeroFlagN is equal to 1.
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived as

$$ctxIdxInc = condTermFlagA + 2 * condTermFlagB \quad (9\text{-}8)$$

9.3.3.1.1.7 Derivation process of ctxIdxInc for the syntax elements mvd_l0 and mvd_l1

Inputs to this process are mbPartIdx, subMbPartIdx, and ctxIdxOffset.

Output of this process is ctxIdxInc.

The interpretation of mvd_lX and Pred_LX within this subclause is specified as follows.

– If this process is invoked for the derivation of mvd_l0, mvd_lX is interpreted as mvd_l0 and Pred_LX is interpreted as Pred_L0.
– Otherwise (this process is invoked for the derivation of mvd_l1), mvd_lX is interpreted as mvd_l1 and Pred_LX is interpreted as Pred_L1.

Let currSubMbType be set equal to sub_mb_type[mbPartIdx].

The derivation process for neighbouring partitions specified in subclause 6.4.10.7 is invoked with mbPartIdx, currSubMbType, and subMbPartIdx as input and the output is assigned to mbAddrA\mbPartIdxA\subMbPartIdxA and mbAddrB\mbPartIdxB\subMbPartIdxB.

Let the variable compIdx be derived as follows.

– If ctxIdxOffset is equal to 40, compIdx is set equal to 0.

– Otherwise (ctxIdxOffset is equal to 47), compIdx is set equal to 1.

Let the variable predModeEqualFlagN be specified as follows.

– If the macroblock mbAddrN has mb_type equal to P_8x8 or B_8x8, the following applies.

  – If SubMbPredMode(sub_mb_type[mbPartIdxN]) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where sub_mb_type specifies the syntax element for the macroblock mbAddrN.

  – Otherwise, predModeEqualFlagN is set equal to 1.

– Otherwise, the following applies.

  – If MbPartPredMode(mb_type, mbPartIdxN) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where mb_type specifies the syntax element for the macroblock mbAddrN.

  – Otherwise, predModeEqualFlagN is set equal to 1.

Let the variable absMvdCompN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, absMvdCompN is set equal to 0.

  – mbAddrN is not available,

  – the macroblock mbAddrN has mb_type equal to P_Skip or B_Skip,

  – the macroblock mbAddrN is coded in an Intra prediction mode,

  – predModeEqualFlagN is equal to 0.

– Otherwise, the following applies.

  – If compIdx is equal to 1, MbaffFrameFlag is equal to 1, the current macroblock is a frame macroblock, and the macroblock mbAddrN is a field macroblock

$$absMvdCompN = Abs(mvd\_lX[mbPartIdxN][subMbPartIdxN][compIdx]) * 2 \quad (9\text{-}9)$$

  – Otherwise, if compIdx is equal to 1, MbaffFrameFlag is equal to 1, the current macroblock is a field macroblock, and the macroblock mbAddrN is a frame macroblock

$$absMvdCompN = Abs(mvd\_lX[mbPartIdxN][subMbPartIdxN][compIdx]) / 2 \quad (9\text{-}10)$$

  – Otherwise,

$$absMvdCompN = Abs(mvd\_lX[mbPartIdxN][subMbPartIdxN][compIdx]) \quad (9\text{-}11)$$

The variable ctxIdxInc is derived as follows.

– If (absMvdCompA + absMvdCompB) is less than 3, ctxIdxInc is set equal to 0.

– Otherwise, if (absMvdCompA + absMvdCompB) is greater than 32, ctxIdxInc is set equal to 2.

– Otherwise ((absMvdCompA + absMvdCompB) is in the range of 3 to 32, inclusive), ctxIdxInc is set equal to 1.

9.3.3.1.1.8 Derivation process of ctxIdxInc for the syntax element intra_chroma_pred_mode

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being replaced by either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0.
  – mbAddrN is not available,
  – The macroblock mbAddrN is coded in Inter prediction mode,
  – mb_type for the macroblock mbAddrN is equal to I_PCM,
  – intra_chroma_pred_mode for the macroblock mbAddrN is equal to 0.
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad (9\text{-}12)$$

9.3.3.1.1.9 Derivation process of ctxIdxInc for the syntax element coded_block_flag

Input to this process is ctxBlockCat and additional input is specified as follows.

– If ctxBlockCat is equal to 0, 6, or 10, no additional input.
– Otherwise, if ctxBlockCat is equal to 1 or 2, luma4x4BlkIdx.
– Otherwise, if ctxBlockCat is equal to 3, the chroma component index iCbCr.
– Otherwise, if ctxBlockCat is equal to 4, chroma4x4BlkIdx and the chroma component index iCbCr.
– Otherwise, if ctxBlockCat is equal to 5, luma8x8BlkIdx.
– Otherwise, if ctxBlockCat is equal to 7 or 8, cb4x4BlkIdx.
– Otherwise, if ctxBlockCat is equal to 9, cb8x8BlkIdx.
– Otherwise, if ctxBlockCat is equal to 11 or 12, cr4x4BlkIdx.
– Otherwise (ctxBlockCat is equal to 13), cr8x8BlkIdx.

Output of this process is ctxIdxInc(ctxBlockCat).

Let the variable transBlockN (with N being either A or B) be derived as follows.

– If ctxBlockCat is equal to 0, 6, or 10, the following applies.
  – The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrN (with N being either A or B).
  – The variable transBlockN is derived as follows.
  – If mbAddrN is available and the macroblock mbAddrN is coded in Intra_16x16 prediction mode, the following applies.
    – If ctxBlockCat is equal to 0, the luma DC block of macroblock mbAddrN is assigned to transBlockN.
    – Otherwise, if ctxBlockCat is equal to 6, the Cb DC block of macroblock mbAddrN is assigned to transBlockN.
    – Otherwise (ctxBlockCat is equal to 10), the Cr DC block of macroblock mbAddrN is assigned to transBlockN.
  – Otherwise, transBlockN is marked as not available.
– Otherwise, if ctxBlockCat is equal to 1 or 2, the following applies.
  – The derivation process for neighbouring 4x4 luma blocks specified in subclause 6.4.10.4 is invoked with luma4x4BlkIdx as input and the output is assigned to mbAddrN, luma4x4BlkIdxN (with N being either A or B).
  – The variable transBlockN is derived as follows.
    – If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ((CodedBlockPatternLuma >> (luma4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 0 for the macroblock mbAddrN, the 4x4 luma block with index luma4x4BlkIdxN of macroblock mbAddrN is assigned to transBlockN.

– Otherwise, if mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, ((CodedBlockPatternLuma >> (luma4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 luma block with index (luma4x4BlkIdxN >> 2) of macroblock mbAddrN is assigned to transBlockN.

– Otherwise, transBlockN is marked as not available.

– Otherwise, if ctxBlockCat is equal to 3, the following applies.

– The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrN (with N being either A or B).

– The variable transBlockN is derived as follows.

– If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, and CodedBlockPatternChroma is not equal to 0 for the macroblock mbAddrN, the chroma DC block of chroma component iCbCr of macroblock mbAddrN is assigned to transBlockN.

– Otherwise, transBlockN is marked as not available.

– Otherwise, if ctxBlockCat is equal to 4, the following applies.

– The derivation process for neighbouring 4x4 chroma blocks specified in subclause 6.4.10.5 is invoked with chroma4x4BlkIdx as input and the output is assigned to mbAddrN, chroma4x4BlkIdxN (with N being either A or B).

– The variable transBlockN is derived as follows.

– If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, and CodedBlockPatternChroma is equal to 2 for the macroblock mbAddrN, the 4x4 chroma block with chroma4x4BlkIdxN of the chroma component iCbCr of macroblock mbAddrN is assigned to transBlockN.

– Otherwise, transBlockN is marked as not available.

– Otherwise, if ctxBlockCat is equal to 5, the following applies.

– The derivation process for neighbouring 8x8 luma blocks specified in subclause 6.4.10.2 is invoked with luma8x8BlkIdx as input and the output is assigned to mbAddrN, luma8x8BlkIdxN (with N being either A or B).

– The variable transBlockN is derived as follows.

– If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ((CodedBlockPatternLuma >>luma8x8BlkIdx) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 luma block with index luma8x8BlkIdxN of macroblock mbAddrN is assigned to transBlockN.

– Otherwise, transBlockN is marked as not available.

– Otherwise, if ctxBlockCat is equal to7 or 8, the following applies.

– The derivation process for neighbouring 4x4 Cb blocks specified in subclause 6.4.10.5 is invoked with cb4x4BlkIdx as input and the output is assigned to mbAddrN, cb4x4BlkIdxN (with N being either A or B).

– The variable transBlockN is derived as follows.

– If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ((CodedBlockPatternLuma >> (cb4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 0 for the macroblock mbAddrN, the 4x4 Cb block with index cb4x4BlkIdxN of macroblock mbAddrN is assigned to transBlockN.

– Otherwise, if mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, ((CodedBlockPatternLuma >> (cb4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cb block with index (cb4x4BlkIdxN >> 2) of macroblock mbAddrN is assigned to transBlockN.

– Otherwise, transBlockN is marked as not available.

– Otherwise, if ctxBlockCat is equal to 9, the following applies.

– The derivation process for neighbouring 8x8 Cb blocks specified in subclause 6.4.10.3 is invoked with cb8x8BlkIdx as input and the output is assigned to mbAddrN, cb8x8BlkIdxN (with N being either A or B).

– The variable transBlockN is derived as follows.

  – If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ((CodedBlockPatternLuma >>cb8x8BlkIdx) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cb block with index cb8x8BlkIdxN of macroblock mbAddrN is assigned to transBlockN.

  – Otherwise, transBlockN is marked as not available.

– Otherwise, if ctxBlockCat is equal to 11 or 12, the following applies.

  – The derivation process for neighbouring 4x4 Cr blocks specified in subclause 6.4.10.5 is invoked with cr4x4BlkIdx as input and the output is assigned to mbAddrN, cr4x4BlkIdxN (with N being either A or B).

  – The variable transBlockN is derived as follows.

    – If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ((CodedBlockPatternLuma >> (cr4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 0 for the macroblock mbAddrN, the 4x4 Cr block with index cr4x4BlkIdxN of macroblock mbAddrN is assigned to transBlockN.

    – Otherwise, if mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, ((CodedBlockPatternLuma >> (cr4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cr block with index (cr4x4BlkIdxN >> 2) of macroblock mbAddrN is assigned to transBlockN.

    – Otherwise, transBlockN is marked as not available.

– Otherwise (ctxBlockCat is equal to 13), the following applies.

  – The derivation process for neighbouring 8x8 Cr blocks specified in subclause 6.4.10.3 is invoked with cr8x8BlkIdx as input and the output is assigned to mbAddrN, cr8x8BlkIdxN (with N being either A or B).

  – The variable transBlockN is derived as follows.

    – If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM,, ((CodedBlockPatternLuma >>cr8x8BlkIdx) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cr block with index cr8x8BlkIdxN of macroblock mbAddrN is assigned to transBlockN.

    – Otherwise, transBlockN is marked as not available.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0.

  – mbAddrN is not available and the current macroblock is coded in Inter prediction mode.

  – mbAddrN is available and transBlockN is not available and mb_type for the macroblock mbAddrN is not equal to I_PCM.

  – The current macroblock is coded in Intra prediction mode, constrained_intra_pred_flag is equal to 1, the macroblock mbAddrN is available and coded in Inter prediction mode, and slice data partitioning is in use (nal_unit_type is in the range of 2 through 4, inclusive).

– Otherwise, if any of the following conditions is true, condTermFlagN is set equal to 1.

  – mbAddrN is not available and the current macroblock is coded in Intra prediction mode.

  – mb_type for the macroblock mbAddrN is equal to I_PCM.

– Otherwise, condTermFlagN is set equal to the value of the coded_block_flag of the transform block transBlockN that was decoded for the macroblock mbAddrN.

The variable ctxIdxInc(ctxBlockCat) is derived by

$$ctxIdxInc(ctxBlockCat) = condTermFlagA + 2 * condTermFlagB \quad (9\text{-}13)$$

9.3.3.1.1.10 Derivation process of ctxIdxInc for the syntax element transform_size_8x8_flag

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0.
  – mbAddrN is not available,
  – transform_size_8x8_flag for the macroblock mbAddrN is equal to 0.
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad (9\text{-}14)$$

9.3.3.1.2 Assignment process of ctxIdxInc using prior decoded bin values

Inputs to this process are ctxIdxOffset and binIdx.

Output of this process is ctxIdxInc.

Table 9-41 contains the specification of ctxIdxInc for the given values of ctxIdxOffset and binIdx.

For each value of ctxIdxOffset and binIdx, ctxIdxInc is derived by using some of the values of prior decoded bin values (b_0, b_1, b_2,…, b_k), where the value of the index k is less than the value of binIdx.

Table 9-41 – Specification of ctxIdxInc for specific values of ctxIdxOffset and binIdx

Value (name) of ctxIdxOffset	binIdx	ctxIdxInc
3	4	(b_3 != 0) ? 5: 6
	5	(b_3 != 0) ? 6: 7
14	2	(b_1 != 1) ? 2: 3
17	4	(b_3 != 0) ? 2: 3
27	2	(b_1 != 0) ? 4: 5
32	4	(b_3 != 0) ? 2: 3
36	2	(b_1 != 0) ? 2: 3

9.3.3.1.3 Assignment process of ctxIdxInc for syntax elements significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1

Inputs to this process are ctxIdxOffset and binIdx.

Output of this process is ctxIdxInc.

The assignment process of ctxIdxInc for syntax elements significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1 as well as for coded_block_flag depends on categories of different blocks denoted by the variable ctxBlockCat. The specification of these block categories is given in Table 9-42.

Table 9-42 – Specification of ctxBlockCat for the different blocks

Block description	maxNumCoeff	ctxBlockCat
block of luma DC transform coefficient levels (i.e., list Intra16x16DCLevel as described in subclause 7.4.5.3)	16	0
block of luma AC transform coefficient levels (i.e., list Intra16x16ACLevel[i] as described in subclause 7.4.5.3)	15	1
block of 16 luma transform coefficient levels (i.e., list LumaLevel[i] as described in subclause 7.4.5.3)	16	2
block of chroma DC transform coefficient levels when ChromaArrayType is equal to 1 or 2 (i.e., list ChromaDCLevel as described in subclause 7.4.5.3)	4 * NumC8x8	3
block of chroma AC transform coefficient levels when ChromaArrayType is equal to 1 or 2 (i.e., list ChromaACLevel as described in subclause 7.4.5.3)	15	4
block of 64 luma transform coefficient levels (i.e., list LumaLevel8x8[i] as described in subclause 7.4.5.3)	64	5
block of Cb DC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbIntra16x16DCLevel as described in subclause 7.4.5.3)	16	6
block of Cb AC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbIntra16x16ACLevel[i] as described in subclause 7.4.5.3)	15	7
block of 16 Cb transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbLevel[i] as described in subclause 7.4.5.3)	16	8
block of 64 Cb transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbLevel8x8[i] as described in subclause 7.4.5.3)	64	9
block of Cr DC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrIntra16x16DCLevel as described in subclause 7.4.5.3)	16	10
block of Cr AC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrIntra16x16ACLevel[i] as described in subclause 7.4.5.3)	15	11
block of 16 Cr transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrLevel[i] as described in subclause 7.4.5.3)	16	12
block of 64 Cr transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrLevel8x8[i] as described in subclause 7.4.5.3)	64	13

Let the variable levelListIdx be set equal to the index of the list of transform coefficient levels as specified in subclause 7.4.5.3.

For the syntax elements significant_coeff_flag and last_significant_coeff_flag in blocks with ctxBlockCat not equal to 3, 5, 9, and 13, the variable ctxIdxInc is derived by

$$ctxIdxInc = levelListIdx \tag{9-15}$$

where levelListIdx ranges from 0 to maxNumCoeff – 2, inclusive.

For the syntax elements significant_coeff_flag and last_significant_coeff_flag in blocks with ctxBlockCat = = 3, the variable ctxIdxInc is derived by

$$ctxIdxInc = Min(levelListIdx / NumC8x8, 2) \tag{9-16}$$

where levelListIdx ranges from 0 to 4 * NumC8x8 – 2, inclusive.

For the syntax elements significant_coeff_flag and last_significant_coeff_flag in 8x8 luma, Cb, or Cr blocks with ctxBlockCat = = 5, 9, or 13, Table 9-43 contains the specification of ctxIdxInc for the given values of levelListIdx, where levelListIdx ranges from 0 to 62, inclusive.

Table 9-43 – Mapping of scanning position to ctxIdxInc for ctxBlockCat = = 5, 9, or 13

levelListIdx	ctxIdxInc for significant_coeff_flag (frame coded macroblocks)	ctxIdxInc for significant_coeff_flag (field coded macroblocks)	ctxIdxInc for last_significant_coeff_flag	levelListIdx	ctxIdxInc for significant_coeff_flag (frame coded macroblocks)	ctxIdxInc for significant_coeff_flag (field coded macroblocks)	ctxIdxInc for last_significant_coeff_flag
0	0	0	0	**32**	7	9	3
1	1	1	1	**33**	6	9	3
2	2	1	1	**34**	11	10	3
3	3	2	1	**35**	12	10	3
4	4	2	1	**36**	13	8	3
5	5	3	1	**37**	11	11	3
6	5	3	1	**38**	6	12	3
7	4	4	1	**39**	7	11	3
8	4	5	1	**40**	8	9	4
9	3	6	1	**41**	9	9	4
10	3	7	1	**42**	14	10	4
11	4	7	1	**43**	10	10	4
12	4	7	1	**44**	9	8	4
13	4	8	1	**45**	8	13	4
14	5	4	1	**46**	6	13	4
15	5	5	1	**47**	11	9	4
16	4	6	2	**48**	12	9	5
17	4	9	2	**49**	13	10	5
18	4	10	2	**50**	11	10	5
19	4	10	2	**51**	6	8	5
20	3	8	2	**52**	9	13	6
21	3	11	2	**53**	14	13	6
22	6	12	2	**54**	10	9	6
23	7	11	2	**55**	9	9	6
24	7	9	2	**56**	11	10	7
25	7	9	2	**57**	12	10	7
26	8	10	2	**58**	13	14	7
27	9	10	2	**59**	11	14	7

Table 9-43 – Mapping of scanning position to ctxIdxInc for ctxBlockCat = = 5, 9, or 13

levelListIdx	ctxIdxInc for significant_coeff_flag (frame coded macroblocks)	ctxIdxInc for significant_coeff_flag (field coded macroblocks)	ctxIdxInc for last_significant_coeff_flag	levelListIdx	ctxIdxInc for significant_coeff_flag (frame coded macroblocks)	ctxIdxInc for significant_coeff_flag (field coded macroblocks)	ctxIdxInc for last_significant_coeff_flag
28	10	8	2	**60**	14	14	8
29	9	11	2	**61**	10	14	8
30	8	12	2	**62**	12	14	8
31	7	11	2				

Let numDecodAbsLevelEq1 denotes the accumulated number of decoded transform coefficient levels with absolute value equal to 1, and let numDecodAbsLevelGt1 denotes the accumulated number of decoded transform coefficient levels with absolute value greater than 1. Both numbers are related to the same transform coefficient block, where the current decoding process takes place. Then, for decoding of coeff_abs_level_minus1, ctxIdxInc for coeff_abs_level_minus1 is specified depending on binIdx as follows.

– If binIdx is equal to 0, ctxIdxInc is derived by

ctxIdxInc = ((numDecodAbsLevelGt1 != 0) ? 0: Min(4, 1 + numDecodAbsLevelEq1)) (9-17)

– Otherwise (binIdx is greater than 0), ctxIdxInc is derived by

ctxIdxInc = 5 + Min(4 – (ctxBlockCat = = 3), numDecodAbsLevelGt1) (9-18)

9.3.3.2 Arithmetic decoding process

Inputs to this process are the bypassFlag, ctxIdx as derived in subclause 9.3.3.1, and the state variables codIRange and codIOffset of the arithmetic decoding engine.

Output of this process is the value of the bin.

Figure 9-2 illustrates the whole arithmetic decoding process for a single bin. For decoding the value of a bin, the context index ctxIdx is passed to the arithmetic decoding process DecodeBin(ctxIdx), which is specified as follows.

– If bypassFlag is equal to 1, DecodeBypass( ) as specified in subclause 9.3.3.2.3 is invoked.

– Otherwise, if bypassFlag is equal to 0 and ctxIdx is equal to 276, DecodeTerminate( ) as specified in subclause 9.3.3.2.4 is invoked.

– Otherwise (bypassFlag is equal to 0 and ctxIdx is not equal to 276), DecodeDecision( ) as specified in subclause 9.3.3.2.1 is applied.

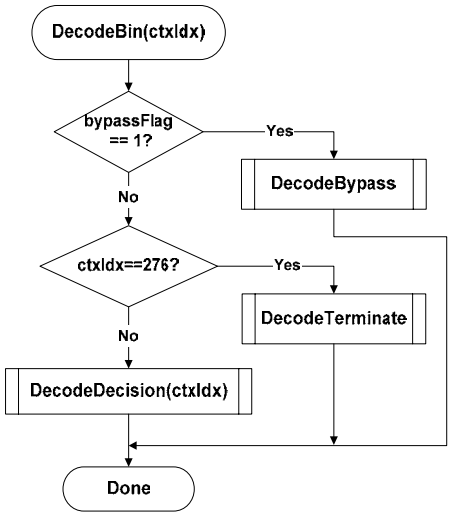


Figure 9-2 – Overview of the arithmetic decoding process for a single bin (informative)

NOTE – Arithmetic coding is based on the principle of recursive interval subdivision. Given a probability estimation p(0) and p(1) = 1 – p(0) of a binary decision (0, 1), an initially given code sub-interval with the range codIRange will be subdivided into two sub-intervals having range p(0) * codIRange and codIRange – p(0) * codIRange, respectively. Depending on the decision, which has been observed, the corresponding sub-interval will be chosen as the new code interval, and a binary code string pointing into that interval will represent the sequence of observed binary decisions. It is useful to distinguish between the most probable symbol (MPS) and the least probable symbol (LPS), so that binary decisions have to be identified as either MPS or LPS, rather than 0 or 1. Given this terminology, each context is specified by the probability p_{LPS} of the LPS and the value of MPS (valMPS), which is either 0 or 1.

The arithmetic core engine in this Recommendation | International Standard has three distinct properties:

– The probability estimation is performed by means of a finite-state machine with a table-based transition process between 64 different representative probability states { p_{LPS}(pStateIdx) | 0 <= pStateIdx < 64 } for the LPS probability p_{LPS}. The numbering of the states is arranged in such a way that the probability state with index pStateIdx = 0 corresponds to an LPS probability value of 0.5, with decreasing LPS probability towards higher state indices.

– The range codIRange representing the state of the coding engine is quantised to a small set $\{Q_1,\ldots,Q_4\}$ of pre-set quantisation values prior to the calculation of the new interval range. Storing a table containing all 64x4 pre-computed product values of $Q_i * p_{LPS}$(pStateIdx) allows a multiplication-free approximation of the product codIRange * p_{LPS}(pStateIdx).

– For syntax elements or parts thereof for which an approximately uniform probability distribution is assumed to be given a separate simplified encoding and decoding bypass process is used.

9.3.3.2.1 Arithmetic decoding process for a binary decision

Inputs to this process are ctxIdx, codIRange, and codIOffset.

Outputs of this process are the decoded value binVal, and the updated variables codIRange and codIOffset.

Figure 9-3 shows the flowchart for decoding a single decision (DecodeDecision).

1. The value of the variable codIRangeLPS is derived as follows.

– Given the current value of codIRange, the variable qCodIRangeIdx is derived by

qCodIRangeIdx =(codIRange >> 6) & 0x03 (9-19)

– Given qCodIRangeIdx and pStateIdx associated with ctxIdx, the value of the variable rangeTabLPS as specified in Table 9-44 is assigned to codIRangeLPS:

codIRangeLPS = rangeTabLPS[pStateIdx][qCodIRangeIdx] (9-20)

2. The variable codIRange is set equal to codIRange – codIRangeLPS and the following applies.

– If codIOffset is greater than or equal to codIRange, the variable binVal is set equal to 1 - valMPS, codIOffset is decremented by codIRange, and codIRange is set equal to codIRangeLPS.

– Otherwise, the variable binVal is set equal to valMPS.

Given the value of binVal, the state transition is performed as specified in subclause 9.3.3.2.1.1. Depending on the current value of codIRange, renormalization is performed as specified in subclause 9.3.3.2.2.

9.3.3.2.1.1 State transition process

Inputs to this process are the current pStateIdx, the decoded value binVal and valMPS values of the context variable associated with ctxIdx.

Outputs of this process are the updated pStateIdx and valMPS of the context variable associated with ctxIdx.

Depending on the decoded value binVal, the update of the two variables pStateIdx and valMPS associated with ctxIdx is derived as follows:

```
if( binVal  = =  valMPS )
    pStateIdx = transIdxMPS( pStateIdx )
else {                                                    (9-21)
    if( pStateIdx  = =  0 )
        valMPS = 1 – valMPS
    pStateIdx = transIdxLPS( pStateIdx )
}
```

Table 9-45 specifies the transition rules transIdxMPS( ) and transIdxLPS( ) after decoding the value of valMPS and 1 – valMPS, respectively.

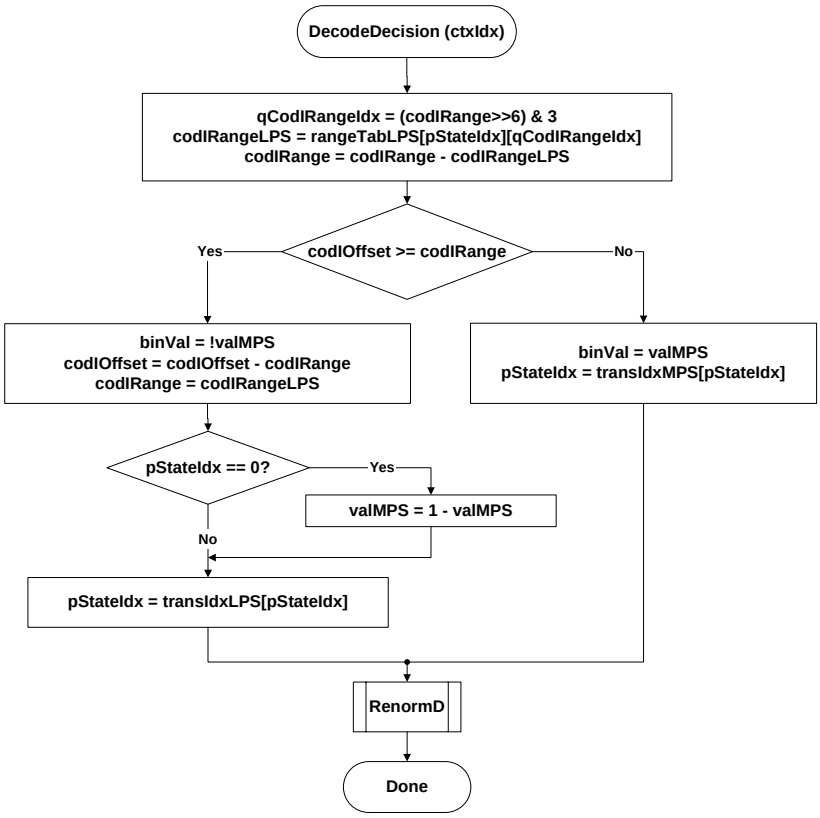


Figure 9-3 – Flowchart for decoding a decision

Table 9-44 – Specification of rangeTabLPS depending on pStateIdx and qCodIRangeIdx

pStateIdx	qCodIRangeIdx				pStateIdx	qCodIRangeIdx			
	0	1	2	3		0	1	2	3
0	128	176	208	240	**32**	27	33	39	45
1	128	167	197	227	**33**	26	31	37	43
2	128	158	187	216	**34**	24	30	35	41
3	123	150	178	205	**35**	23	28	33	39
4	116	142	169	195	**36**	22	27	32	37
5	111	135	160	185	**37**	21	26	30	35
6	105	128	152	175	**38**	20	24	29	33
7	100	122	144	166	**39**	19	23	27	31
8	95	116	137	158	**40**	18	22	26	30
9	90	110	130	150	**41**	17	21	25	28
10	85	104	123	142	**42**	16	20	23	27
11	81	99	117	135	**43**	15	19	22	25
12	77	94	111	128	**44**	14	18	21	24
13	73	89	105	122	**45**	14	17	20	23
14	69	85	100	116	**46**	13	16	19	22
15	66	80	95	110	**47**	12	15	18	21
16	62	76	90	104	**48**	12	14	17	20
17	59	72	86	99	**49**	11	14	16	19
18	56	69	81	94	**50**	11	13	15	18
19	53	65	77	89	**51**	10	12	15	17
20	51	62	73	85	**52**	10	12	14	16
21	48	59	69	80	**53**	9	11	13	15
22	46	56	66	76	**54**	9	11	12	14
23	43	53	63	72	**55**	8	10	12	14
24	41	50	59	69	**56**	8	9	11	13
25	39	48	56	65	**57**	7	9	11	12
26	37	45	54	62	**58**	7	9	10	12
27	35	43	51	59	**59**	7	8	10	11
28	33	41	48	56	**60**	6	8	9	11
29	32	39	46	53	**61**	6	7	9	10
30	30	37	43	50	**62**	6	7	8	9
31	29	35	41	48	**63**	2	2	2	2

Table 9-45 – State transition table

pStateIdx	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
transIdxLPS	0	0	1	2	2	4	4	5	6	7	8	9	9	11	11	12
transIdxMPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
pStateIdx	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
transIdxLPS	13	13	15	15	16	16	18	18	19	19	21	21	22	22	23	24
transIdxMPS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
pStateIdx	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**
transIdxLPS	24	25	26	26	27	27	28	29	29	30	30	30	31	32	32	33
transIdxMPS	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
pStateIdx	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**
transIdxLPS	33	33	34	34	35	35	35	36	36	36	37	37	37	38	38	63
transIdxMPS	49	50	51	52	53	54	55	56	57	58	59	60	61	62	62	63

9.3.3.2.2 Renormalization process in the arithmetic decoding engine

Inputs to this process are bits from slice data and the variables codIRange and codIOffset.

Outputs of this process are the updated variables codIRange and codIOffset.

A flowchart of the renormalization is shown in Figure 9-4. The current value of codIRange is first compared to 0x0100 and further steps are specified as follows.

– If codIRange is greater than or equal to 0x0100, no renormalization is needed and the RenormD process is finished;

– Otherwise (codIRange is less than 0x0100), the renormalization loop is entered. Within this loop, the value of codIRange is doubled, i.e., left-shifted by 1 and a single bit is shifted into codIOffset by using read_bits(1).

The bitstream shall not contain data that results in a value of codIOffset being greater than or equal to codIRange upon completion of this process.

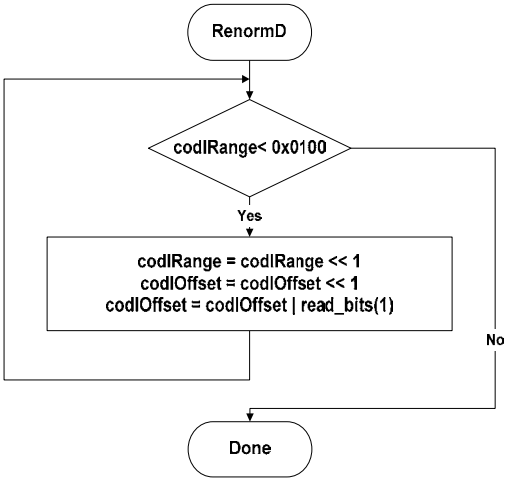


Figure 9-4 – Flowchart of renormalization

9.3.3.2.3 Bypass decoding process for binary decisions

Inputs to this process are bits from slice data and the variables codIRange and codIOffset.

Outputs of this process are the updated variable codIOffset and the decoded value binVal.

The bypass decoding process is invoked when bypassFlag is equal to 1. Figure 9-5 shows a flowchart of the corresponding process.

First, the value of codIOffset is doubled, i.e., left-shifted by 1 and a single bit is shifted into codIOffset by using read_bits(1). Then, the value of codIOffset is compared to the value of codIRange and further steps are specified as follows.

– If codIOffset is greater than or equal to codIRange, the variable binVal is set equal to 1 and codIOffset is decremented by codIRange.

– Otherwise (codIOffset is less than codIRange), the variable binVal is set equal to 0.

The bitstream shall not contain data that results in a value of codIOffset being greater than or equal to codIRange upon completion of this process.

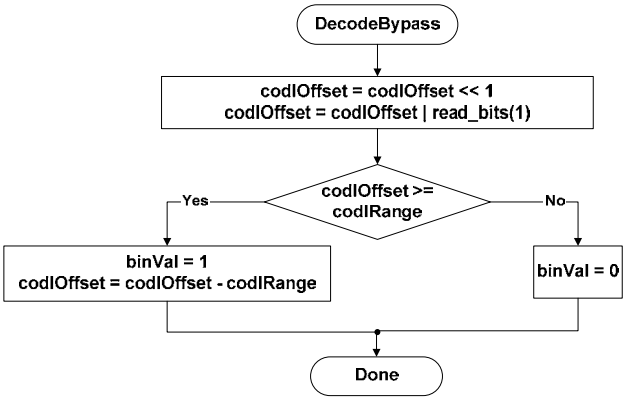


Figure 9-5 – Flowchart of bypass decoding process

9.3.3.2.4 Decoding process for binary decisions before termination

Inputs to this process are bits from slice data and the variables codIRange and codIOffset.

Outputs of this process are the updated variables codIRange and codIOffset, and the decoded value binVal.

This special decoding routine applies to decoding of end_of_slice_flag and of the bin indicating the I_PCM mode corresponding to ctxIdx equal to 276. Figure 9-6 shows the flowchart of the corresponding decoding process, which is specified as follows.

First, the value of codIRange is decremented by 2. Then, the value of codIOffset is compared to the value of codIRange and further steps are specified as follows.

– If codIOffset is greater than or equal to codIRange, the variable binVal is set equal to 1, no renormalization is carried out, and CABAC decoding is terminated. The last bit inserted in register codIOffset is equal to 1. When decoding end_of_slice_flag, this last bit inserted in register codIOffset is interpreted as rbsp_stop_one_bit.

– Otherwise (codIOffset is less than codIRange), the variable binVal is set equal to 0 and renormalization is performed as specified in subclause 9.3.3.2.2.

NOTE – This procedure may also be implemented using DecodeDecision(ctxIdx) with ctxIdx = 276. In the case where the decoded value is equal to 1, seven more bits would be read by DecodeDecision(ctxIdx) and a decoding process would have to adjust its bitstream pointer accordingly to properly decode following syntax elements.

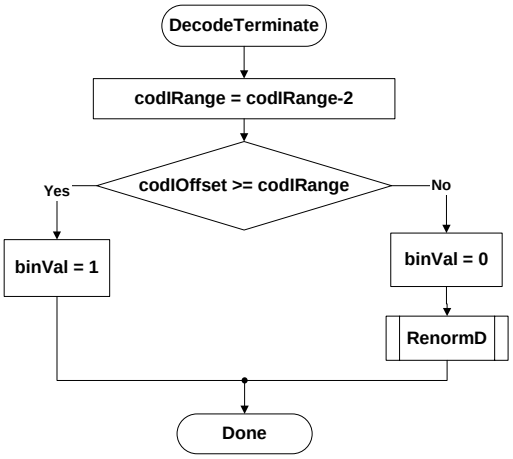


Figure 9-6 – Flowchart of decoding a decision before termination

9.3.4 Arithmetic encoding process (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Inputs to this process are decisions that are to be encoded and written.

Outputs of this process are bits that are written to the RBSP.

This informative subclause describes an arithmetic encoding engine that matches the arithmetic decoding engine described in subclause 9.3.3.2. The encoding engine is essentially symmetric with the decoding engine, i.e., procedures are called in the same order. The following procedures are described in this section: InitEncoder, EncodeDecision, EncodeBypass, EncodeTerminate, which correspond to InitDecoder, DecodeDecision, DecodeBypass, and DecodeTerminate, respectively. The state of the arithmetic encoding engine is represented by a value of the variable codILow pointing to the lower end of a sub-interval and a value of the variable codIRange specifying the corresponding range of that sub-interval.

9.3.4.1 Initialisation process for the arithmetic encoding engine (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

This process is invoked before encoding the first macroblock of a slice, and after encoding any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data for a macroblock of type I_PCM.

Outputs of this process are the values codILow, codIRange, firstBitFlag, bitsOutstanding, and symCnt of the arithmetic encoding engine.

In the initialisation procedure of the encoder, codILow is set equal to 0, and codIRange is set equal to 0x01FE. Furthermore, a firstBitFlag is set equal to 1, and bitsOutstanding and symCnt counters are set equal to 0.

NOTE – The minimum register precision required for codILow is 10 bits and for CodIRange is 9 bits. The precision required for the counters bitsOutstanding and symCnt should be sufficiently large to prevent overflow of the related registers. When MaxBinCountInSlice denotes the maximum total number of binary decisions to encode in one slice, the minimum register precision required for the variables bitsOutstanding and symCnt is given by Ceil(Log2(MaxBinCountInSlice + 1)).

9.3.4.2 Encoding process for a binary decision (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Inputs to this process are the context index ctxIdx, the value of binVal to be encoded, and the variables codIRange, codILow and symCnt.

Outputs of this process are the variables codIRange, codILow, and symCnt.

Figure 9-7 shows the flowchart for encoding a single decision. In a first step, the variable codIRangeLPS is derived as follows.

Given the current value of codIRange, codIRange is mapped to the index qCodIRangeIdx of a quantised value of codIRange by using Equation 9-19. The value of qCodIRangeIdx and the value of pStateIdx associated with ctxIdx are used to determine the value of the variable rangeTabLPS as specified in Table 9-44, which is assigned to codIRangeLPS. The value of codIRange – codIRangeLPS is assigned to codIRange.

In a second step, the value of binVal is compared to valMPS associated with ctxIdx. When binVal is different from valMPS, codIRange is added to codILow and codIRange is set equal to the value codIRangeLPS. Given the encoded decision, the state transition is performed as specified in subclause 9.3.3.2.1.1. Depending on the current value of codIRange, renormalization is performed as specified in subclause 9.3.4.3. Finally, the variable symCnt is incremented by 1.

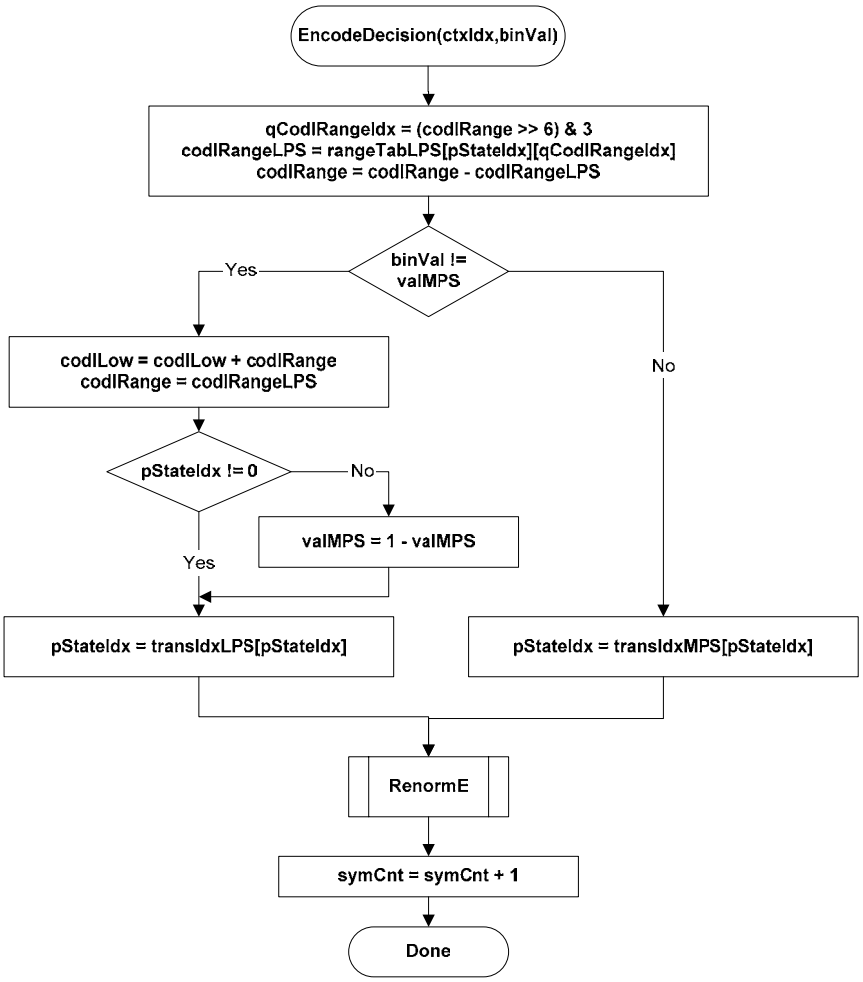


Figure 9-7 – Flowchart for encoding a decision

9.3.4.3 Renormalization process in the arithmetic encoding engine (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Inputs to this process are the variables codIRange, codILow, firstBitFlag, and bitsOutstanding.

Outputs of this process are zero or more bits written to the RBSP and the updated variables codIRange, codILow, firstBitFlag, and bitsOutstanding.

Renormalization is illustrated in Figure 9-8.

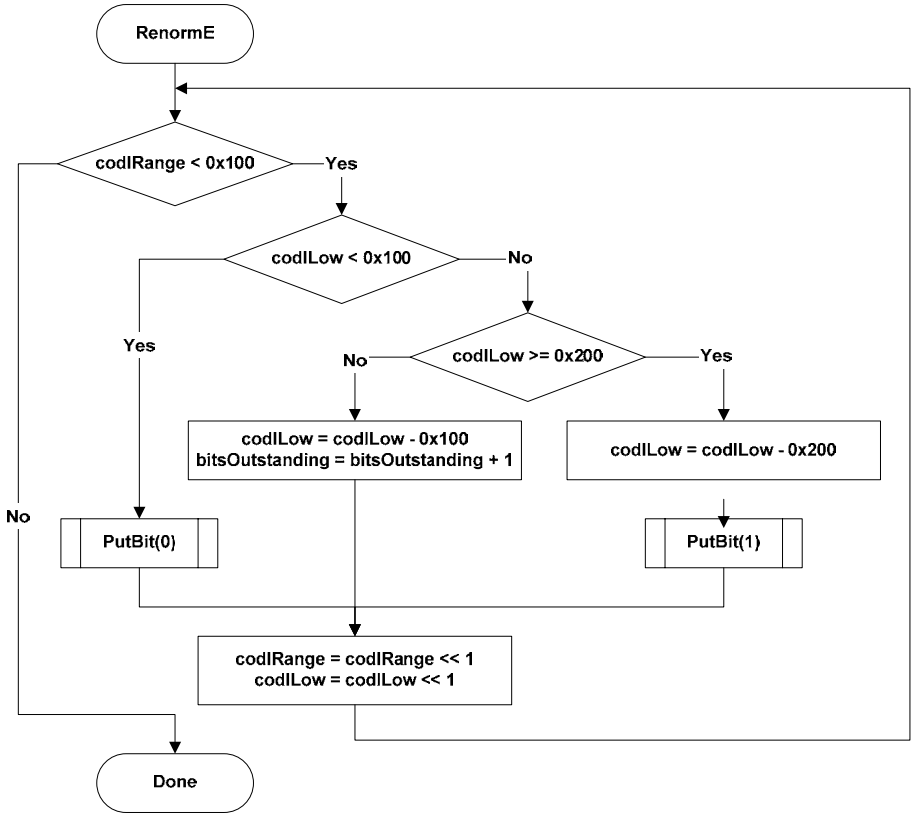


Figure 9-8 – Flowchart of renormalization in the encoder

The PutBit( ) procedure described in Figure 9-9 provides carry over control. It uses the function WriteBits(B, N) that writes N bits with value B to the bitstream and advances the bitstream pointer by N bit positions. This function assumes the existence of a bitstream pointer with an indication of the position of the next bit to be written to the bitstream by the encoding process.

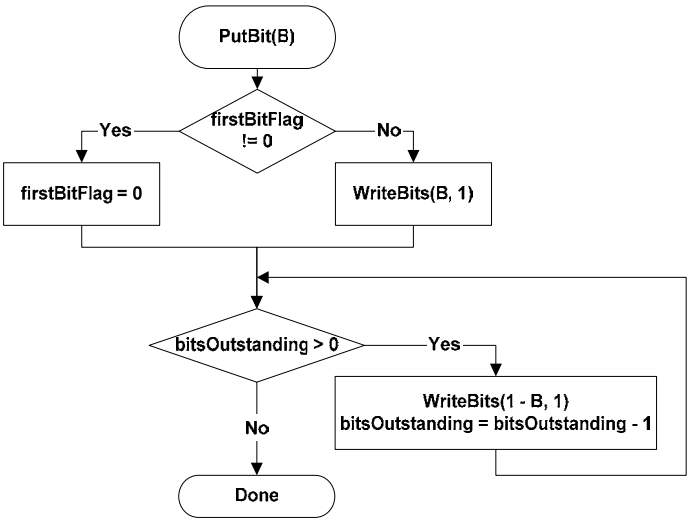


Figure 9-9 – Flowchart of PutBit(B)

9.3.4.4 Bypass encoding process for binary decisions (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Inputs to this process are the variables binVal, codILow, codIRange, bitsOutstanding, and symCnt.

Output of this process is a bit written to the RBSP and the updated variables codILow, bitsOutstanding, and symCnt.

This encoding process applies to all binary decisions with bypassFlag equal to 1. Renormalization is included in the specification of this process as given in Figure 9-10.

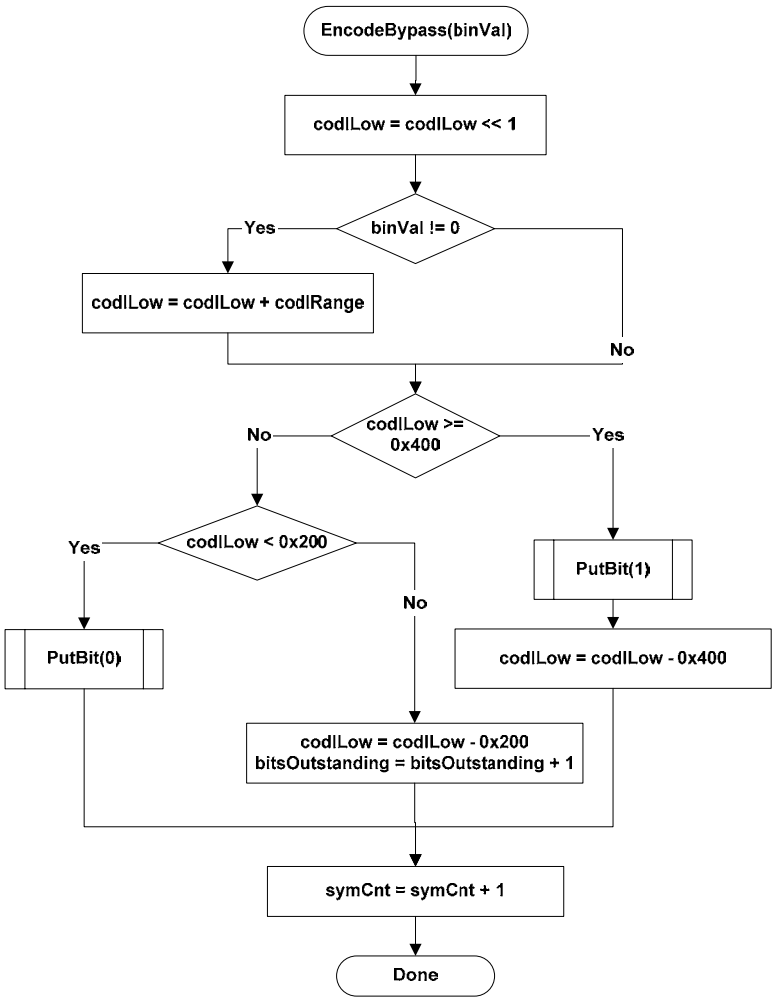


Figure 9-10 – Flowchart of encoding bypass

9.3.4.5 Encoding process for a binary decision before termination (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Inputs to this process are the variables binVal, codIRange, codILow, bitsOutstanding, and symCnt.

Outputs of this process are zero or more bits written to the RBSP and the updated variables codILow, codIRange, bitsOutstanding, and symCnt.

This encoding routine shown in Figure 9-11 applies to encoding of the end_of_slice_flag and of the bin indicating the I_PCM mb_type both associated with ctxIdx equal to 276.

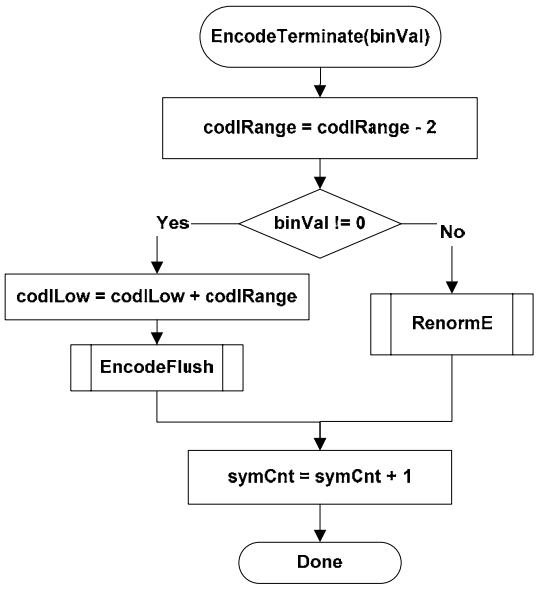


Figure 9-11 – Flowchart of encoding a decision before termination

When the value of binVal to encode is equal to 1, CABAC encoding is terminated and the flushing procedure shown in Figure 9-12 is applied. In this flushing procedure, the last bit written by WriteBits(B, N) is equal to 1. When encoding end_of_slice_flag, this last bit is interpreted as the rbsp_stop_one_bit.

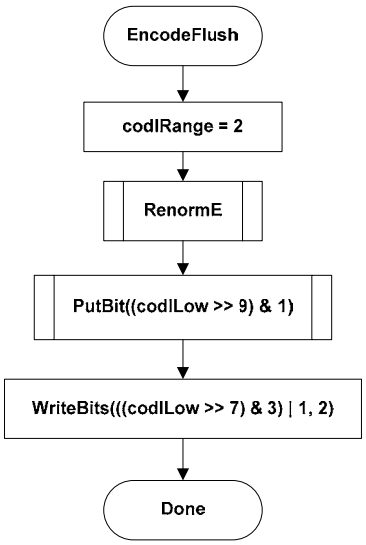


Figure 9-12 – Flowchart of flushing at termination

9.3.4.6 Byte stuffing process (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

This process is invoked after encoding the last macroblock of the last slice of a picture and after encapsulation.

Inputs to this process are the number of bytes NumBytesInVclNALunits of all VCL NAL units of a picture, the number of macroblocks PicSizeInMbs in the picture, and the number of binary symbols BinCountsInNALunits resulting from encoding the contents of all VCL NAL units of the picture.

Outputs of this process are zero or more bytes appended to the NAL unit.

Let the variable k be set equal to Ceil((Ceil(3 * (32 * BinCountsInNALunits – RawMbBits * PicSizeInMbs) ÷ 1024) – NumBytesInVclNALunits) ÷ 3). Depending on the variable k the following applies.

– If k is less than or equal to 0, no cabac_zero_word is appended to the NAL unit.

– Otherwise (k is greater than 0), the 3-byte sequence 0x000003 is appended k times to the NAL unit after encapsulation, where the first two bytes 0x0000 represent a cabac_zero_word and the third byte 0x03 represents an emulation_prevention_three_byte.

Annex A
Profiles and levels

(This annex forms an integral part of this Recommendation | International Standard)

Profiles and levels specify restrictions on bitstreams and hence limits on the capabilities needed to decode the bitstreams. Profiles and levels may also be used to indicate interoperability points between individual decoder implementations.

NOTE 1 – This Recommendation | International Standard does not include individually selectable "options" at the decoder, as this would increase interoperability difficulties.

Each profile specifies a subset of algorithmic features and limits that shall be supported by all decoders conforming to that profile.

NOTE 2 – Encoders are not required to make use of any particular subset of features supported in a profile.

Each level specifies a set of limits on the values that may be taken by the syntax elements of this Recommendation | International Standard. The same set of level definitions is used with all profiles, but individual implementations may support a different level for each supported profile. For any given profile, levels generally correspond to decoder processing load and memory capability.

A.1 Requirements on video decoder capability

Capabilities of video decoders conforming to this Recommendation | International Standard are specified in terms of the ability to decode video streams conforming to the constraints of profiles and levels specified in this annex. For each such profile, the level supported for that profile shall also be expressed.

Specific values are specified in this annex for the syntax elements profile_idc and level_idc. All other values of profile_idc and level_idc are reserved for future use by ITU-T | ISO/IEC.

NOTE – Decoders should not infer that when a reserved value of profile_idc or level_idc falls between the values specified in this Recommendation | International Standard that this indicates intermediate capabilities between the specified profiles or levels, as there are no restrictions on the method to be chosen by ITU-T | ISO/IEC for the use of such future reserved values.

A.2 Profiles

A.2.1 Baseline profile

Bitstreams conforming to the Baseline profile shall obey the following constraints:

– Only I and P slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Sequence parameter sets shall have frame_mbs_only_flag equal to 1.

– The syntax elements chroma_format_idc, bit_depth_luma_minus8, bit_depth_chroma_minus8, qpprime_y_zero_transform_bypass_flag, and seq_scaling_matrix_present_flag shall not be present in sequence parameter sets.

– Picture parameter sets shall have weighted_pred_flag and weighted_bipred_idc both equal to 0.

– Picture parameter sets shall have entropy_coding_mode_flag equal to 0.

– Picture parameter sets shall have num_slice_groups_minus1 in the range of 0 to 7, inclusive.

– The syntax elements transform_8x8_mode_flag, pic_scaling_matrix_present_flag, and second_chroma_qp_index_offset shall not be present in picture parameter sets.

– The syntax element level_prefix shall not be greater than 15.

– The level constraints specified for the Baseline profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the Baseline profile is specified by profile_idc being equal to 66.

Decoders conforming to the Baseline profile at a specific level shall be capable of decoding all bitstreams in which profile_idc is equal to 66 or constraint_set0_flag is equal to 1 and in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

A.2.2 Main profile

Bitstreams conforming to the Main profile shall obey the following constraints:

– Only I, P, and B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– The syntax elements chroma_format_idc, bit_depth_luma_minus8, bit_depth_chroma_minus8, qpprime_y_zero_transform_bypass_flag, and seq_scaling_matrix_present_flag shall not be present in sequence parameter sets.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– The syntax elements transform_8x8_mode_flag, pic_scaling_matrix_present_flag, and second_chroma_qp_index_offset shall not be present in picture parameter sets.

– The syntax element level_prefix shall not be greater than 15 (when present).

– The level constraints specified for the Main profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the Main profile is specified by profile_idc being equal to 77.

Decoders conforming to the Main profile at a specified level shall be capable of decoding all bitstreams in which profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

A.2.3 Extended profile

Bitstreams conforming to the Extended profile shall obey the following constraints:

– Sequence parameter sets shall have direct_8x8_inference_flag equal to 1.

– The syntax elements chroma_format_idc, bit_depth_luma_minus8, bit_depth_chroma_minus8, qpprime_y_zero_transform_bypass_flag, and seq_scaling_matrix_present_flag shall not be present in sequence parameter sets.

– Picture parameter sets shall have entropy_coding_mode_flag equal to 0.

– Picture parameter sets shall have num_slice_groups_minus1 in the range of 0 to 7, inclusive.

– The syntax elements transform_8x8_mode_flag, pic_scaling_matrix_present_flag, and second_chroma_qp_index_offset shall not be present in picture parameter sets.

– The syntax element level_prefix shall not be greater than 15 (when present).

– The level constraints specified for the Extended profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the Extended profile is specified by profile_idc being equal to 88.

Decoders conforming to the Extended profile at a specified level shall be capable of decoding all bitstreams in which profile_idc is equal to 88 or constraint_set2_flag is equal to 1 and in which level_idc represents a level less than or equal to specified level.

Decoders conforming to the Extended profile at a specified level shall also be capable of decoding all bitstreams in which profile_idc is equal to 66 or constraint_set0_flag is equal to 1, in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

A.2.4 High profile

Bitstreams conforming to the High profile shall obey the following constraints:

– Only I, P, and B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– Sequence parameter sets shall have chroma_format_idc in the range of 0 to 1 inclusive.

– Sequence parameter sets shall have bit_depth_luma_minus8 equal to 0 only.

– Sequence parameter sets shall have bit_depth_chroma_minus8 equal to 0 only.

– Sequence parameter sets shall have qpprime_y_zero_transform_bypass_flag equal to 0 only.

– The level constraints specified for the High profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High profile is specified by profile_idc being equal to 100. Decoders conforming to the High profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

– profile_idc is equal to 100 and level_idc represents a level less than or equal to the specified level.

NOTE – The value 100 for profile_idc indicates that the bitstream conforms to the High profile as specified in this subclause. When profile_idc is equal to 100 and constraint_set3_flag is equal to 1, this indicates that the bitstream conforms to the High profile and additionally conforms to the constraints specified for the High 10 Intra profile in subclause A.2.8. For example, such a bitstream must have bit_depth_luma_minus8 equal to 0, have bit_depth_chroma_minus8 equal to 0, obey the MinCr, MaxBR and MaxCPB constraints of the High profile, contain only IDR pictures, have num_ref_frames equal to 0, have dpb_output_delay equal to 0, and obey the maximum slice size constraint of the High 10 Intra profile.

A.2.5 High 10 profile

Bitstreams conforming to the High 10 profile shall obey the following constraints:

– Only I, P, and B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– Sequence parameter sets shall have chroma_format_idc in the range of 0 to 1 inclusive.

– Sequence parameter sets shall have bit_depth_luma_minus8 in the range of 0 to 2 inclusive.

– Sequence parameter sets shall have bit_depth_chroma_minus8 in the range of 0 to 2 inclusive.

– Sequence parameter sets shall have qpprime_y_zero_transform_bypass_flag equal to 0 only.

– The level constraints specified for the High 10 profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 10 profile is specified by profile_idc being equal to 110. Decoders conforming to the High 10 profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

– profile_idc is equal to 100 or 110 and level_idc represents a level less than or equal to the specified level.

A.2.6 High 4:2:2 profile

Bitstreams conforming to the High 4:2:2 profile shall obey the following constraints:

– Only I, P, and B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– Sequence parameter sets shall have chroma_format_idc in the range of 0 to 2 inclusive.

– Sequence parameter sets shall have bit_depth_luma_minus8 in the range of 0 to 2 inclusive.

– Sequence parameter sets shall have bit_depth_chroma_minus8 in the range of 0 to 2 inclusive.

– Sequence parameter sets shall have qpprime_y_zero_transform_bypass_flag equal to 0 only.

– The level constraints specified for the High 4:2:2 profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 4:2:2 profile is specified by profile_idc being equal to 122. Decoders conforming to the High 4:2:2 profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

– profile_idc is equal to 100, 110, or 122 and level_idc represents a level less than or equal to the specified level.

A.2.7 High 4:4:4 Predictive profile

Bitstreams conforming to the High 4:4:4 Predictive profile shall obey the following constraints:

– Only I, P, B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– Sequence parameter sets shall have bit_depth_luma_minus8 in the range of 0 to 6 inclusive.

– Sequence parameter sets shall have bit_depth_chroma_minus8 in the range of 0 to 6 inclusive.

– The level constraints specified for the High 4:4:4 Predictive profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 4:4:4 Predictive profile is specified by profile_idc being equal to 244. Decoders conforming to the High 4:4:4 Predictive profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

– profile_idc is equal to 44, 100, 110, 122, or 244 and the value of level_idc represents a level less than or equal to the specified level.

A.2.8 High 10 Intra profile

Bitstreams conforming to the High 10 Intra profile shall obey the following constraints:

– All constraints specified in subclause A.2.5 for the High 10 profile shall be obeyed.

– All pictures shall be IDR pictures.

– Sequence parameter sets shall have num_ref_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have num_reorder_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have max_dec_frame_buffering equal to 0.

– Picture timing SEI messages, whether present in the bitstream (by non-VCL NAL units) or conveyed equivalently by other means not specified in this Recommendation | International Standard, shall have dpb_output_delay equal to 0.

– The level constraints specified for the High 10 Intra profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 10 Intra profile is specified by constraint_set3_flag being equal to 1 with profile_idc equal to 110. Decoders conforming to the High 10 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true.

– profile_idc is equal to 100 or 110.

– constraint_set3_flag is equal to 1.

– level_idc represents a level less than or equal to the specified level.

NOTE – The value 100 for profile_idc indicates that the bitstream conforms to the High profile as specified in subclause A.2.4. When profile_idc is equal to 100 and constraint_set3_flag is equal to 1, this indicates that the bitstream conforms to the High profile and additionally conforms to the constraints specified for the High 10 Intra profile in this subclause. For example, such a bitstream must have bit_depth_luma_minus8 equal to 0, have bit_depth_chroma_minus8 equal to 0, obey the MinCr, MaxBR and MaxCPB constraints of the High profile, contain only IDR pictures, have num_ref_frames equal to 0, have dpb_output_delay equal to 0, and obey the maximum slice size constraint of the High 10 Intra profile.

The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the High 10 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 10 Intra profile. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 10 Intra profile. However, the application of the deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 10, High 4:2:2, and High 4:4:4 Predictive profiles when decoding bitstreams that conform to the High 10 Intra profile.

A.2.9 High 4:2:2 Intra profile

Bitstreams conforming to the High 4:2:2 Intra profile shall obey the following constraints:

– All constraints specified in subclause A.2.6 for the High 4:2:2 profile shall be obeyed.

– All pictures shall be IDR pictures.

– Sequence parameter sets shall have num_ref_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have num_reorder_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have max_dec_frame_buffering equal to 0.

– Picture timing SEI messages, whether present in the bitstream (by non-VCL NAL units) or conveyed equivalently by other means not specified in this Recommendation | International Standard, shall have dpb_output_delay equal to 0.

– The level constraints specified for the High 4:2:2 Intra profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 4:2:2 Intra profile is specified by constraint_set3_flag being equal to 1 with profile_idc equal to 122. Decoders conforming to the High 4:2:2 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true:

– profile_idc is equal to 100, 110, or 122.

– constraint_set3_flag is equal to 1.

– level_idc represents a level less than or equal to the specified level.

The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the High 4:2:2 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 4:2:2 Intra profile. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 4:2:2 Intra profile. However, the application of the deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 4:2:2, and High 4:4:4 Predictive profiles when decoding bitstreams that conform to the High 4:2:2 Intra profile.

A.2.10 High 4:4:4 Intra profile

Bitstreams conforming to the High 4:4:4 Intra profile shall obey the following constraints:

– All constraints specified in subclause A.2.7 for the High 4:4:4 Predictive profile shall be obeyed.

– All pictures shall be IDR pictures.

– Sequence parameter sets shall have num_ref_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have num_reorder_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have max_dec_frame_buffering equal to 0.

– Picture timing SEI messages, whether present in the bitstream (by non-VCL NAL units) or conveyed equivalently by other means not specified in this Recommendation | International Standard, shall have dpb_output_delay equal to 0.

– The level constraints specified for the High 4:4:4 Intra profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 4:4:4 Intra profile is specified by constraint_set3_flag being equal to 1 with profile_idc equal to 244. Decoders conforming to the High 4:4:4 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true:

– profile_idc is equal to 44, 100, 110, 122, or 244.

– constraint_set3_flag is equal to 1.

– level_idc represents a level less than or equal to the specified level.

The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the High 4:4:4 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. However, the application of the

deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 4:4:4 Predictive profile when decoding bitstreams that conform to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles.

A.2.11 CAVLC 4:4:4 Intra profile

Bitstreams conforming to the CAVLC 4:4:4 Intra profile shall obey the following constraints:

– All constraints specified in subclause A.2.10 for the High 4:4:4 Intra profile shall be obeyed.

– Picture parameter sets shall have entropy_coding_mode_flag equal to 0.

– The level constraints specified for the CAVLC 4:4:4 Intra profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the CAVLC 4:4:4 Intra profile is specified by profile_idc being equal to 44. Decoders conforming to the CAVLC 4:4:4 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true:

– profile_idc is equal to 44.

– level_idc represents a level less than or equal to the specified level.

The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the CAVLC 4:4:4 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. However, the application of the deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 4:4:4 Predictive profile when decoding bitstreams that conform to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles.

A.3 Levels

The following is specified for expressing the constraints in this annex.

– Let access unit n be the n-th access unit in decoding order with the first access unit being access unit 0.

– Let picture n be the primary coded picture or the corresponding decoded picture of access unit n.

A.3.1 Level limits common to the Baseline, Main, and Extended profiles

Let the variable fR be derived as follows.

– If picture n is a frame, fR is set equal to 1 ÷ 172.

– Otherwise (picture n is a field), fR is set equal to 1 ÷ (172 * 2).

Bitstreams conforming to the Baseline, Main, or Extended profiles at a specified level shall obey the following constraints:

a) The nominal removal time of access unit n (with n > 0) from the CPB as specified in subclause C.1.2, satisfies the constraint that $t_{r,n}(n) - t_r(n - 1)$ is greater than or equal to Max(PicSizeInMbs ÷ MaxMBPS, fR), where MaxMBPS is the value specified in Table A-1 that applies to picture n – 1, and PicSizeInMbs is the number of macroblocks in picture n – 1.

b) The difference between consecutive output times of pictures from the DPB as specified in subclause C.2.2, satisfies the constraint that $\Delta t_{o,dpb}(n) >= Max(PicSizeInMbs \div MaxMBPS, fR)$, where MaxMBPS is the value specified in Table A-1 for picture n, and PicSizeInMbs is the number of macroblocks of picture n, provided that picture n is a picture that is output and is not the last picture of the bitstream that is output.

c) The sum of the NumBytesInNALunit variables for access unit 0 is less than or equal to $384 * (PicSizeInMbs + MaxMBPS * (t_r(0) - t_{r,n}(0))) \div MinCR$, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture 0 and PicSizeInMbs is the number of macroblocks in picture 0.

d) The sum of the NumBytesInNALunit variables for access unit n (with n > 0) is less than or equal to $384 * MaxMBPS * (t_r(n) - t_r(n – 1)) \div MinCR$, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture n.

e) PicWidthInMbs * FrameHeightInMbs <= MaxFS, where MaxFS is specified in Table A-1.

f) PicWidthInMbs <= Sqrt(MaxFS * 8).

g) FrameHeightInMbs <= Sqrt(MaxFS * 8).

h) max_dec_frame_buffering <= MaxDpbSize, where MaxDpbSize is equal to Min(1024 * MaxDPB / (PicWidthInMbs * FrameHeightInMbs * 384), 16) and MaxDPB is given in Table A-1 in units of 1024 bytes.

i) For the VCL HRD parameters, BitRate[SchedSelIdx] <= 1000 * MaxBR and CpbSize[SchedSelIdx] <= 1000 * MaxCPB for at least one value of SchedSelIdx, where BitRate[SchedSelIdx] is given by Equation E-37 and CpbSize[SchedSelIdx] is given by Equation E-38 when vcl_hrd_parameters_present_flag is equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of 1000 bits/s and 1000 bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1, inclusive.

j) For the NAL HRD parameters, BitRate[SchedSelIdx] <= 1200 * MaxBR and CpbSize[SchedSelIdx] <= 1200 * MaxCPB for at least one value of SchedSelIdx, where BitRate[SchedSelIdx] is given by Equation E-37 and CpbSize[SchedSelIdx] is given by Equation E-38 when nal_hrd_parameters_present_flag equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of 1200 bits/s and 1200 bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1.

k) Vertical motion vector component range luma motion vectors does not exceed MaxVmvR in units of luma frame samples, where MaxVmvR is specified in Table A-1.

   NOTE 1 – When chroma_format_idc is equal to 1 and the current macroblock is a field macroblock, the motion vector component range for chroma motion vectors may exceed MaxVmvR in units of luma frame samples, due to the method of deriving chroma motion vectors as specified in subclause 8.4.1.4.

l) Horizontal motion vector range does not exceed the range of -2048 to 2047.75, inclusive, in units of luma samples.

m) Number of motion vectors per two consecutive macroblocks in decoding order (also applying to the total from the last macroblock of a slice and the first macroblock of the next slice in decoding order, and in particular also applying to the total from the last macroblock of the last slice of a picture and the first macroblock of the first slice of the next picture in decoding order) does not exceed MaxMvsPer2Mb, where MaxMvsPer2Mb is specified in Table A-1. The number of motion vectors for each macroblock is the value of the variable MvCnt after the completion of the intra or inter prediction process for the macroblock.

n) Number of bits of macroblock_layer( ) data for any macroblock is not greater than 3200. Depending on entropy_coding_mode_flag, the bits of macroblock_layer( ) data are counted as follows.

   – If entropy_coding_mode_flag is equal to 0, the number of bits of macroblock_layer( ) data is given by the number of bits in the macroblock_layer( ) syntax structure for a macroblock.

   – Otherwise (entropy_coding_mode_flag is equal to 1), the number of bits of macroblock_layer( ) data for a macroblock is given by the number of times read_bits(1) is called in subclauses 9.3.3.2.2 and 9.3.3.2.3 when parsing the macroblock_layer( ) associated with the macroblock.

Table A-1 specifies the limits for each level. Entries marked "-" in Table A-1 denote the absence of a corresponding limit. For purposes of comparison of level capabilities, a level shall be considered to be a lower (higher) level than some other level if the level appears nearer to the top (bottom) row of Table A-1 than the other level.

A level to which the bitstream conforms shall be indicated by the syntax elements level_idc and constraint_set3_flag as follows.

– If level_idc is equal to 11 and constraint_set3_flag is equal to 1, the indicated level is level 1b.

– Otherwise (level_idc is not equal to 11 or constraint_set3_flag is not equal to 1), level_idc shall be set equal to a value of ten times the level number specified in Table A-1 and constraint_set3_flag shall be set equal to 0.

Table A-1 – Level limits

Level number	Max macroblock processing rate MaxMBPS (MB/s)	Max frame size MaxFS (MBs)	Max decoded picture buffer size MaxDPB (1024 bytes for 4:2:0)	Max video bit rate MaxBR (1000 bits/s, 1200 bits/s, cpbBrVclFactor bits/s, or cpbBrNalFactor bits/s)	Max CPB size MaxCPB (1000 bits, 1200 bits, cpbBrVclFactor bits, or cpbBrNalFactor bits)	Vertical MV component range MaxVmvR (luma frame samples)	Min compression ratio MinCR	Max number of motion vectors per two consecutive MBs MaxMvsPer2Mb
1	1 485	99	148.5	64	175	[-64,+63.75]	2	-
1b	1 485	99	148.5	128	350	[-64,+63.75]	2	-
1.1	3 000	396	337.5	192	500	[-128,+127.75]	2	-
1.2	6 000	396	891.0	384	1 000	[-128,+127.75]	2	-
1.3	11 880	396	891.0	768	2 000	[-128,+127.75]	2	-
2	11 880	396	891.0	2 000	2 000	[-128,+127.75]	2	-
2.1	19 800	792	1 782.0	4 000	4 000	[-256,+255.75]	2	-
2.2	20 250	1 620	3 037.5	4 000	4 000	[-256,+255.75]	2	-
3	40 500	1 620	3 037.5	10 000	10 000	[-256,+255.75]	2	32
3.1	108 000	3 600	6 750.0	14 000	14 000	[-512,+511.75]	4	16
3.2	216 000	5 120	7 680.0	20 000	20 000	[-512,+511.75]	4	16
4	245 760	8 192	12 288.0	20 000	25 000	[-512,+511.75]	4	16
4.1	245 760	8 192	12 288.0	50 000	62 500	[-512,+511.75]	2	16
4.2	522 240	8 704	13 056.0	50 000	62 500	[-512,+511.75]	2	16
5	589 824	22 080	41 400.0	135 000	135 000	[-512,+511.75]	2	16
5.1	983 040	36 864	69 120.0	240 000	240 000	[-512,+511.75]	2	16

Levels with non-integer level numbers in Table A-1 are referred to as “intermediate levels”.

NOTE 2 – All levels have the same status, but some applications may choose to use only the integer-numbered levels.

Informative subclause A.3.4 shows the effect of these limits on frame rates for several example picture formats.

A.3.2 Level limits common to the High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles

Let the variable fR be derived as follows.

– If picture n is a frame, fR is set equal to 1 ÷ 172.

– Otherwise (picture n is a field), fR is set equal to 1 ÷ (172 * 2).

Bitstreams conforming to the High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles at a specified level shall obey the following constraints:

a) The nominal removal time of access unit n (with n > 0) from the CPB as specified in subclause C.1.2, satisfies the constraint that $t_{r,n}(n) - t_r(n - 1)$ is greater than or equal to Max(PicSizeInMbs ÷ MaxMBPS, fR), where MaxMBPS is the value specified in Table A-1 that applies to picture n – 1, and PicSizeInMbs is the number of macroblocks in picture n – 1.

b) The difference between consecutive output times of pictures from the DPB as specified in subclause C.2.2, satisfies the constraint that $\Delta t_{o,dpb}(n)$ >= Max(PicSizeInMbs ÷ MaxMBPS, fR), where MaxMBPS is the value specified in Table A-1 for picture n, and PicSizeInMbs is the number of macroblocks of picture n, provided that picture n is a picture that is output and is not the last picture of the bitstream that is output.

c) PicWidthInMbs * FrameHeightInMbs <= MaxFS, where MaxFS is specified in Table A-1.

d) PicWidthInMbs <= Sqrt(MaxFS * 8).

e) FrameHeightInMbs <= Sqrt(MaxFS * 8).

f) max_dec_frame_buffering <= MaxDpbSize, where MaxDpbSize is equal to Min(1024 * MaxDPB / (PicWidthInMbs * FrameHeightInMbs * 384), 16) and MaxDPB is specified in Table A-1.

g) Vertical motion vector component range does not exceed MaxVmvR in units of luma frame samples, where MaxVmvR is specified in Table A-1.

h) Horizontal motion vector range does not exceed the range of -2048 to 2047.75, inclusive, in units of luma samples.

i) Number of motion vectors per two consecutive macroblocks in decoding order (also applying to the total from the last macroblock of a slice and the first macroblock of the next slice in decoding order) does not exceed MaxMvsPer2Mb, where MaxMvsPer2Mb is specified in Table A-1. The number of motion vectors for each macroblock is value of the variable MvCnt after the completion of the intra or inter prediction process for the macroblock.

j) Number of bits of macroblock_layer( ) data for any macroblock is not greater than 128 + RawMbBits. Depending on entropy_coding_mode_flag, the bits of macroblock_layer( ) data are counted as follows.

   – If entropy_coding_mode_flag is equal to 0, the number of bits of macroblock_layer( ) data is given by the number of bits in the macroblock_layer( ) syntax structure for a macroblock.

   – Otherwise (entropy_coding_mode_flag is equal to 1), the number of bits of macroblock_layer( ) data for a macroblock is given by the number of times read_bits(1) is called in subclauses 9.3.3.2.2 and 9.3.3.2.3 when parsing the macroblock_layer( ) associated with the macroblock.

Table A-1 specifies the limits for each level. Entries marked "-" in Table A-1 denote the absence of a corresponding limit. The use of the MinCR parameter column of Table A-1 for these profiles is specified in subclause A.3.3.

A level to which the bitstream conforms shall be indicated by the syntax element level_idc as follows.

– If level_idc is equal to 9, the indicated level is level 1b.

– Otherwise (level_idc is not equal to 9), level_idc shall be set equal to a value of ten times the level number specified in Table A-1.

A.3.3 Profile-specific level limits

a) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, the removal time of access unit 0 shall satisfy the constraint that the number of slices in picture 0 is less than or equal to (PicSizeInMbs + MaxMBPS * (t_r(0) - $t_{r,n}$(0))) ÷ SliceRate, where SliceRate is the value specified in Table A-4 that applies to picture 0.

b) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, the difference between consecutive removal time of access units n and n - 1 (with n > 0) shall satisfy the constraint that the number of slices in picture n is less than or equal to MaxMBPS * (t_r(n) - t_r(n - 1)) ÷ SliceRate, where SliceRate is the value specified in Table A-4 that applies to picture n.

c) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, sequence parameter sets shall have direct_8x8_inference_flag equal to 1 for the levels specified in Table A-4.

   NOTE 1 – direct_8x8_inference_flag is not relevant to the Baseline profile as it does not allow B slice types (specified in subclause A.2.1), and direct_8x8_inference_flag is equal to 1 for all levels of the Extended profile (specified in subclause A.2.3).

d) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, CAVLC 4:4:4 Intra, or Extended profiles, sequence parameter sets shall have frame_mbs_only_flag equal to 1 for the levels specified in Table A-4 for the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles and in Table A-5 for the Extended profile.

   NOTE 2 – frame_mbs_only_flag is equal to 1 for all levels of the Baseline profile (specified in subclause A.2.1).

e) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, CAVLC 4:4:4 Intra, or Extended profiles, the value of sub_mb_type in B macroblocks shall not be equal to B_Bi_8x4, B_Bi_4x8, or B_Bi_4x4 for the levels in which MinLumaBiPredSize is shown as 8x8 in Table A-4 for the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles and in Table A-5 for the Extended profile.

f) In bitstreams conforming to the Baseline or Extended profiles, ($xInt_{max} - xInt_{min} + 6$) * ($yInt_{max} - yInt_{min} + 6$) <= MaxSubMbRectSize in macroblocks coded with mb_type equal to P_8x8, P_8x8ref0 or B_8x8 for all invocations of the process specified in subclause 8.4.2.2.1 used to generate the predicted luma sample array for a single reference picture list (reference picture list 0 or reference picture list 1) for each 8x8 sub-macroblock, where NumSubMbPart(sub_mb_type) > 1, where MaxSubMbRectSize is specified in Table A-3 for the Baseline profile and in Table A-5 for the Extended profile and

- $xInt_{min}$ is the minimum value of $xInt_L$ among all luma sample predictions for the sub-macroblock,
- $xInt_{max}$ is the maximum value of $xInt_L$ among all luma sample predictions for the sub-macroblock,
- $yInt_{min}$ is the minimum value of $yInt_L$ among all luma sample predictions for the sub-macroblock,
- $yInt_{max}$ is the maximum value of $yInt_L$ among all luma sample predictions for the sub-macroblock.

g) In bitstreams conforming to the High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, for the VCL HRD parameters, BitRate[SchedSelIdx] <= cpbBrVclFactor * MaxBR and CpbSize[SchedSelIdx] <= cpbBrVclFactor * MaxCPB for at least one value of SchedSelIdx, where cpbBrVclFactor is specified in Table A-2, BitRate[SchedSelIdx] is specified by Equation E-37 and CpbSize[SchedSelIdx] is specified by Equation E-38 when vcl_hrd_parameters_present_flag is equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of cpbBrVclFactor bits/s and cpbBrVclFactor bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1, inclusive.

h) In bitstreams conforming to the High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, for the NAL HRD parameters, BitRate[SchedSelIdx] <= cpbBrNalFactor * MaxBR and CpbSize[SchedSelIdx] <= cpbBrNalFactor * MaxCPB for at least one value of SchedSelIdx, where cpbBrNalFactor is specified in Table A-2, BitRate[SchedSelIdx] is specified by Equation E-37 and CpbSize[SchedSelIdx] is specified by Equation E-38 when nal_hrd_parameters_present_flag equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of cpbBrNalFactor bits/s and cpbBrNalFactor bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1.

i) In bitstreams conforming to the High profile, the sum of the NumBytesInNALunit variables for access unit 0 is less than or equal to 384 * (PicSizeInMbs + MaxMBPS * ($t_r(0) - t_{r,n}(0)$)) ÷ MinCR, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture 0 and PicSizeInMbs is the number of macroblocks in picture 0.

NOTE 2 – Such a limit involving MinCR is not imposed for bitstream conformance to the High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles.

j) In bitstreams conforming to the High profile, the sum of the NumBytesInNALunit variables for access unit n (with n > 0) is less than or equal to 384 * MaxMBPS * ($t_r(n) - t_r(n - 1)$) ÷ MinCR, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture n.

NOTE 3 – Such a limit involving MinCR is not imposed for bitstream conformance to the High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles.

k) In bitstreams conforming to the High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, when PicSizeInMbs is greater than 1620, the number of macroblocks in any coded slice shall not exceed MaxFS / 4, where MaxFS is specified in Table A-1.

NOTE 4 – Items i), j), and k) above are included herein for purposes of specification of the High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles. The aspects of these items as they relate to the High, High 10, and High 4:2:2 profiles are included herein for completeness, and reflect corrections of the intended specification of these profiles.

Table A-2 – Specification of cpbBrVclFactor and cpbBrNalFactor

Profile	cpbBrVclFactor	cpbBrNalFactor
High	1 250	1 500
High 10 **High 10 Intra**	3 000	3 600
High 4:2:2 **High 4:2:2 Intra**	4 000	4 800
High 4:4:4 Predictive **High 4:4:4 Intra** **CAVLC 4:4:4 Intra**	4 000	4 800

A.3.3.1 Baseline profile level limits

Table A-3 specifies limits for each level that are specific to bitstreams conforming to the Baseline profile. Entries marked "-" in Table A-3 denote the absence of a corresponding limit.

Table A-3 – Baseline profile level limits

Level number	MaxSubMbRectSize
1	576
1b	576
1.1	576
1.2	576
1.3	576
2	576
2.1	576
2.2	576
3	576
3.1	-
3.2	-
4	-
4.1	-
4.2	-
5	-
5.1	-

A.3.3.2 Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profile level limits

Table A-4 specifies limits for each level that are specific to bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles. Entries marked "-" in Table A-4 denote the absence of a corresponding limit.

Table A-4 – Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profile level limits

Level number	SliceRate	MinLumaBiPredSize	direct_8x8_inference_flag	frame_mbs_only_flag
1	-	-	-	1
1b	-	-	-	1
1.1	-	-	-	1
1.2	-	-	-	1
1.3	-	-	-	1
2	-	-	-	1
2.1	-	-	-	-
2.2	-	-	-	-
3	22	-	1	-
3.1	60	8x8	1	-
3.2	60	8x8	1	-
4	60	8x8	1	-
4.1	24	8x8	1	-
4.2	24	8x8	1	1
5	24	8x8	1	1
5.1	24	8x8	1	1

A.3.3.3 Extended Profile level limits

Table A-5 specifies limits for each level that are specific to bitstreams conforming to the Extended profile. Entries marked "-" in Table A-5 denote the absence of a corresponding limit.

Table A-5 – Extended profile level limits

Level number	MaxSubMbRectSize	MinLumaBiPredSize	frame_mbs_only_flag
1	576	-	1
1b	576	-	1
1.1	576	-	1
1.2	576	-	1
1.3	576	-	1
2	576	-	1
2.1	576	-	-
2.2	576	-	-
3	576	-	-
3.1	-	8x8	-
3.2	-	8x8	-
4	-	8x8	-
4.1	-	8x8	-
4.2	-	8x8	1
5	-	8x8	1
5.1	-	8x8	1

A.3.4 Effect of level limits on frame rate (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Table A-6 – Maximum frame rates (frames per second) for some example frame sizes

Level:					**1**	**1b**	**1.1**	**1.2**	**1.3**	**2**	**2.1**
Max frame size (macroblocks):					**99**	**99**	**396**	**396**	**396**	**396**	**792**
Max macroblocks/second:					**1 485**	**1 485**	**3 000**	**6 000**	**11 880**	**11 880**	**19 800**
Max frame size (samples):					25 344	25 344	101 376	101 376	101 376	101 376	202 752
Max samples/second:					380 160	380 160	768 000	1 536 000	3 041 280	3 041 280	5 068 800
Format	**Luma Width**	**Luma Height**	**MBs Total**	**Luma Samples**							
SQCIF	**128**	**96**	48	12 288	30.9	30.9	62.5	125.0	172.0	172.0	172.0
QCIF	**176**	**144**	99	25 344	15.0	15.0	30.3	60.6	120.0	120.0	172.0
QVGA	**320**	**240**	300	76 800	-	-	10.0	20.0	39.6	39.6	66.0
525 SIF	**352**	**240**	330	84 480	-	-	9.1	18.2	36.0	36.0	60.0
CIF	**352**	**288**	396	101 376	-	-	7.6	15.2	30.0	30.0	50.0
525 HHR	**352**	**480**	660	168 960	-	-	-	-	-	-	30.0
625 HHR	**352**	**576**	792	202 752	-	-	-	-	-	-	25.0
VGA	**640**	**480**	1 200	307 200	-	-	-	-	-	-	-
525 4SIF	**704**	**480**	1 320	337 920	-	-	-	-	-	-	-
525 SD	**720**	**480**	1 350	345 600	-	-	-	-	-	-	-
4CIF	**704**	**576**	1 584	405 504	-	-	-	-	-	-	-
625 SD	**720**	**576**	1 620	414 720	-	-	-	-	-	-	-
SVGA	**800**	**600**	1 900	486 400	-	-	-	-	-	-	-
XGA	**1024**	**768**	3 072	786 432	-	-	-	-	-	-	-
720p HD	**1280**	**720**	3 600	921 600	-	-	-	-	-	-	-
4VGA	**1280**	**960**	4 800	1 228 800	-	-	-	-	-	-	-
SXGA	**1280**	**1024**	5 120	1 310 720	-	-	-	-	-	-	-
525 16SIF	**1408**	**960**	5 280	1 351 680	-	-	-	-	-	-	-
16CIF	**1408**	**1152**	6 336	1 622 016	-	-	-	-	-	-	-
4SVGA	**1600**	**1200**	7 500	1 920 000	-	-	-	-	-	-	-
1080 HD	**1920**	**1088**	8 160	2 088 960	-	-	-	-	-	-	-
2Kx1K	**2048**	**1024**	8 192	2 097 152	-	-	-	-	-	-	-
2Kx1080	**2048**	**1088**	8 704	2 228 224	-	-	-	-	-	-	-
4XGA	**2048**	**1536**	12 288	3 145 728	-	-	-	-	-	-	-
16VGA	**2560**	**1920**	19 200	4 915 200	-	-	-	-	-	-	-
3616x1536 (2.35:1)	**3616**	**1536**	21 696	5 554 176	-	-	-	-	-	-	-
3672x1536 (2.39:1)	**3680**	**1536**	22 080	5 652 480	-	-	-	-	-	-	-
4Kx2K	**4096**	**2048**	32 768	8 388 608	-	-	-	-	-	-	-
4096x2304 (16:9)	**4096**	**2304**	36 864	9 437 184	-	-	-	-	-	-	-

Table A-6 (continued) – Maximum frame rates (frames per second) for some example frame sizes

Level:					**2.2**	**3**	**3.1**	**3.2**	**4**	**4.1**	**4.2**
Max frame size (macroblocks):					**1 620**	**1 620**	**3 600**	**5 120**	**8 192**	**8 192**	**8 704**
Max macroblocks/second:					**20 250**	**40 500**	**108 000**	**216 000**	**245 760**	**245 760**	**522 240**
Max frame size (samples):					414 720	414 720	921 600	1 310 720	2 097 152	2 097 152	2 228 224
Max samples/second:					5 184 000	10 368 000	27 648 000	55 296 000	62 914 560	62 914 560	133 693 440
Format	**Luma Width**	**Luma Height**	**MBs Total**	**Luma Samples**							
SQCIF	**128**	**96**	48	12 288	172.0	172.0	172.0	172.0	172.0	172.0	172.0
QCIF	**176**	**144**	99	25 344	172.0	172.0	172.0	172.0	172.0	172.0	172.0
QVGA	**320**	**240**	300	76 800	67.5	135.0	172.0	172.0	172.0	172.0	172.0
525 SIF	**352**	**240**	330	84 480	61.4	122.7	172.0	172.0	172.0	172.0	172.0
CIF	**352**	**288**	396	101 376	51.1	102.3	172.0	172.0	172.0	172.0	172.0
525 HHR	**352**	**480**	660	168 960	30.7	61.4	163.6	172.0	172.0	172.0	172.0
625 HHR	**352**	**576**	792	202 752	25.6	51.1	136.4	172.0	172.0	172.0	172.0
VGA	**640**	**480**	1 200	307 200	16.9	33.8	90.0	172.0	172.0	172.0	172.0
525 4SIF	**704**	**480**	1 320	337 920	15.3	30.7	81.8	163.6	172.0	172.0	172.0
525 SD	**720**	**480**	1 350	345 600	15.0	30.0	80.0	160.0	172.0	172.0	172.0
4CIF	**704**	**576**	1 584	405 504	12.8	25.6	68.2	136.4	155.2	155.2	172.0
625 SD	**720**	**576**	1 620	414 720	12.5	25.0	66.7	133.3	151.7	151.7	172.0
SVGA	**800**	**600**	1 900	486 400	-	-	56.8	113.7	129.3	129.3	172.0
XGA	**1024**	**768**	3 072	786 432	-	-	35.2	70.3	80.0	80.0	172.0
720p HD	**1280**	**720**	3 600	921 600	-	-	30.0	60.0	68.3	68.3	145.1
4VGA	**1280**	**960**	4 800	1 228 800	-	-	-	45.0	51.2	51.2	108.8
SXGA	**1280**	**1024**	5 120	1 310 720	-	-	-	42.2	48.0	48.0	102.0
525 16SIF	**1408**	**960**	5 280	1 351 680	-	-	-	-	46.5	46.5	98.9
16CIF	**1408**	**1152**	6 336	1 622 016	-	-	-	-	38.8	38.8	82.4
4SVGA	**1600**	**1200**	7 500	1 920 000	-	-	-	-	32.8	32.8	69.6
1080 HD	**1920**	**1088**	8 160	2 088 960	-	-	-	-	30.1	30.1	64.0
2Kx1K	**2048**	**1024**	8 192	2 097 152	-	-	-	-	30.0	30.0	63.8
2Kx1080	**2048**	**1088**	8 704	2 228 224	-	-	-	-	-	-	60.0
4XGA	**2048**	**1536**	12 288	3 145 728	-	-	-	-	-	-	-
16VGA	**2560**	**1920**	19 200	4 915 200	-	-	-	-	-	-	-
3616x1536 (2.35:1)	**3616**	**1536**	21 696	5 554 176	-	-	-	-	-	-	-
3672x1536 (2.39:1)	**3680**	**1536**	22 080	5 652 480	-	-	-	-	-	-	-
4Kx2K	**4096**	**2048**	32 768	8 388 608	-	-	-	-	-	-	-
4096x2304 (16:9)	**4096**	**2304**	36 864	9 437 184	-	-	-	-	-	-	-

Table A-6 (concluded) – Maximum frame rates (frames per second) for some example frame sizes

Level:					**5**	**5.1**
Max frame size (macroblocks):					**22 080**	**36 864**
Max macroblocks/second:					**589 824**	**983 040**
Max frame size (samples):					5 652 480	9 437 184
Max samples/second:					150 994 944	251 658 240
Format	**Luma Width**	**Luma Height**	**MBs Total**	**Luma Samples**		
SQCIF	**128**	**96**	48	12 288	172.0	172.0
QCIF	**176**	**144**	99	25 344	172.0	172.0
QVGA	**320**	**240**	300	76 800	172.0	172.0
525 SIF	**352**	**240**	330	84 480	172.0	172.0
CIF	**352**	**288**	396	101 376	172.0	172.0
525 HHR	**352**	**480**	660	168 960	172.0	172.0
625 HHR	**352**	**576**	792	202 752	172.0	172.0
VGA	**640**	**480**	1 200	307 200	172.0	172.0
525 4SIF	**704**	**480**	1 320	337 920	172.0	172.0
525 SD	**720**	**480**	1 350	345 600	172.0	172.0
4CIF	**704**	**576**	1 584	405 504	172.0	172.0
625 SD	**720**	**576**	1 620	414 720	172.0	172.0
SVGA	**800**	**600**	1 900	486 400	172.0	172.0
XGA	**1024**	**768**	3 072	786 432	172.0	172.0
720p HD	**1280**	**720**	3 600	921 600	163.8	172.0
4VGA	**1280**	**960**	4 800	1 228 800	122.9	172.0
SXGA	**1280**	**1024**	5 120	1 310 720	115.2	172.0
525 16SIF	**1408**	**960**	5 280	1 351 680	111.7	172.0
16CIF	**1408**	**1152**	6 336	1 622 016	93.1	155.2
4SVGA	**1600**	**1200**	7 500	1 920 000	78.6	131.1
1080 HD	**1920**	**1088**	8 160	2 088 960	72.3	120.5
2Kx1K	**2048**	**1024**	8 192	2 097 152	72.0	120.0
2Kx1080	**2048**	**1088**	8 704	2 228 224	67.8	112.9
4XGA	**2048**	**1536**	12 288	3 145 728	48.0	80.0
16VGA	**2560**	**1920**	19 200	4 915 200	30.7	51.2
3616x1536 (2.35:1)	**3616**	**1536**	21 696	5 554 176	27.2	45.3
3672x1536 (2.39:1)	**3680**	**1536**	22 080	5 652 480	26.7	44.5
4Kx2K	**4096**	**2048**	32 768	8 388 608	-	30.0
4096x2304 (16:9)	**4096**	**2304**	36 864	9 437 184	-	26.7

The following should be noted.

– This Recommendation | International Standard is a variable-frame-size specification. The specific frame sizes in Table A-6 are illustrative examples only.

– As used in Table A-6, "525" refers to typical use for environments using 525 analogue scan lines (of which approximately 480 lines contain the visible picture region), and "625" refers to environments using 625 analogue scan lines (of which approximately 576 lines contain the visible picture region).

– XGA is also known as (aka) XVGA, 4SVGA aka UXGA, 16XGA aka 4Kx3K, CIF aka 625 SIF, 625 HHR aka 2CIF aka half 625 D-1, aka half 625 ITU-R BT.601, 525 SD aka 525 D-1 aka 525 ITU-R BT.601, 625 SD aka 625 D-1 aka 625 ITU-R BT.601.

– Frame rates given are correct for progressive scan modes. The frame rates are also correct for interlaced video coding for the cases of frame height divisible by 32.

Annex B
Byte stream format

(This annex forms an integral part of this Recommendation | International Standard)

This annex specifies syntax and semantics of a byte stream format specified for use by applications that deliver some or all of the NAL unit stream as an ordered stream of bytes or bits within which the locations of NAL unit boundaries need to be identifiable from patterns in the data, such as ITU-T Rec. H.222.0 | ISO/IEC 13818-1 systems or ITU-T Rec. H.320 systems. For bit-oriented delivery, the bit order for the byte stream format is specified to start with the MSB of the first byte, proceed to the LSB of the first byte, followed by the MSB of the second byte, etc.

The byte stream format consists of a sequence of byte stream NAL unit syntax structures. Each byte stream NAL unit syntax structure contains one start code prefix followed by one nal_unit(NumBytesInNALunit) syntax structure. It may (and under some circumstances, it shall) also contain an additional zero_byte syntax element. It may also contain one or more additional trailing_zero_8bits syntax elements. When it is the first byte stream NAL unit in the bitstream, it may also contain one or more additional leading_zero_8bits syntax elements.

B.1 Byte stream NAL unit syntax and semantics

B.1.1 Byte stream NAL unit syntax

byte_stream_nal_unit(NumBytesInNALunit) {	C	Descriptor
while(next_bits(24) != 0x000001 && next_bits(32) != 0x00000001)		
leading_zero_8bits /* equal to 0x00 */		f(8)
if(next_bits(24) != 0x000001)		
zero_byte /* equal to 0x00 */		f(8)
start_code_prefix_one_3bytes /* equal to 0x000001 */		f(24)
nal_unit(NumBytesInNALunit)		
while(more_data_in_byte_stream( ) && next_bits(24) != 0x000001 && next_bits(32) != 0x00000001)		
trailing_zero_8bits /* equal to 0x00 */		f(8)
}		

B.1.2 Byte stream NAL unit semantics

The order of byte stream NAL units in the byte stream shall follow the decoding order of the NAL units contained in the byte stream NAL units (see subclause 7.4.1.2). The content of each byte stream NAL unit is associated with the same access unit as the NAL unit contained in the byte stream NAL unit (see subclause 7.4.1.2.3).

leading_zero_8bits is a byte equal to 0x00.

NOTE – The leading_zero_8bits syntax element can only be present in the first byte stream NAL unit of the bitstream, because (as shown in the syntax diagram of subclause B.1.1) any bytes equal to 0x00 that follow a NAL unit syntax structure and precede the four-byte sequence 0x00000001 (which is to be interpreted as a zero_byte followed by a start_code_prefix_one_3bytes) will be considered to be trailing_zero_8bits syntax elements that are part of the preceding byte stream NAL unit.

zero_byte is a single byte equal to 0x00.

When any of the following conditions are fulfilled, the zero_byte syntax element shall be present.

– the nal_unit_type within the nal_unit( ) is equal to 7 (sequence parameter set) or 8 (picture parameter set),

– the byte stream NAL unit syntax structure contains the first NAL unit of an access unit in decoding order, as specified by subclause 7.4.1.2.3.

start_code_prefix_one_3bytes is a fixed-value sequence of 3 bytes equal to 0x000001. This syntax element is called a start code prefix.

trailing_zero_8bits is a byte equal to 0x00.

B.2 Byte stream NAL unit decoding process

Input to this process consists of an ordered stream of bytes consisting of a sequence of byte stream NAL unit syntax structures.

Output of this process consists of a sequence of NAL unit syntax structures.

At the beginning of the decoding process, the decoder initialises its current position in the byte stream to the beginning of the byte stream. It then extracts and discards each leading_zero_8bits syntax element (if present), moving the current position in the byte stream forward one byte at a time, until the current position in the byte stream is such that the next four bytes in the bitstream form the four-byte sequence 0x00000001.

The decoder then performs the following step-wise process repeatedly to extract and decode each NAL unit syntax structure in the byte stream until the end of the byte stream has been encountered (as determined by unspecified means) and the last NAL unit in the byte stream has been decoded:

1. When the next four bytes in the bitstream form the four-byte sequence 0x00000001, the next byte in the byte stream (which is a zero_byte syntax element) is extracted and discarded and the current position in the byte stream is set equal to the position of the byte following this discarded byte.
2. The next three-byte sequence in the byte stream (which is a start_code_prefix_one_3bytes) is extracted and discarded and the current position in the byte stream is set equal to the position of the byte following this three-byte sequence.
3. NumBytesInNALunit is set equal to the number of bytes starting with the byte at the current position in the byte stream up to and including the last byte that precedes the location of any of the following conditions:
    a. A subsequent byte-aligned three-byte sequence equal to 0x000000, or
    b. A subsequent byte-aligned three-byte sequence equal to 0x000001, or
    c. The end of the byte stream, as determined by unspecified means.
4. NumBytesInNALunit bytes are removed from the bitstream and the current position in the byte stream is advanced by NumBytesInNALunit bytes. This sequence of bytes is nal_unit(NumBytesInNALunit) and is decoded using the NAL unit decoding process.
5. When the current position in the byte stream is not at the end of the byte stream (as determined by unspecified means) and the next bytes in the byte stream do not start with a three-byte sequence equal to 0x000001 and the next bytes in the byte stream do not start with a four byte sequence equal to 0x00000001, the decoder extracts and discards each trailing_zero_8bits syntax element, moving the current position in the byte stream forward one byte at a time, until the current position in the byte stream is such that the next bytes in the byte stream form the four-byte sequence 0x00000001 or the end of the byte stream has been encountered (as determined by unspecified means).

B.3 Decoder byte-alignment recovery (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Many applications provide data to a decoder in a manner that is inherently byte aligned, and thus have no need for the bit-oriented byte alignment detection procedure described in this subclause.

A decoder is said to have byte-alignment with a bitstream when the decoder is able to determine whether or not the positions of data in the bitstream are byte-aligned. When a decoder does not have byte alignment with the encoder's byte stream, the decoder may examine the incoming bitstream for the binary pattern '00000000 00000000 00000000 00000001' (31 consecutive bits equal to 0 followed by a bit equal to 1). The bit immediately following this pattern is the first bit of an aligned byte following a start code prefix. Upon detecting this pattern, the decoder will be byte aligned with the encoder and positioned at the start of a NAL unit in the byte stream.

Once byte aligned with the encoder, the decoder can examine the incoming byte stream for subsequent three-byte sequences 0x000001 and 0x000003.

When the three-byte sequence 0x000001 is detected, this is a start code prefix.

When the three-byte sequence 0x000003 is detected, the third byte (0x03) is an emulation_prevention_three_byte to be discarded as specified in subclause 7.4.1.

When an error in the bitstream syntax is detected (e.g., a non-zero value of the forbidden_zero_bit or one of the three-byte or four-byte sequences that are prohibited in subclause 7.4.1), the decoder may consider the detected condition as an indication that byte alignment may have been lost and may discard all bitstream data until the detection of byte alignment at a later position in the bitstream as described in this subclause.

Annex C
Hypothetical reference decoder

(This annex forms an integral part of this Recommendation | International Standard)

This annex specifies the hypothetical reference decoder (HRD) and its use to check bitstream and decoder conformance.

Two types of bitstreams are subject to HRD conformance checking for this Recommendation | International Standard. The first such type of bitstream, called Type I bitstream, is a NAL unit stream containing only the VCL NAL units and filler data NAL units for all access units in the bitstream. The second type of bitstream, called a Type II bitstream, contains, in addition to the VCL NAL units and filler data NAL units for all access units in the bitstream, at least one of the following.

– additional non-VCL NAL units other than filler data NAL units.

– all leading_zero_8bits, zero_byte, start_code_prefix_one_3bytes, and trailing_zero_8bits syntax elements that form a byte stream from the NAL unit stream (as specified in Annex B).

Figure C-1 shows the types of bitstream conformance points checked by the HRD.

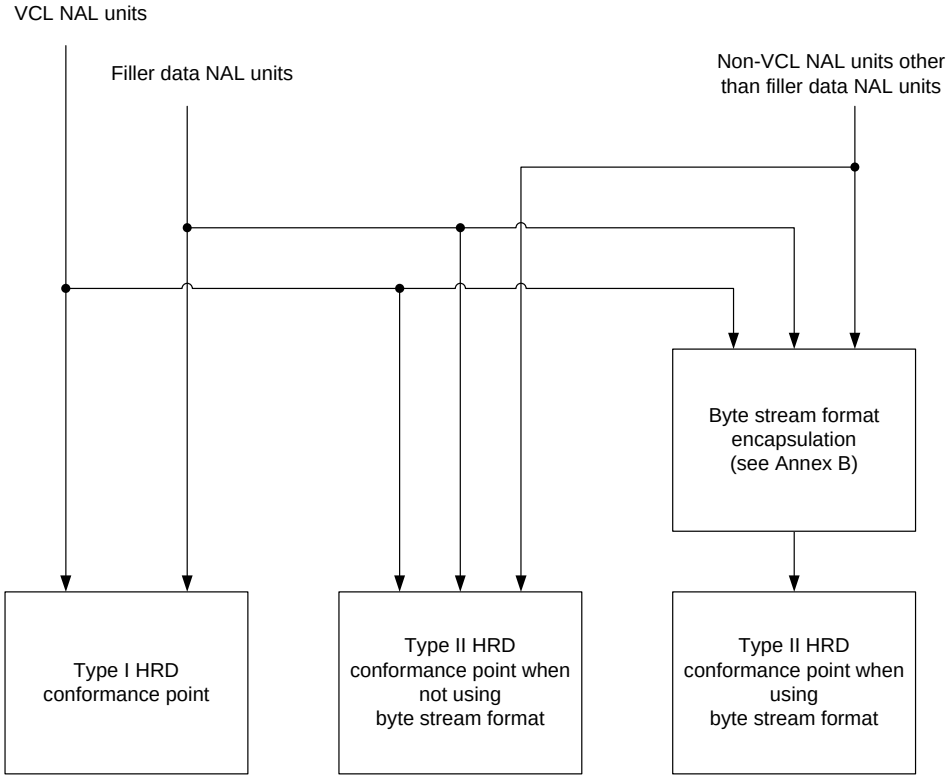


Figure C-1 – Structure of byte streams and NAL unit streams for HRD conformance checks

The syntax elements of non-VCL NAL units (or their default values for some of the syntax elements), required for the HRD, are specified in the semantic subclauses of clause 7 and Annexes D and E.

Two types of HRD parameter sets are used. The HRD parameter sets are signalled through video usability information as specified in subclauses E.1 and E.2, which is part of the sequence parameters set syntax structure.

In order to check conformance of a bitstream using the HRD, all sequence parameter sets and picture parameters sets referred to in the VCL NAL units, and corresponding buffering period and picture timing SEI messages shall be conveyed to the HRD, in a timely manner, either in the bitstream (by non-VCL NAL units), or by other means not specified in this Recommendation | International Standard.

In Annexes C, D and E, the specification for "presence" of non-VCL NAL units is also satisfied when those NAL units (or just some of them) are conveyed to decoders (or to the HRD) by other means not specified by this Recommendation | International Standard. For the purpose of counting bits, only the appropriate bits that are actually present in the bitstream are counted.

NOTE 1 – As an example, synchronization of a non-VCL NAL unit, conveyed by means other than presence in the bitstream, with the NAL units that are present in the bitstream, can be achieved by indicating two points in the bitstream, between which the non-VCL NAL unit would have been present in the bitstream, had the encoder decided to convey it in the bitstream.

When the content of a non-VCL NAL unit is conveyed for the application by some means other than presence within the bitstream, the representation of the content of the non-VCL NAL unit is not required to use the same syntax specified in this annex.

NOTE 2 – When HRD information is contained within the bitstream, it is possible to verify the conformance of a bitstream to the requirements of this subclause based solely on information contained in the bitstream. When the HRD information is not present in the bitstream, as is the case for all "stand-alone" Type I bitstreams, conformance can only be verified when the HRD data is supplied by some other means not specified in this Recommendation | International Standard.

The HRD contains a coded picture buffer (CPB), an instantaneous decoding process, a decoded picture buffer (DPB), and output cropping as shown in Figure C-2.

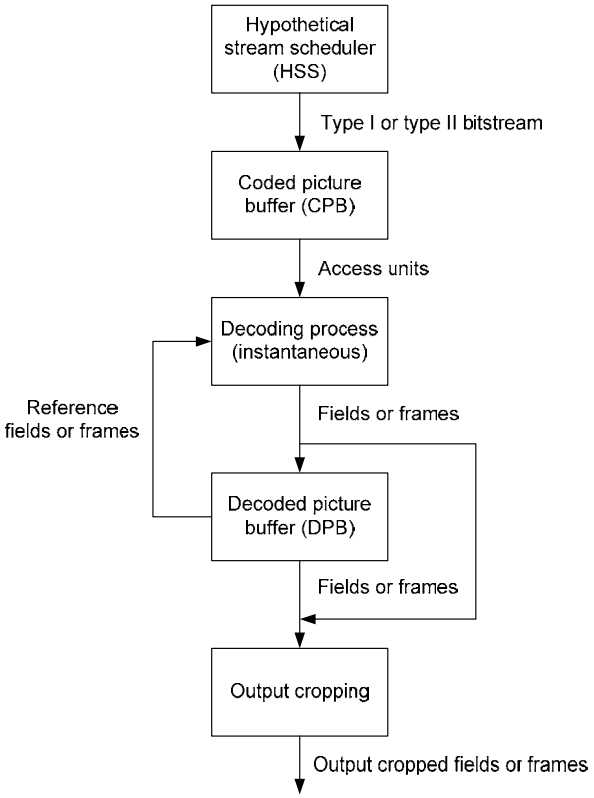


Figure C-2 – HRD buffer model

The CPB size (number of bits) is CpbSize[SchedSelIdx]. The DPB size (number of frame buffers) is Max(1, max_dec_frame_buffering).

The HRD operates as follows. Data associated with access units that flow into the CPB according to a specified arrival schedule are delivered by the HSS. The data associated with each access unit are removed and decoded instantaneously by the instantaneous decoding process at CPB removal times. Each decoded picture is placed in the DPB at its CPB removal time unless it is output at its CPB removal time and is a non-reference picture. When a picture is placed in the DPB it is removed from the DPB at the later of the DPB output time or the time that it is marked as "unused for reference".

For each picture in the bitstream, the variable OutputFlag for the decoded picture and, when applicable, the reference base picture is set as follows.

– If the coded video sequence containing the picture conforms to one or more of the profiles specified in Annex A and the decoding process specified in clauses 2-9 is used), OutputFlag is set equal to 1.

– Otherwise (the coded video sequence containing the picture conforms to a profile specified in Annex G and the decoding process specified in Annex G is used), the following applies.
  – For a reference base picture, OutputFlag is set equal to 0.
  – For a decoded picture, OutputFlag is set equal to the value of the output_flag syntax element of the target layer representation.

The operation of the CPB is specified in subclause C.1. The instantaneous decoder operation is specified in clauses 8 and 9. The operation of the DPB is specified in subclause C.2. The output cropping is specified in subclause C.2.2.

HSS and HRD information concerning the number of enumerated delivery schedules and their associated bit rates and buffer sizes is specified in subclauses E.1.1, E.1.2, E.2.1 and E.2.2. The HRD is initialised as specified by the buffering period SEI message as specified in subclauses D.1.1 and D.2.1. The removal timing of access units from the CPB and output timing from the DPB are specified in the picture timing SEI message as specified in subclauses D.1.2 and D.2.2. All timing information relating to a specific access unit shall arrive prior to the CPB removal time of the access unit.

The HRD is used to check conformance of bitstreams and decoders as specified in subclauses C.3 and C.4, respectively.

NOTE 3 – While conformance is guaranteed under the assumption that all frame-rates and clocks used to generate the bitstream match exactly the values signalled in the bitstream, in a real system each of these may vary from the signalled or specified value.

All the arithmetic in this annex is done with real values, so that no rounding errors can propagate. For example, the number of bits in a CPB just prior to or after removal of an access unit is not necessarily an integer.

The variable t_c is derived as follows and is called a clock tick.

$$t_c = num\_units\_in\_tick \div time\_scale \quad (C\text{-}1)$$

The following is specified for expressing the constraints in this annex.

– Let access unit n be the n-th access unit in decoding order with the first access unit being access unit 0.

– Let picture n be the primary coded picture or the decoded primary picture of access unit n.

C.1 Operation of coded picture buffer (CPB)

The specifications in this subclause apply independently to each set of CPB parameters that is present and to both the Type I and Type II conformance points shown in Figure C-1.

C.1.1 Timing of bitstream arrival

The HRD may be initialised at any one of the buffering period SEI messages. Prior to initialisation, the CPB is empty.

NOTE – After initialisation, the HRD is not initialised again by subsequent buffering period SEI messages.

Each access unit is referred to as access unit n, where the number n identifies the particular access unit. The access unit that is associated with the buffering period SEI message that initialises the CPB is referred to as access unit 0. The value of n is incremented by 1 for each subsequent access unit in decoding order.

The time at which the first bit of access unit n begins to enter the CPB is referred to as the initial arrival time $t_{ai}(n)$.

The initial arrival time of access units is derived as follows.

– If the access unit is access unit 0, $t_{ai}(0) = 0$,

– Otherwise (the access unit is access unit n with $n > 0$), the following applies.
  – If cbr_flag[SchedSelIdx] is equal to 1, the initial arrival time for access unit n, is equal to the final arrival time (which is derived below) of access unit n - 1, i.e.,

$$t_{ai}(n) = t_{af}(n - 1) \quad (C\text{-}2)$$

  – Otherwise (cbr_flag[SchedSelIdx] is equal to 0), the initial arrival time for access unit n is derived by

$$t_{ai}(n) = Max(t_{af}(n - 1), t_{ai,earliest}(n)) \quad (C\text{-}3)$$

where $t_{ai,earliest}(n)$ is derived as follows

– If access unit n is not the first access unit of a subsequent buffering period, $t_{ai,earliest}(n)$ is derived as

$$t_{ai,earliest}(n) = t_{r,n}(n) - (initial\_cpb\_removal\_delay[SchedSelIdx] + initial\_cpb\_removal\_delay\_offset[SchedSelIdx]) \div 90000 \quad (C\text{-}4)$$

with $t_{r,n}(n)$ being the nominal removal time of access unit n from the CPB as specified in subclause C.1.2 and initial_cpb_removal_delay[SchedSelIdx] and initial_cpb_removal_delay_offset[SchedSelIdx] being specified in the previous buffering period SEI message.

– Otherwise (access unit n is the first access unit of a subsequent buffering period), $t_{ai,earliest}(n)$ is derived as

$$t_{ai,earliest}(n) = t_{r,n}(n) - (initial\_cpb\_removal\_delay[SchedSelIdx] \div 90000) \quad (C\text{-}5)$$

with initial_cpb_removal_delay[SchedSelIdx] being specified in the buffering period SEI message associated with access unit n.

The final arrival time for access unit n is derived by

$$t_{af}(n) = t_{ai}(n) + b(n) \div BitRate[SchedSelIdx] \quad (C\text{-}6)$$

where b(n) is the size in bits of access unit n, counting the bits of the VCL NAL units and the filler data NAL units for the Type I conformance point or all bits of the Type II bitstream for the Type II conformance point, where the Type I and Type II conformance points are as shown in Figure C-1.

The values of SchedSelIdx, BitRate[SchedSelIdx], and CpbSize[SchedSelIdx] are constrained as follows.

– If the content of the active sequence parameter sets for access unit n and access unit n – 1 differ, the HSS selects a value SchedSelIdx1 of SchedSelIdx from among the values of SchedSelIdx provided in the active sequence parameter set for access unit n that results in a BitRate[SchedSelIdx1] or CpbSize[SchedSelIdx1] for access unit n. The value of BitRate[SchedSelIdx1] or CpbSize[SchedSelIdx1] may differ from the value of BitRate[SchedSelIdx0] or CpbSize[SchedSelIdx0] for the value SchedSelIdx0 of SchedSelIdx that was in use for access unit n - 1.

– Otherwise, the HSS continues to operate with the previous values of SchedSelIdx, BitRate[SchedSelIdx] and CpbSize[SchedSelIdx].

When the HSS selects values of BitRate[SchedSelIdx] or CpbSize[SchedSelIdx] that differ from those of the previous access unit, the following applies.

– the variable BitRate[SchedSelIdx] comes into effect at time $t_{ai}(n)$.

– the variable CpbSize[SchedSelIdx] comes into effect as follows.

  – If the new value of CpbSize[SchedSelIdx] exceeds the old CPB size, it comes into effect at time $t_{ai}(n)$,

  – Otherwise, the new value of CpbSize[SchedSelIdx] comes into effect at the time $t_r(n)$.

C.1.2 Timing of coded picture removal

For access unit 0, the nominal removal time of the access unit from the CPB is specified by

$$t_{r,n}(0) = initial\_cpb\_removal\_delay[SchedSelIdx] \div 90000 \quad (C\text{-}7)$$

For the first access unit of a buffering period that does not initialise the HRD, the nominal removal time of the access unit from the CPB is specified by

$$t_{r,n}(n) = t_{r,n}(n_b) + t_c * cpb\_removal\_delay(n) \quad (C\text{-}8)$$

where $t_{r,n}(n_b)$ is the nominal removal time of the first access unit of the previous buffering period and cpb_removal_delay(n) is the value of cpb_removal_delay specified in the picture timing SEI message associated with access unit n.

When an access unit n is the first access unit of a buffering period, n_b is set equal to n at the removal time of access unit n.

The nominal removal time $t_{r,n}(n)$ of an access unit n that is not the first access unit of a buffering period is given by

$$t_{r,n}(n) = t_{r,n}(n_b) + t_c * cpb\_removal\_delay(n) \quad (C\text{-}9)$$

where $t_{r,n}(n_b)$ is the nominal removal time of the first access unit of the current buffering period and cpb_removal_delay(n) is the value of cpb_removal_delay specified in the picture timing SEI message associated with access unit n.

The removal time of access unit n is specified as follows.

– If low_delay_hrd_flag is equal to 0 or $t_{r,n}(n) >= t_{af}(n)$, the removal time of access unit n is specified by

$$t_r(n) = t_{r,n}(n) \quad (C\text{-}10)$$

– Otherwise (low_delay_hrd_flag is equal to 1 and $t_{r,n}(n) < t_{af}(n)$), the removal time of access unit n is specified by

$$t_r(n) = t_{r,n}(n) + t_c * Ceil((t_{af}(n) - t_{r,n}(n)) \div t_c) \quad (C\text{-}11)$$

NOTE – The latter case indicates that the size of access unit n, b(n), is so large that it prevents removal at the nominal removal time.

C.2 Operation of the decoded picture buffer (DPB)

The decoded picture buffer contains frame buffers. When decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, each of the frame buffers may contain a decoded frame, a decoded complementary field pair or a single (non-paired) decoded field that are marked as "used for reference" (reference pictures) or are held for future output (reordered or delayed pictures). When decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G, each frame buffer may contain a decoded frame, a decoded complementary field pair, a single (non-paired) decoded field, a decoded reference base frame, a decoded reference base complementary field pair or a single (non-paired) decoded reference base field that are marked as "used for reference" (reference pictures) or are held for future output (reordered or delayed pictures). Prior to initialisation, the DPB is empty (the DPB fullness is set to zero). The following steps of the subclauses of this subclause all happen instantaneously at $t_r(n)$ and in the sequence listed.

C.2.1 Decoding of gaps in frame_num and storage of "non-existing" frames

If applicable, gaps in frame_num are detected by the decoding process and the generated frames are marked and inserted into the DPB as specified below.

Gaps in frame_num are detected by the decoding process and the generated frames are marked as specified in subclause 8.2.5.2.

After the marking of each generated frame, each picture m marked by the “sliding window” process as “unused for reference” is removed from the DPB when it is also marked as "non-existing" or its DPB output time is less than or equal to the CPB removal time of the current picture n; i.e., $t_{o,dpb}(m) <= t_r(n)$, or it has OutputFlag equal to 0. When a frame or the last field in a frame buffer is removed from the DPB, the DPB fullness is decremented by one. The “non-existing” generated frame is inserted into the DPB and the DPB fullness is incremented by one.

C.2.2 Picture decoding and output

Picture n is decoded. When it has OutputFlag equal to 1, its DPB output time $t_{o,dpb}(n)$ is derived by

$$t_{o,dpb}(n) = t_r(n) + t_c * dpb\_output\_delay(n) \quad (C\text{-}12)$$

The output of the current picture is specified as follows.

– If OutputFlag is equal to 1 and $t_{o,dpb}(n) = t_r(n)$, the current picture is output.
NOTE – When the current picture is a reference picture it will be stored in the DPB.

– Otherwise, if OutputFlag is equal to 0, the current picture is not output, but it may be stored in the DPB as specified in subclause C.2.4.

– Otherwise (OutputFlag is equal to 1 and $t_{o,dpb}(n) > t_r(n)$), the current picture is output later and will be stored in the DPB (as specified in subclause C.2.4) and is output at time $t_{o,dpb}(n)$ unless indicated not to be output by the decoding or inference of no_output_of_prior_pics_flag equal to 1 at a time that precedes $t_{o,dpb}(n)$.

When output, the picture shall be cropped, using the cropping rectangle specified in the active sequence parameter set for the picture.

When picture n is a picture that is output and is not the last picture of the bitstream that is output, the value of $\Delta t_{o,dpb}(n)$ is defined as:

$$\Delta t_{o,dpb}(n) = t_{o,dpb}(n_n) - t_{o,dpb}(n) \quad \text{(C-13)}$$

where n_n indicates the picture that follows after picture n in output order and has OutputFlag equal to 1.

The decoded picture is temporarily stored (not in the DPB).

C.2.3 Removal of pictures from the DPB before possible insertion of the current picture

The removal of pictures from the DPB before possible insertion of the current picture proceeds as follows.

– If the decoded picture is an IDR picture the following applies.
  – All reference pictures in the DPB are marked as "unused for reference" as specified in subclause 8.2.5.1 when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, or as specified in subclause G.8.2.4when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G.
  – When the IDR picture is not the first IDR picture decoded and the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the active sequence parameter set is different from the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the sequence parameter set that was active for the preceding picture, respectively, no_output_of_prior_pics_flag is inferred to be equal to 1 by the HRD, regardless of the actual value of no_output_of_prior_pics_flag.

    NOTE – Decoder implementations should try to handle frame or DPB size changes more gracefully than the HRD in regard to changes in PicWidthInMbs or FrameHeightInMbs.
  – When no_output_of_prior_pics_flag is equal to 1 or is inferred to be equal to 1, all frame buffers in the DPB are emptied without output of the pictures they contain, and DPB fullness is set to 0.

– Otherwise (the decoded picture is not an IDR picture), the following applies.
  – If the slice header of the current picture includes memory_management_control_operation equal to 5, all reference pictures in the DPB are marked as "unused for reference".
  – Otherwise (the slice header of the current picture does not include memory_management_control_operation equal to 5), the decoded reference picture marking process specified in subclause 8.2.5 is invoked when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, or the decoded reference picture marking process specified in subclause G.8.2.4 is invoked when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G.

All pictures m in the DPB, for which all of the following conditions are true, are removed from the DPB.

– picture m is marked as “unused for reference” or picture m is a non-reference picture. When a picture is a reference frame, it is considered to be marked as "unused for reference" only when both of its fields have been marked as "unused for reference".

– picture m is marked as "non-existing" or it has OutputFlag equal to 0 or its DPB output time is less than or equal to the CPB removal time of the current picture n; i.e., $t_{o,dpb}(m) <= t_r(n)$

When a frame or the last field in a frame buffer is removed from the DPB, the DPB fullness is decremented by one.

C.2.4 Current decoded picture marking and storage

C.2.4.1 Marking and storage of a reference decoded picture into the DPB

When the current picture is a reference picture it is stored in the DPB as follows.

– If the current decoded picture is a second field (in decoding order) of a complementary reference field pair, and the first field of the pair is still in the DPB, the current decoded picture is stored in the same frame buffer as the first field of the pair.

– Otherwise, the current decoded picture is stored in an empty frame buffer, and the DPB fullness is incremented by one.

C.2.4.2 Storage of a non-reference picture into the DPB

When the current picture is a non-reference picture and current picture n has $t_{o,dpb}(n) > t_r(n)$, it is stored in the DPB as follows.

– If the current decoded picture is a second field (in decoding order) of a complementary non-reference field pair, and the first field of the pair is still in the DPB, the current decoded picture is stored in the same frame buffer as the first field of the pair.

– Otherwise, the current decoded picture is stored in an empty frame buffer, and the DPB fullness is incremented by one.

C.3 Bitstream conformance

A bitstream of coded data conforming to this Recommendation | International Standard fulfils the following requirements.

The bitstream is constructed according to the syntax, semantics, and constraints specified in this Recommendation | International Standard outside of this annex.

The bitstream is tested by the HRD as specified below:

For Type I bitstreams, the number of tests carried out is equal to cpb_cnt_minus1 + 1 where cpb_cnt_minus1 is either the syntax element of hrd_parameters( ) following the vcl_hrd_parameters_present_flag or is determined by the application by other means not specified in this Recommendation | International Standard. One test is carried out for each bit rate and CPB size combination specified by hrd_parameters( ) following the vcl_hrd_parameters_present_flag. Each of these tests is conducted at the Type I conformance point shown in Figure C-1.

For Type II bitstreams there are two sets of tests. The number of tests of the first set is equal to cpb_cnt_minus1 + 1 where cpb_cnt_minus1 is either the syntax element of hrd_parameters( ) following the vcl_hrd_parameters_present_flag or is determined by the application by other means not specified in this Recommendation | International Standard. One test is carried out for each bit rate and CPB size combination. Each of these tests is conducted at the Type I conformance point shown in Figure C-1. For these tests, only VCL and filler data NAL units are counted for the input bit rate and CPB storage.

The number of tests of the second set, for Type II bitstreams, is equal to cpb_cnt_minus1 + 1 where cpb_cnt_minus1 is either the syntax element of hrd_parameters( ) following the nal_hrd_parameters_present_flag or is determined by the application by other means not specified in this Recommendation | International Standard. One test is carried out for each bit rate and CPB size combination specified by hrd_parameters( ) following the nal_hrd_parameters_present_flag. Each of these tests is conducted at the Type II conformance point shown in Figure C-1. For these tests, all NAL units (of a Type II NAL unit stream) or all bytes (of a byte stream) are counted for the input bit rate and CPB storage.

NOTE 1 – NAL HRD parameters established by a value of SchedSelIdx for the Type II conformance point shown in Figure C-1 are sufficient to also establish VCL HRD conformance for the Type I conformance point shown in Figure C-1 for the same values of initial_cpb_removal_delay[SchedSelIdx], BitRate[SchedSelIdx], and CpbSize[SchedSelIdx] for the VBR case (cbr_flag[SchedSelIdx] equal to 0). This is because the data flow into the Type I conformance point is a subset of the data flow into the Type II conformance point and because, for the VBR case, the CPB is allowed to become empty and stay empty until the time a next picture is scheduled to begin to arrive. For example, when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, when NAL HRD parameters are provided for the Type II conformance point that not only fall within the bounds set for NAL HRD parameters for profile conformance in item j of subclause A.3.1 or item i of subclause A.3.3 (depending on the profile in use) but also fall within the bounds set for VCL HRD parameters for profile conformance in item i of subclause A.3.1 or item h of subclause A.3.3 (depending on the profile in use), conformance of the VCL HRD for the Type I conformance point is also assured to fall within the bounds of item i of subclause A.3.1.

For conforming bitstreams, all of the following conditions shall be fulfilled for each of the tests.

– For each access unit n, with n>0, associated with a buffering period SEI message, with $\Delta t_{g,90}(n)$ specified by

$$\Delta t_{g,90}(n) = 90000 * (t_{r,n}(n) - t_{af}(n - 1)) \quad \text{(C-14)}$$

The value of initial_cpb_removal_delay[SchedSelIdx] shall be constrained as follows.

– If cbr_flag[SchedSelIdx] is equal to 0,

$$\text{initial\_cpb\_removal\_delay[SchedSelIdx]} <= \text{Ceil}(\Delta t_{g,90}(n)) \quad \text{(C-15)}$$

– Otherwise (cbr_flag[SchedSelIdx] is equal to 1),

$$\text{Floor}(\Delta t_{g,90}(n)) <= \text{initial\_cpb\_removal\_delay}[\text{SchedSelIdx}] <= \text{Ceil}(\Delta t_{g,90}(n)) \quad \text{(C-16)}$$

NOTE 2 – The exact number of bits in the CPB at the removal time of each picture may depend on which buffering period SEI message is selected to initialise the HRD. Encoders must take this into account to ensure that all specified constraints must be obeyed regardless of which buffering period SEI message is selected to initialise the HRD, as the HRD may be initialised at any one of the buffering period SEI messages.

– A CPB overflow is specified as the condition in which the total number of bits in the CPB is larger than the CPB size. The CPB shall never overflow.

– A CPB underflow is specified as the condition in which tr,n(n) is less than taf(n). When low_delay_hrd_flag is equal to 0, the CPB shall never underflow.

– The nominal removal times of pictures from the CPB (starting from the second picture in decoding order), shall satisfy the constraints on $t_{r,n}(n)$ and $t_r(n)$ expressed in subclauses A.3.1 through A.3.3 for the profile and level specified in the bitstream when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, and they shall satisfy the constraints on tr,n(n) and tr(n) expressed in subclauses G.10.2.1 and G.10.2.2 for profile and level specified in the bitstream when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G.

– Immediately after any decoded picture is added to the DPB, the fullness of the DPB shall be less than or equal to the DPB size as constrained by Annexes A, D, and E for the profile and level specified in the bitstream.

– All reference pictures shall be present in the DPB when needed for prediction. Each picture shall be present in the DPB at its DPB output time unless it is not stored in the DPB at all, or is removed from the DPB before its output time by one of the processes specified in subclause C.2.

– The value of $\Delta_{to,dpb}(n)$ as given by Equation C-13, which is the difference between the output time of a picture and that of the first picture following it in output order and having OutputFlag equal to 1, shall satisfy the constraint expressed in subclause A.3.1 for the profile and level specified in the bitstream when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, and it shall satisfy the constraint expressed in subclause G.10.2.1 for profile and level specified in the bitstream when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G.

C.4 Decoder conformance

A decoder conforming to this Recommendation | International Standard fulfils the following requirements.

A decoder claiming conformance to a specific profile and level shall be able to decode successfully all conforming bitstreams specified for decoder conformance in subclause C.3, provided that all sequence parameter sets and picture parameters sets referred to in the VCL NAL units, and appropriate buffering period and picture timing SEI messages are conveyed to the decoder, in a timely manner, either in the bitstream (by non-VCL NAL units), or by external means not specified by this Recommendation | International Standard.

There are two types of conformance that can be claimed by a decoder: output timing conformance and output order conformance.

To check conformance of a decoder, test bitstreams conforming to the claimed profile and level, as specified by subclause C.3 are delivered by a hypothetical stream scheduler (HSS) both to the HRD and to the decoder under test (DUT). All pictures output by the HRD shall also be output by the DUT and, for each picture output by the HRD, the values of all samples that are output by the DUT for the corresponding picture shall be equal to the values of the samples output by the HRD.

For output timing decoder conformance, the HSS operates as described above, with delivery schedules selected only from the subset of values of SchedSelIdx for which the bit rate and CPB size are restricted as specified in Annex A for the specified profile and level, or with "interpolated" delivery schedules as specified below for which the bit rate and CPB size are restricted as specified in Annex A. The same delivery schedule is used for both the HRD and DUT.

When the HRD parameters and the buffering period SEI messages are present with cpb_cnt_minus1 greater than 0, the decoder shall be capable of decoding the bitstream as delivered from the HSS operating using an "interpolated" delivery schedule specified as having peak bit rate r, CPB size c(r), and initial CPB removal delay (f(r) ÷ r) as follows

$$\alpha = (r - \text{BitRate}[\text{SchedSelIdx} - 1]) \div (\text{BitRate}[\text{SchedSelIdx}] - \text{BitRate}[\text{SchedSelIdx} - 1]), \quad \text{(C-17)}$$

$$c(r) = \alpha * CpbSize[SchedSelIdx] + (1 – \alpha) * CpbSize[SchedSelIdx-1], \quad \text{(C-18)}$$

$$f(r) = \alpha * initial\_cpb\_removal\_delay[SchedSelIdx] * BitRate[SchedSelIdx] + (1 – \alpha) * initial\_cpb\_removal\_delay[SchedSelIdx - 1] * BitRate[SchedSelIdx - 1] \quad \text{(C-19)}$$

for any SchedSelIdx > 0 and r such that BitRate[SchedSelIdx - 1] <= r <= BitRate[SchedSelIdx] such that r and c(r) are within the limits as specified in Annex A for the maximum bit rate and buffer size for the specified profile and level.

NOTE 1 – initial_cpb_removal_delay[SchedSelIdx] can be different from one buffering period to another and have to be re-calculated.

For output timing decoder conformance, an HRD as described above is used and the timing (relative to the delivery time of the first bit) of picture output is the same for both HRD and the DUT up to a fixed delay.

For output order decoder conformance, the HSS delivers the bitstream to the DUT "by demand" from the DUT, meaning that the HSS delivers bits (in decoding order) only when the DUT requires more bits to proceed with its processing.

NOTE 2 – This means that for this test, the coded picture buffer of the DUT could be as small as the size of the largest access unit.

A modified HRD as described below is used, and the HSS delivers the bitstream to the HRD by one of the schedules specified in the bitstream such that the bit rate and CPB size are restricted as specified in Annex A. The order of pictures output shall be the same for both HRD and the DUT.

For output order decoder conformance, the HRD CPB size is equal to CpbSize[SchedSelIdx] for the selected schedule and the DPB size is equal to MaxDpbSize. Removal time from the CPB for the HRD is equal to final bit arrival time and decoding is immediate. The operation of the DPB of this HRD is described below.

C.4.1 Operation of the output order DPB

The decoded picture buffer contains frame buffers. When decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, each of the frame buffers may contain a decoded frame, a decoded complementary field pair or a single (non-paired) decoded field that is marked as "used for reference" or is held for future output (reordered pictures). When decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G, each frame buffer may contain a decoded frame, a decoded complementary field pair, a single (non-paired) decoded field, a decoded reference base frame, a decoded reference base complementary field pair or a single (non-paired) decoded reference base field that are marked as "used for reference" (reference pictures) or are held for future output (reordered or delayed pictures). At HRD initialisation, the DPB fullness, measured in frames, is set to 0. The following steps all happen instantaneously when an access unit is removed from the CPB, and in the order listed.

C.4.2 Decoding of gaps in frame_num and storage of "non-existing" pictures

When applicable, gaps in frame_num are detected by the decoding process and the necessary number of "non-existing" frames are inferred in the order specified by the generation of values of UnusedShortTermFrameNum in Equation 7-22 and are marked as specified in subclause 8.2.5.2. Frame buffers containing a frame or a complementary field pair or a non-paired field which are marked as "not needed for output" and "unused for reference" are emptied (without output), and the DPB fullness is decremented by the number of frame buffers emptied. Each "non-existing" frame is stored in the DPB as follows.

- When there is no empty frame buffer (i.e., DPB fullness is equal to DPB size), the "bumping" process specified in subclause C.4.5.3 is invoked repeatedly until there is an empty frame buffer in which to store the "non-existing" frame.
- The "non-existing" frame is stored in an empty frame buffer and is marked as "not needed for output", and the DPB fullness is incremented by one.

C.4.3 Picture decoding

Primary coded picture n is decoded and is temporarily stored (not in the DPB).

C.4.4 Removal of pictures from the DPB before possible insertion of the current picture

The removal of pictures from the DPB before possible insertion of the current picture proceeds as follows.

– If the decoded picture is an IDR picture the following applies.
  – All reference pictures in the DPB are marked as "unused for reference" as specified in subclause 8.2.5 when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, or as specified in subclause G.8.2.4 when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G.
  – When the IDR picture is not the first IDR picture decoded and the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the active sequence parameter set is different from the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the sequence parameter set that was active for the preceding picture, respectively, no_output_of_prior_pics_flag is inferred to be equal to 1 by the HRD, regardless of the actual value of no_output_of_prior_pics_flag.

    NOTE – Decoder implementations should try to handle changes in the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering more gracefully than the HRD.
  – When no_output_of_prior_pics_flag is equal to 1 or is inferred to be equal to 1, all frame buffers in the DPB are emptied without output of the pictures they contain, and DPB fullness is set to 0.

– Otherwise (the decoded picture is not an IDR picture), the decoded reference picture marking process is invoked as specified in subclause 8.2.5 when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, or as specified in subclause G.8.2.4 when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G. Frame buffers containing a frame or a complementary field pair or a non-paired field which are marked as "not needed for output" and "unused for reference" are emptied (without output), and the DPB fullness is decremented by the number of frame buffers emptied.

When the current picture has a memory_management_control_operation equal to 5 or is an IDR picture for which no_output_of_prior_pics_flag is not equal to 1 and is not inferred to be equal to 1, the following two steps are performed.

1. Frame buffers containing a frame or a complementary field pair or a non-paired field which are marked as "not needed for output" and "unused for reference" are emptied (without output), and the DPB fullness is decremented by the number of frame buffers emptied.
2. All non-empty frame buffers in the DPB are emptied by repeatedly invoking the “bumping” process specified in subclause C.4.5.3, and the DPB fullness is set to 0.

C.4.5 Current decoded picture marking and storage

C.4.5.1 Storage and marking of a reference decoded picture into the DPB

When the current picture is a reference picture, it is stored in the DPB as follows.

– If the current decoded picture is the second field (in decoding order) of a complementary reference field pair, and the first field of the pair is still in the DPB, the current picture is stored in the same frame buffer as the first field of the pair and the following applies.
  – If the current decoded picture has OutputFlag equal to 1, it is marked as "needed for output".
  – Otherwise (the current decoded picture has OutputFlag equal to 0), it is marked as "not needed for output".
– Otherwise, the following operations are performed:
  – When there is no empty frame buffer (i.e., DPB fullness is equal to DPB size), the "bumping" process specified in subclause C.4.5.3 is invoked repeatedly until there is an empty frame buffer in which to store the current decoded picture.
  – The current decoded picture is stored in an empty frame buffer, the DPB fullness is incremented by one, and the following applies.
    – If the current decoded picture has OutputFlag equal to 1, it is marked as “needed for output”.
    – Otherwise (the current decoded picture has OutputFlag equal to 0), it is marked as “not needed for output”.

C.4.5.2 Storage and marking of a non-reference decoded picture into the DPB

When the current picture is a non-reference picture, the following operations are performed.

– If the current decoded picture is the second field (in decoding order) of a complementary non-reference field pair and the first field of the pair is still in the DPB, the current picture is stored in the same frame buffer as the first field of the pair and the following applies.
  – If the current decoded picture has OutputFlag equal to 1, it is marked as "needed for output".
  – Otherwise (the current decoded picture has OutputFlag equal to 0), it is marked as "not needed for output".
– Otherwise, if the current picture has OutputFlag equal to 0, the DPB is not modified and the current picture is not output.
– Otherwise, the following operations are performed repeatedly until the current decoded picture has been cropped and output or has been stored in the DPB:
  – If there is no empty frame buffer (i.e., DPB fullness is equal to DPB size), the following applies.
    – If the current picture does not have a lower value of PicOrderCnt( ) than all pictures in the DPB that are marked as "needed for output", the "bumping" process described in subclause C.4.5.3 is performed.
    – Otherwise (the current picture has a lower value of PicOrderCnt( ) than all pictures in the DPB that are marked as "needed for output"), the current picture is cropped, using the cropping rectangle specified in the active sequence parameter set for the picture and the cropped picture is output.
  – Otherwise (there is an empty frame buffer, i.e., DPB fullness is less than DPB size) the current decoded picture is stored in an empty frame buffer and is marked as "needed for output", and the DPB fullness is incremented by one.

C.4.5.3 "Bumping" process

The "bumping" process is invoked in the following cases.

– There is no empty frame buffer (i.e., DPB fullness is equal to DPB size) and an empty frame buffer is needed for storage of an inferred "non-existing" frame, as specified in subclause C.4.2.
– The current picture is an IDR picture and no_output_of_prior_pics_flag is not equal to 1 and is not inferred to be equal to 1, as specified in subclause C.4.4.
– The current picture has memory_management_control_operation equal to 5, as specified in subclause C.4.4.
– There is no empty frame buffer (i.e., DPB fullness is equal to DPB size) and an empty frame buffer is needed for storage of a decoded (non-IDR) reference picture, as specified in subclause C.4.5.1.
– There is no empty frame buffer (i.e., DPB fullness is equal to DPB size) and the current picture is a non-reference picture that is not the second field of a complementary non-reference field pair and the current picture has OutputFlag equal to 1 and there are pictures in the DPB that are marked as "needed for output" that precede the current non-reference picture in output order, as specified in subclause C.4.5.2, so an empty buffer is needed for storage of the current picture.

The "bumping" process consists of the following:

– The picture or complementary reference field pair that is first for output is selected as follows.
  – The frame buffer is selected that contains the picture having the smallest value of PicOrderCnt( ) of all pictures in the DPB marked as "needed for output".
  – If this frame buffer contains a complementary non-reference field pair with both fields marked as "needed for output" and both fields have the same PicOrderCnt( ), the first of these two fields in decoding order is considered first for output.
  – Otherwise, if this frame buffer contains a complementary reference field pair with both fields marked as "needed for output" and both fields have the same PicOrderCnt( ), the entire complementary reference field pair is considered first for output.
  – Otherwise, the picture in this frame buffer that has the smallest value of PicOrderCnt( ) is considered first for output.
– If a single picture is considered first for output, this picture is cropped, using the cropping rectangle specified in the active sequence parameter set for the picture, the cropped picture is output, and the picture is marked as "not needed for output".

– Otherwise (a complementary reference field pair is considered first for output), the two fields of the complementary reference field pair are both cropped, using the cropping rectangle specified in the active sequence parameter set for the pictures, the two fields of the complementary reference field pair are output together, and both fields of the complementary reference field pair are marked as "not needed for output".
– The frame buffer that included the picture or complementary reference field pair that was cropped and output is checked, and when any of the following conditions is satisfied, the frame buffer is emptied and the DPB fullness is decremented by 1.
  – The frame buffer contains a non-reference non-paired field.
  – The frame buffer contains a non-reference frame.
  – The frame buffer contains a complementary non-reference field pair with both fields marked as "not needed for output".
  – The frame buffer contains a non-paired reference field marked as "unused for reference".
  – The frame buffer contains a reference frame with both fields marked as "unused for reference".
  – The frame buffer contains a complementary reference field pair with both fields marked as "unused for reference" and "not needed for output".

Annex D
Supplemental enhancement information

(This annex forms an integral part of this Recommendation | International Standard)

This annex specifies syntax and semantics for SEI message payloads.

SEI messages assist in processes related to decoding, display or other purposes. However, SEI messages are not required for constructing the luma or chroma samples by the decoding process. Conforming decoders are not required to process this information for output order conformance to this Recommendation | International Standard (see Annex C for the specification of conformance). Some SEI message information is required to check bitstream conformance and for output timing decoder conformance.

In Annex D, specification for presence of SEI messages are also satisfied when those messages (or some subset of them) are conveyed to decoders (or to the HRD) by other means not specified by this Recommendation | International Standard. When present in the bitstream, SEI messages shall obey the syntax and semantics specified in subclauses 7.3.2.3 and 7.4.2.3 and this annex. When the content of an SEI message is conveyed for the application by some means other than presence within the bitstream, the representation of the content of the SEI message is not required to use the same syntax specified in this annex. For the purpose of counting bits, only the appropriate bits that are actually present in the bitstream are counted.

D.1 SEI payload syntax

sei_payload(payloadType, payloadSize) {	C	Descriptor
if(payloadType == 0)		
buffering_period(payloadSize)	5	
else if(payloadType == 1)		
pic_timing(payloadSize)	5	
else if(payloadType == 2)		
pan_scan_rect(payloadSize)	5	
else if(payloadType == 3)		
filler_payload(payloadSize)	5	
else if(payloadType == 4)		
user_data_registered_itu_t_t35(payloadSize)	5	
else if(payloadType == 5)		
user_data_unregistered(payloadSize)	5	
else if(payloadType == 6)		
recovery_point(payloadSize)	5	
else if(payloadType == 7)		
dec_ref_pic_marking_repetition(payloadSize)	5	
else if(payloadType == 8)		
spare_pic(payloadSize)	5	
else if(payloadType == 9)		
scene_info(payloadSize)	5	
else if(payloadType == 10)		
sub_seq_info(payloadSize)	5	
else if(payloadType == 11)		
sub_seq_layer_characteristics(payloadSize)	5	
else if(payloadType == 12)		
sub_seq_characteristics(payloadSize)	5	

else if(payloadType = = 13)		
full_frame_freeze(payloadSize)	5	
else if(payloadType = = 14)		
full_frame_freeze_release(payloadSize)	5	
else if(payloadType = = 15)		
full_frame_snapshot(payloadSize)	5	
else if(payloadType = = 16)		
progressive_refinement_segment_start(payloadSize)	5	
else if(payloadType = = 17)		
progressive_refinement_segment_end(payloadSize)	5	
else if(payloadType = = 18)		
motion_constrained_slice_group_set(payloadSize)	5	
else if(payloadType = = 19)		
film_grain_characteristics(payloadSize)	5	
else if(payloadType = = 20)		
deblocking_filter_display_preference(payloadSize)	5	
else if(payloadType = = 21)		
stereo_video_info(payloadSize)	5	
else if(payloadType = = 22)		
post_filter_hint(payloadSize)	5	
else if(payloadType = = 23)		
tone_mapping_info(payloadSize)	5	
else if(payloadType = = 24)		
scalability_info(payloadSize) /* specified in Annex G */	5	
else if(payloadType = = 25)		
sub_pic_scalable_layer(payloadSize) /* specified in Annex G */	5	
else if(payloadType = = 26)		
non_required_layer_rep(payloadSize) /* specified in Annex G */	5	
else if(payloadType = = 27)		
priority_layer_info(payloadSize) /* specified in Annex G */	5	
else if(payloadType = = 28)		
layers_not_present(payloadSize) /* specified in Annex G */	5	
else if(payloadType = = 29)		
layer_dependency_change(payloadSize) /* specified in Annex G */	5	
else if(payloadType = = 30)		
scalable_nesting(payloadSize) /* specified in Annex G */	5	
else if(payloadType = = 31)		
base_layer_temporal_hrd(payloadSize) /* specified in Annex G */	5	
else if(payloadType = = 32)		
quality_layer_integrity_check(payloadSize) /* specified in Annex G */	5	
else if(payloadType = = 33)		
redundant_pic_property(payloadSize) /* specified in Annex G */	5	
else if(payloadType = = 34)		
tl0_picture_index(payloadSize) /* specified in Annex G */	5	
else if(payloadType = = 35)		
tl_switching_point(payloadSize) /* specified in Annex G */	5	
else		

reserved_sei_message(payloadSize)	5	
if(!byte_aligned( )) {		
bit_equal_to_one /* equal to 1 */	5	f(1)
while(!byte_aligned( ))		
bit_equal_to_zero /* equal to 0 */	5	f(1)
}		
}		

D.1.1 Buffering period SEI message syntax

buffering_period(payloadSize) {	C	Descriptor
seq_parameter_set_id	5	ue(v)
if(NalHrdBpPresentFlag) {		
for(SchedSelIdx = 0; SchedSelIdx <= cpb_cnt_minus1; SchedSelIdx++) {		
initial_cpb_removal_delay[SchedSelIdx **]**	5	u(v)
initial_cpb_removal_delay_offset[SchedSelIdx **]**	5	u(v)
}		
}		
if(VclHrdBpPresentFlag) {		
for(SchedSelIdx = 0; SchedSelIdx <= cpb_cnt_minus1; SchedSelIdx++) {		
initial_cpb_removal_delay[SchedSelIdx **]**	5	u(v)
initial_cpb_removal_delay_offset[SchedSelIdx **]**	5	u(v)
}		
}		
}		

D.1.2 Picture timing SEI message syntax

pic_timing(payloadSize) {	C	Descriptor
if(CpbDpbDelaysPresentFlag) {		
cpb_removal_delay	5	u(v)
dpb_output_delay	5	u(v)
}		
if(pic_struct_present_flag) {		
pic_struct	5	u(4)
for(i = 0; i < NumClockTS ; i++) {		
clock_timestamp_flag[i]	5	u(1)
if(clock_timestamp_flag[i]) {		
ct_type	5	u(2)
nuit_field_based_flag	5	u(1)
counting_type	5	u(5)
full_timestamp_flag	5	u(1)
discontinuity_flag	5	u(1)
cnt_dropped_flag	5	u(1)
n_frames	5	u(8)
if(full_timestamp_flag) {		

seconds_value /* 0..59 */	5	u(6)
minutes_value /* 0..59 */	5	u(6)
hours_value /* 0..23 */	5	u(5)
} else {		
seconds_flag	5	u(1)
if(seconds_flag) {		
seconds_value /* range 0..59 */	5	u(6)
minutes_flag	5	u(1)
if(minutes_flag) {		
minutes_value /* 0..59 */	5	u(6)
hours_flag	5	u(1)
if(hours_flag)		
hours_value /* 0..23 */	5	u(5)
}		
}		
}		
if(time_offset_length > 0)		
time_offset	5	i(v)
}		
}		
}		
}		

D.1.3 Pan-scan rectangle SEI message syntax

pan_scan_rect(payloadSize) {	C	Descriptor
pan_scan_rect_id	5	ue(v)
pan_scan_rect_cancel_flag	5	u(1)
if(!pan_scan_rect_cancel_flag) {		
pan_scan_cnt_minus1	5	ue(v)
for(i = 0; i <= pan_scan_cnt_minus1; i++) {		
pan_scan_rect_left_offset[i **]**	5	se(v)
pan_scan_rect_right_offset[i **]**	5	se(v)
pan_scan_rect_top_offset[i **]**	5	se(v)
pan_scan_rect_bottom_offset[i **]**	5	se(v)
}		
pan_scan_rect_repetition_period	5	ue(v)
}		
}		

D.1.4 Filler payload SEI message syntax

filler_payload(payloadSize) {	C	Descriptor
for(k = 0; k < payloadSize; k++)		
ff_byte /* equal to 0xFF */	5	f(8)
}		

D.1.5 User data registered by ITU-T Rec. T.35 SEI message syntax

user_data_registered_itu_t_t35(payloadSize) {	C	Descriptor
itu_t_t35_country_code	5	b(8)
if(itu_t_t35_country_code != 0xFF)		
i = 1		
else {		
itu_t_t35_country_code_extension_byte	5	b(8)
i = 2		
}		
do {		
itu_t_t35_payload_byte	5	b(8)
i++		
} while(i < payloadSize)		
}		

D.1.6 User data unregistered SEI message syntax

user_data_unregistered(payloadSize) {	C	Descriptor
uuid_iso_iec_11578	**5**	u(128)
for(i = 16; i < payloadSize; i++)		
user_data_payload_byte	5	b(8)
}		

D.1.7 Recovery point SEI message syntax

recovery_point(payloadSize) {	C	Descriptor
recovery_frame_cnt	5	ue(v)
exact_match_flag	5	u(1)
broken_link_flag	5	u(1)
changing_slice_group_idc	5	u(2)
}		

D.1.8 Decoded reference picture marking repetition SEI message syntax

dec_ref_pic_marking_repetition(payloadSize) {	C	Descriptor
original_idr_flag	5	u(1)
original_frame_num	5	ue(v)
if(!frame_mbs_only_flag) {		
original_field_pic_flag	5	u(1)
if(original_field_pic_flag)		
original_bottom_field_flag	5	u(1)
}		
dec_ref_pic_marking( )	5	
}		

D.1.9 Spare picture SEI message syntax

spare_pic(payloadSize) {	C	Descriptor
target_frame_num	5	ue(v)
spare_field_flag	5	u(1)
if(spare_field_flag)		
target_bottom_field_flag	5	u(1)
num_spare_pics_minus1	5	ue(v)
for(i = 0; i < num_spare_pics_minus1 + 1; i++) {		
delta_spare_frame_num[i **]**	5	ue(v)
if(spare_field_flag)		
spare_bottom_field_flag[i **]**	5	u(1)
spare_area_idc[i **]**	5	ue(v)
if(spare_area_idc[i] = = 1)		
for(j = 0; j < PicSizeInMapUnits; j++)		
spare_unit_flag[i **][** j **]**	5	u(1)
else if(spare_area_idc[i] = = 2) {		
mapUnitCnt = 0		
for(j=0; mapUnitCnt < PicSizeInMapUnits; j++) {		
zero_run_length[i **][** j **]**	5	ue(v)
mapUnitCnt += zero_run_length[i][j] + 1		
}		
}		
}		
}		

D.1.10 Scene information SEI message syntax

scene_info(payloadSize) {	C	Descriptor
scene_info_present_flag	5	u(1)
if(scene_info_present_flag) {		
scene_id	5	ue(v)
scene_transition_type	5	ue(v)
if(scene_transition_type > 3)		
second_scene_id	5	ue(v)
}		
}		

D.1.11 Sub-sequence information SEI message syntax

sub_seq_info(payloadSize) {	C	Descriptor
sub_seq_layer_num	5	ue(v)
sub_seq_id	5	ue(v)
first_ref_pic_flag	5	u(1)
leading_non_ref_pic_flag	5	u(1)
last_pic_flag	5	u(1)
sub_seq_frame_num_flag	5	u(1)
if(sub_seq_frame_num_flag)		
sub_seq_frame_num	5	ue(v)
}		

D.1.12 Sub-sequence layer characteristics SEI message syntax

sub_seq_layer_characteristics(payloadSize) {	C	Descriptor
num_sub_seq_layers_minus1	5	ue(v)
for(layer = 0; layer <= num_sub_seq_layers_minus1; layer++) {		
accurate_statistics_flag	5	u(1)
average_bit_rate	5	u(16)
average_frame_rate	5	u(16)
}		
}		

D.1.13 Sub-sequence characteristics SEI message syntax

sub_seq_characteristics(payloadSize) {	C	Descriptor
sub_seq_layer_num	5	ue(v)
sub_seq_id	5	ue(v)
duration_flag	5	u(1)
if(duration_flag)		
sub_seq_duration	5	u(32)
average_rate_flag	5	u(1)
if(average_rate_flag) {		
accurate_statistics_flag	5	u(1)
average_bit_rate	5	u(16)
average_frame_rate	5	u(16)
}		
num_referenced_subseqs	5	ue(v)
for(n = 0; n < num_referenced_subseqs; n++) {		
ref_sub_seq_layer_num	5	ue(v)
ref_sub_seq_id	5	ue(v)
ref_sub_seq_direction	5	u(1)
}		
}		

D.1.14 Full-frame freeze SEI message syntax

full_frame_freeze(payloadSize) {	C	Descriptor
full_frame_freeze_repetition_period	5	ue(v)
}		

D.1.15 Full-frame freeze release SEI message syntax

full_frame_freeze_release(payloadSize) {	C	Descriptor
}		

D.1.16 Full-frame snapshot SEI message syntax

full_frame_snapshot(payloadSize) {	C	Descriptor
snapshot_id	5	ue(v)
}		

D.1.17 Progressive refinement segment start SEI message syntax

progressive_refinement_segment_start(payloadSize) {	C	Descriptor
progressive_refinement_id	5	ue(v)
num_refinement_steps_minus1	5	ue(v)
}		

D.1.18 Progressive refinement segment end SEI message syntax

progressive_refinement_segment_end(payloadSize) {	C	Descriptor
progressive_refinement_id	5	ue(v)
}		

D.1.19 Motion-constrained slice group set SEI message syntax

motion_constrained_slice_group_set(payloadSize) {	C	Descriptor
num_slice_groups_in_set_minus1	5	ue(v)
for(i = 0; i <= num_slice_groups_in_set_minus1; i++)		
slice_group_id[i **]**	5	u(v)
exact_sample_value_match_flag	5	u(1)
pan_scan_rect_flag	5	u(1)
if(pan_scan_rect_flag)		
pan_scan_rect_id	5	ue(v)
}		

D.1.20 Film grain characteristics SEI message syntax

film_grain_characteristics(payloadSize) {	C	Descriptor
film_grain_characteristics_cancel_flag	5	u(1)
if(!film_grain_**characteristics_**cancel_flag) {		
model_id	5	u(2)
separate_colour_description_present_flag	5	u(1)
if(separate_colour_description_present_flag) {		
film_grain_bit_depth_luma_minus8	5	u(3)
film_grain_bit_depth_chroma_minus8	5	u(3)
film_grain_full_range_flag	5	u(1)
film_grain_colour_primaries	5	u(8)
film_grain_transfer_characteristics	5	u(8)
film_grain_matrix_coefficients	5	u(8)
}		
blending_mode_id	5	u(2)
log2_scale_factor	5	u(4)
for(c = 0; c < 3; c++)		
comp_model_present_flag[c]	5	u(1)
for(c = 0; c < 3; c++)		
if(comp_model_present_flag[c]) {		
num_intensity_intervals_minus1[c **]**	5	u(8)
num_model_values_minus1[c **]**	5	u(3)
for(i = 0; i <= num_intensity_intervals_minus1[c]; i++) {		
intensity_interval_lower_bound[c **][** i **]**	5	u(8)
intensity_interval_upper_bound[c **][** i **]**	5	u(8)
for(j = 0; j <= num_model_values_minus1[c]; j++)		
comp_model_value[c **][** i **][** j **]**	5	se(v)
}		
}		
film_grain_characteristics_repetition_period	5	ue(v)
}		
}		

D.1.21 Deblocking filter display preference SEI message syntax

deblocking_filter_display_preference(payloadSize) {	C	Descriptor
deblocking_display_preference_cancel_flag	5	u(1)
if(!deblocking_display_preference_cancel_flag) {		
display_prior_to_deblocking_preferred_flag	5	u(1)
dec_frame_buffering_constraint_flag	5	u(1)
deblocking_display_preference_repetition_period	5	ue(v)
}		
}		

D.1.22 Stereo video information SEI message syntax

stereo_video_info(payloadSize) {	C	Descriptor
field_views_flag	5	u(1)
if(field_views_flag)		
top_field_is_left_view_flag	5	u(1)
else {		
current_frame_is_left_view_flag	5	u(1)
next_frame_is_second_view_flag	5	u(1)
}		
left_view_self_contained_flag	5	u(1)
right_view_self_contained_flag	5	u(1)
}		

D.1.23 Post-filter hint SEI message syntax

post_filter_hint(payloadSize) {	C	Descriptor
filter_hint_size_y	5	ue(v)
filter_hint_size_x	5	ue(v)
filter_hint_type	5	u(2)
for(colour_component = 0; colour_component < 3; colour_component ++)		
for(cy = 0; cy < filter_hint_size_y; cy ++)		
for(cx = 0; cx < filter_hint_size_x; cx ++)		
filter_hint[colour_component **][** cy **][** cx **]**	5	se(v)
additional_extension_flag	5	u(1)
}		

D.1.24 Tone mapping information SEI message syntax

tone_mapping_info(payloadSize) {	C	Descriptor
tone_map_id	5	ue(v)
tone_map_cancel_flag	5	u(1)
if(!tone_map_cancel_flag) {		
tone_map_repetition_period	5	ue(v)
coded_data_bit_depth	5	u(8)
target_bit_depth	5	u(8)
model_id	5	ue(v)
if(model_id = = 0) {		
min_value	5	u(32)
max_value	5	u(32)
}		
if(model_id = = 1) {		
sigmoid_midpoint	5	u(32)
sigmoid_width	5	u(32)
}		
if(model_id = = 2)		
for(i = 0; i < (1 << target_bit_depth); i++)		
start_of_coded_interval[i]	5	u(v)
if(model_id = = 3) {		
num_pivots	5	u(16)
for(i=0; i < num_pivots; i++) {		
coded_pivot_value[i]	5	u(v)
target_pivot_value[i]	5	u(v)
}		
}		
}		
}		

D.1.25 Reserved SEI message syntax

reserved_sei_message(payloadSize) {	C	Descriptor
for(i = 0; i < payloadSize; i++)		
reserved_sei_message_payload_byte	5	b(8)
}		

D.2 SEI payload semantics

D.2.1 Buffering period SEI message semantics

When NalHrdBpPresentFlag or VclHrdBpPresentFlag are equal to 1, a buffering period SEI message can be associated with any access unit in the bitstream, and a buffering period SEI message shall be associated with each IDR access unit and with each access unit associated with a recovery point SEI message.

NOTE – For some applications, the frequent presence of a buffering period SEI message may be desirable.

A buffering period is specified as the set of access units between two instances of the buffering period SEI message in decoding order.

seq_parameter_set_id specifies the sequence parameter set that contains the sequence HRD attributes. The value of seq_parameter_set_id shall be equal to the value of seq_parameter_set_id in the picture parameter set referenced by the primary coded picture associated with the buffering period SEI message. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

initial_cpb_removal_delay[SchedSelIdx] specifies the delay for the SchedSelIdx-th CPB between the time of arrival in the CPB of the first bit of the coded data associated with the access unit associated with the buffering period SEI message and the time of removal from the CPB of the coded data associated with the same access unit, for the first buffering period after HRD initialisation. The syntax element has a length in bits given by initial_cpb_removal_delay_length_minus1 + 1. It is in units of a 90 kHz clock. initial_cpb_removal_delay[SchedSelIdx] shall not be equal to 0 and shall not exceed 90000 * (CpbSize[SchedSelIdx] ÷ BitRate[SchedSelIdx]), the time-equivalent of the CPB size in 90 kHz clock units.

initial_cpb_removal_delay_offset[SchedSelIdx] is used for the SchedSelIdx-th CPB in combination with the cpb_removal_delay to specify the initial delivery time of coded access units to the CPB. initial_cpb_removal_delay_offset[SchedSelIdx] is in units of a 90 kHz clock. The initial_cpb_removal_delay_offset[SchedSelIdx] syntax element is a fixed length code whose length in bits is given by initial_cpb_removal_delay_length_minus1 + 1. This syntax element is not used by decoders and is needed only for the delivery scheduler (HSS) specified in Annex C.

Over the entire coded video sequence, the sum of initial_cpb_removal_delay[SchedSelIdx] and initial_cpb_removal_delay_offset[SchedSelIdx] shall be constant for each value of SchedSelIdx.

D.2.2 Picture timing SEI message semantics

The presence of picture timing SEI message in the bitstream is specified as follows.

– If CpbDpbDelaysPresentFlag is equal to 1 or pic_struct_present_flag is equal to 1, one picture timing SEI message shall be present in every access unit of the coded video sequence.

– Otherwise (CpbDpbDelaysPresentFlag is equal to 0 and pic_struct_present_flag is equal to 0), no picture timing SEI messages shall be present in any access unit of the coded video sequence.

cpb_removal_delay specifies how many clock ticks (see subclause E.2.1) to wait after removal from the CPB of the access unit associated with the most recent buffering period SEI message before removing from the buffer the access unit data associated with the picture timing SEI message. This value is also used to calculate an earliest possible time of arrival of access unit data into the CPB for the HSS, as specified in Annex C. The syntax element is a fixed length code whose length in bits is given by cpb_removal_delay_length_minus1 + 1. The cpb_removal_delay is the remainder of a $2^{(\text{cpb\_removal\_delay\_length\_minus1} + 1)}$ counter.

The value of cpb_removal_delay for the first picture in the bitstream shall be equal to 0.

dpb_output_delay is used to compute the DPB output time of the picture. It specifies how many clock ticks to wait after removal of an access unit from the CPB before the decoded picture can be output from the DPB (see subclause C.2).

NOTE 1 – A picture is not removed from the DPB at its output time when it is still marked as "used for short-term reference" or "used for long-term reference".

NOTE 2 – Only one dpb_output_delay is specified for a decoded picture.

The size of the syntax element dpb_output_delay is given in bits by dpb_output_delay_length_minus1 + 1. When max_dec_frame_buffering is equal to 0, dpb_output_delay shall be equal to 0.

The output time derived from the dpb_output_delay of any picture that is output from an output timing conforming decoder as specified in subclause C.2 shall precede the output time derived from the dpb_output_delay of all pictures in any subsequent coded video sequence in decoding order.

The output time derived from the dpb_output_delay of the second field, in decoding order, of a complementary non-reference field pair shall exceed the output time derived from the dpb_output_delay of the first field of the same complementary non-reference field pair.

The picture output order established by the values of this syntax element shall be the same order as established by the values of PicOrderCnt( ) as specified by subclauses C.4.1 to C.4.5, except that when the two fields of a complementary reference field pair have the same value of PicOrderCnt( ), the two fields have different output times.

For pictures that are not output by the "bumping" process of subclause C.4.5 because they precede, in decoding order, an IDR picture with no_output_of_prior_pics_flag equal to 1 or inferred to be equal to 1, the output times derived from dpb_output_delay shall be increasing with increasing value of PicOrderCnt( ) relative to all pictures within the same coded video sequence subsequent to any picture having a memory_management_control_operation equal to 5.

pic_struct indicates whether a picture should be displayed as a frame or one or more fields, according to Table D-1. Frame doubling (pic_struct equal to 7) indicates that the frame should be displayed two times consecutively, and frame tripling (pic_struct equal to 8) indicates that the frame should be displayed three times consecutively.

NOTE 3 – Frame doubling can facilitate the display, for example, of 25p video on a 50p display and 29.97p video on a 59.94p display. Using frame doubling and frame tripling in combination on every other frame can facilitate the display of 23.98p video on a 59.94p display.

Table D-1 – Interpretation of pic_struct

Value	Indicated display of picture	Restrictions	NumClockTS
0	frame	field_pic_flag shall be 0	1
1	top field	field_pic_flag shall be 1, bottom_field_flag shall be 0	1
2	bottom field	field_pic_flag shall be 1, bottom_field_flag shall be 1	1
3	top field, bottom field, in that order	field_pic_flag shall be 0	2
4	bottom field, top field, in that order	field_pic_flag shall be 0	2
5	top field, bottom field, top field repeated, in that order	field_pic_flag shall be 0	3
6	bottom field, top field, bottom field repeated, in that order	field_pic_flag shall be 0	3
7	frame doubling	field_pic_flag shall be 0 fixed_frame_rate_flag shall be 1	2
8	frame tripling	field_pic_flag shall be 0 fixed_frame_rate_flag shall be 1	3
9..15	reserved		

NumClockTS is determined by pic_struct as specified in Table D-1. There are up to NumClockTS sets of clock timestamp information for a picture, as specified by clock_timestamp_flag[i] for each set. The sets of clock timestamp information apply to the field(s) or the frame(s) associated with the picture by pic_struct.

The contents of the clock timestamp syntax elements indicate a time of origin, capture, or alternative ideal display. This indicated time is computed as

$$\begin{aligned} \text{clockTimestamp} = {} & ((hH * 60 + mM) * 60 + sS) * \text{time\_scale} + \\ & \text{nFrames} * (\text{num\_units\_in\_tick} * (1 + \text{nuit\_field\_based\_flag})) + \text{tOffset}, \end{aligned} \tag{D-1}$$

in units of clock ticks of a clock with clock frequency equal to time_scale Hz, relative to some unspecified point in time for which clockTimestamp is equal to 0. Output order and DPB output timing are not affected by the value of clockTimestamp. When two or more frames with pic_struct equal to 0 are consecutive in output order and have equal values of clockTimestamp, the indication is that the frames represent the same content and that the last such frame in output order is the preferred representation.

NOTE 4 – clockTimestamp time indications may aid display on devices with refresh rates other than those well-matched to DPB output times.

clock_timestamp_flag[i **]** equal to 1 indicates that a number of clock timestamp syntax elements are present and follow immediately. clock_timestamp_flag[i] equal to 0 indicates that the associated clock timestamp syntax elements are not present. When NumClockTS is greater than 1 and clock_timestamp_flag[i] is equal to 1 for more than one value of i, the value of clockTimestamp shall be non-decreasing with increasing value of i.

ct_type indicates the scan type (interlaced or progressive) of the source material as specified in Table D-2.

Two fields of a coded frame may have different values of ct_type.

When clockTimestamp is equal for two fields of opposite parity that are consecutive in output order, both with ct_type equal to 0 (progressive) or ct_type equal to 2 (unknown), the two fields are indicated to have come from the same original progressive frame. Two consecutive fields in output order shall have different values of clockTimestamp when the value of ct_type for either field is 1 (interlaced).

Table D-2 – Mapping of ct_type to source picture scan

Value	Original picture scan
0	progressive
1	interlaced
2	unknown
3	reserved

nuit_field_based_flag is used in calculating clockTimestamp, as specified in Equation D-1.

counting_type specifies the method of dropping values of the n_frames as specified in Table D-3.

Table D-3 – Definition of counting_type values

Value	Interpretation
0	no dropping of n_frames count values and no use of time_offset
1	no dropping of n_frames count values
2	dropping of individual zero values of n_frames count
3	dropping of individual MaxFPS-1 values of n_frames count
4	dropping of the two lowest (value 0 and 1) n_frames counts when seconds_value is equal to 0 and minutes_value is not an integer multiple of 10
5	dropping of unspecified individual n_frames count values
6	dropping of unspecified numbers of unspecified n_frames count values
7..31	reserved

full_timestamp_flag equal to 1 specifies that the n_frames syntax element is followed by seconds_value, minutes_value, and hours_value. full_timestamp_flag equal to 0 specifies that the n_frames syntax element is followed by seconds_flag.

discontinuity_flag equal to 0 indicates that the difference between the current value of clockTimestamp and the value of clockTimestamp computed from the previous clock timestamp in output order can be interpreted as the time difference between the times of origin or capture of the associated frames or fields. discontinuity_flag equal to 1 indicates that the difference between the current value of clockTimestamp and the value of clockTimestamp computed from the previous clock timestamp in output order should not be interpreted as the time difference between the times of origin or capture of the associated frames or fields. When discontinuity_flag is equal to 0, the value of clockTimestamp shall be greater than or equal to all values of clockTimestamp present for the preceding picture in DPB output order.

cnt_dropped_flag specifies the skipping of one or more values of n_frames using the counting method specified by counting_type.

n_frames specifies the value of nFrames used to compute clockTimestamp. n_frames shall be less than

$$MaxFPS = Ceil(time\_scale \div num\_units\_in\_tick) \quad (D\text{-}2)$$

NOTE 5 – n_frames is a frame-based counter. For field-specific timing indications, time_offset should be used to indicate a distinct clockTimestamp for each field.

When counting_type is equal to 2 and cnt_dropped_flag is equal to 1, n_frames shall be equal to 1 and the value of n_frames for the previous picture in output order shall not be equal to 0 unless discontinuity_flag is equal to 1.

NOTE 6 – When counting_type is equal to 2, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates (e.g., 12.5 frames per second with time_scale equal to 25 and num_units_in_tick equal to 2 and nuit_field_based_flag equal to 0) can be avoided by occasionally skipping over the value n_frames equal to 0 when counting (e.g., counting n_frames from 0 to 12, then incrementing seconds_value and counting n_frames from 1 to 12, then incrementing seconds_value and counting n_frames from 0 to 12, etc.).

When counting_type is equal to 3 and cnt_dropped_flag is equal to 1, n_frames shall be equal to 0 and the value of n_frames for the previous picture in output order shall not be equal to MaxFPS – 1 unless discontinuity_flag is equal to 1.

NOTE 7 – When counting_type is equal to 3, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates (e.g., 12.5 frames per second with time_scale equal to 25 and num_units_in_tick equal to 2 and nuit_field_based_flag equal to 0) can be avoided by occasionally skipping over the value n_frames equal to MaxFPS when counting (e.g., counting n_frames from 0 to 12, then incrementing seconds_value and counting n_frames from 0 to 11, then incrementing seconds_value and counting n_frames from 0 to 12, etc.).

When counting_type is equal to 4 and cnt_dropped_flag is equal to 1, n_frames shall be equal to 2 and the specified value of sS shall be zero and the specified value of mM shall not be an integer multiple of ten and n_frames for the previous picture in output order shall not be equal to 0 or 1 unless discontinuity_flag is equal to 1.

NOTE 8 – When counting_type is equal to 4, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates (e.g., 30000÷1001 frames per second with time_scale equal to 60000 and num_units_in_tick equal to 1 001 and nuit_field_based_flag equal to 1) can be reduced by occasionally skipping over the value n_frames equal to MaxFPS when counting (e.g., counting n_frames from 0 to 29, then incrementing seconds_value and counting n_frames from 0 to 29, etc., until the seconds_value is zero and minutes_value is not an integer multiple of ten, then counting n_frames from 2 to 29, then incrementing seconds_value and counting n_frames from 0 to 29, etc.). This counting method is well known in industry and is often referred to as "NTSC drop-frame" counting.

When counting_type is equal to 5 or 6 and cnt_dropped_flag is equal to 1, n_frames shall not be equal to 1 plus the value of n_frames for the previous picture in output order modulo MaxFPS unless discontinuity_flag is equal to 1.

NOTE 9 – When counting_type is equal to 5 or 6, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates can be avoided by occasionally skipping over some values of n_frames when counting. The specific values of n_frames that are skipped are not specified when counting_type is equal to 5 or 6.

seconds_flag equal to 1 specifies that seconds_value and minutes_flag are present when full_timestamp_flag is equal to 0. seconds_flag equal to 0 specifies that seconds_value and minutes_flag are not present.

seconds_value specifies the value of sS used to compute clockTimestamp. The value of seconds_value shall be in the range of 0 to 59, inclusive. When seconds_value is not present, the previous seconds_value in decoding order shall be used as sS to compute clockTimestamp.

minutes_flag equal to 1 specifies that minutes_value and hours_flag are present when full_timestamp_flag is equal to 0 and seconds_flag is equal to 1. minutes_flag equal to 0 specifies that minutes_value and hours_flag are not present.

minutes_value specifies the value of mM used to compute clockTimestamp. The value of minutes_value shall be in the range of 0 to 59, inclusive. When minutes_value is not present, the previous minutes_value in decoding order shall be used as mM to compute clockTimestamp.

hours_flag equal to 1 specifies that hours_value is present when full_timestamp_flag is equal to 0 and seconds_flag is equal to 1 and minutes_flag is equal to 1.

hours_value specifies the value of hH used to compute clockTimestamp. The value of hours_value shall be in the range of 0 to 23, inclusive. When hours_value is not present, the previous hours_value in decoding order shall be used as hH to compute clockTimestamp.

time_offset specifies the value of tOffset used to compute clockTimestamp. The number of bits used to represent time_offset shall be equal to time_offset_length. When time_offset is not present, the value 0 shall be used as tOffset to compute clockTimestamp.

D.2.3 Pan-scan rectangle SEI message semantics

The pan-scan rectangle SEI message syntax elements specify the coordinates of a rectangle relative to the cropping rectangle of the sequence parameter set. Each coordinate of this rectangle is specified in units of one-sixteenth sample spacing relative to the luma sampling grid.

pan_scan_rect_id contains an identifying number that may be used to identify the purpose of the pan-scan rectangle (for example, to identify the rectangle as the area to be shown on a particular display device or as the area that contains a particular actor in the scene). The value of pan_scan_rect_id shall be in the range of 0 to $2^{32} – 1$, inclusive.

Values of pan_scan_rect_id from 0 to 255 and from 512 to 2^{31}-1 may be used as determined by the application. Values of pan_scan_rect_id from 256 to 511 and from 2^{31} to 2^{32}-1 are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of pan_scan_rect_id in the range of 256 to 511 or in the range of 2^{31} to 2^{32} - 1 shall ignore (remove from the bitstream and discard) it.

pan_scan_rect_cancel_flag equal to 1 indicates that the SEI message cancels the persistence of any previous pan-scan rectangle SEI message in output order. pan_scan_rect_cancel_flag equal to 0 indicates that pan-scan rectangle information follows.

pan_scan_cnt_minus1 specifies the number of pan-scan rectangles that are present in the SEI message. pan_scan_cnt_minus1 shall be in the range of 0 to 2, inclusive. pan_scan_cnt_minus1 equal to 0 indicates that a single pan-scan rectangle is present that applies to all fields of the decoded picture. pan_scan_cnt_minus1 shall be equal to 0 when the current picture is a field. pan_scan_cnt_minus1 equal to 1 indicates that two pan-scan rectangles are present, the first of which applies to the first field of the picture in output order and the second of which applies to the second field of the picture in output order. pan_scan_cnt_minus1 equal to 2 indicates that three pan-scan rectangles are present, the first of which applies to the first field of the picture in output order, the second of which applies to the second field of the picture in output order, and the third of which applies to a repetition of the first field as a third field in output order.

pan_scan_rect_left_offset[i **]**, **pan_scan_rect_right_offset[** i **]**, **pan_scan_rect_top_offset[** i **]**, and **pan_scan_rect_bottom_offset[** i **]**, specify, as signed integer quantities in units of one-sixteenth sample spacing relative to the luma sampling grid, the location of the pan-scan rectangle. The values of each of these four syntax elements shall be in the range of -2^{31} to 2^{31} - 1, inclusive.

The pan-scan rectangle is specified, in units of one-sixteenth sample spacing relative to a luma frame sampling grid, as the region with frame horizontal coordinates from 16*CropUnitX * frame_crop_left_offset + pan_scan_rect_left_offset[i] to 16 * (16 * PicWidthInMbs – CropUnitX * frame_crop_right_offset) + pan_scan_rect_right_offset[i] – 1 and with vertical coordinates from 16 *CropUnitY * frame_crop_top_offset + pan_scan_rect_top_offset[i] to 16 * (16 * PicHeightInMbs – CropUnitY * frame_crop_bottom_offset) + pan_scan_rect_bottom_offset[i] – 1, inclusive. The value of 16 * CropUnitX * frame_crop_left_offset + pan_scan_rect_left_offset[i] shall be less than or equal to 16 * (16 * PicWidthInMbs – CropUnitX * frame_crop_right_offset) + pan_scan_rect_right_offset[i] – 1; and the value of 16 CropUnitY * frame_crop_top_offset + pan_scan_rect_top_offset[i] shall be less than or equal to 16 * (16 * PicHeightInMbs – CropUnitY * frame_crop_bottom_offset) + pan_scan_rect_bottom_offset[i] – 1.

When the pan-scan rectangular area includes samples outside of the cropping rectangle, the region outside of the cropping rectangle may be filled with synthesized content (such as black video content or neutral grey video content) for display.

pan_scan_rect_repetition_period specifies the persistence of the pan-scan rectangle SEI message and may specify a picture order count interval within which another pan-scan rectangle SEI message with the same value of pan_scan_rect_id or the end of the coded video sequence shall be present in the bitstream. The value of pan_scan_rect_repetition_period shall be in the range of 0 to 16 384, inclusive. When pan_scan_cnt_minus1 is greater than 0, pan_scan_rect_repetition_period shall not be greater than 1.

pan_scan_rect_repetition_period equal to 0 specifies that the pan-scan rectangle information applies to the current decoded picture only.

pan_scan_rect_repetition_period equal to 1 specifies that the pan-scan rectangle information persists in output order until any of the following conditions are true.

- A new coded video sequence begins.
- A picture in an access unit containing a pan-scan rectangle SEI message with the same value of pan_scan_rect_id is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic).

pan_scan_rect_repetition_period equal to 0 or equal to 1 indicates that another pan-scan rectangle SEI message with the same value of pan_scan_rect_id may or may not be present.

pan_scan_rect_repetition_period greater than 1 specifies that the pan-scan rectangle information persists until any of the following conditions are true.

- A new coded video sequence begins.

– A picture in an access unit containing a pan-scan rectangle SEI message with the same value of pan_scan_rect_id is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + pan_scan_rect_repetition_period.

pan_scan_rect_repetition_period greater than 1 indicates that another pan-scan rectangle SEI message with the same value of pan_scan_rect_id shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + pan_scan_rect_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

D.2.4 Filler payload SEI message semantics

This message contains a series of payloadSize bytes of value 0xFF, which can be discarded.

ff_byte shall be a byte having the value 0xFF.

D.2.5 User data registered by ITU-T Rec. T.35 SEI message semantics

This message contains user data registered as specified by ITU-T Rec. T.35, the contents of which are not specified by this Recommendation | International Standard.

itu_t_t35_country_code shall be a byte having a value specified as a country code by ITU-T Rec. T.35 Annex A.

itu_t_t35_country_code_extension_byte shall be a byte having a value specified as a country code by ITU-T Rec. T.35 Annex B.

itu_t_t35_payload_byte shall be a byte containing data registered as specified by ITU-T Rec. T.35.

The ITU-T T.35 terminal provider code and terminal provider oriented code shall be contained in the first one or more bytes of the itu_t_t35_payload_byte, in the format specified by the Administration that issued the terminal provider code. Any remaining itu_t_t35_payload_byte data shall be data having syntax and semantics as specified by the entity identified by the ITU-T T.35 country code and terminal provider code.

D.2.6 User data unregistered SEI message semantics

This message contains unregistered user data identified by a UUID, the contents of which are not specified by this Recommendation | International Standard.

uuid_iso_iec_11578 shall have a value specified as a UUID according to the procedures of ISO/IEC 11578:1996 Annex A.

user_data_payload_byte shall be a byte containing data having syntax and semantics as specified by the UUID generator.

D.2.7 Recovery point SEI message semantics

The recovery point SEI message assists a decoder in determining when the decoding process will produce acceptable pictures for display after the decoder initiates random access or after the encoder indicates a broken link in the sequence. When the decoding process is started with the access unit in decoding order associated with the recovery point SEI message, all decoded pictures at or subsequent to the recovery point in output order specified in this SEI message are indicated to be correct or approximately correct in content. Decoded pictures produced by random access at or before the picture associated with the recovery point SEI message need not be correct in content until the indicated recovery point, and the operation of the decoding process starting at the picture associated with the recovery point SEI message may contain references to pictures not available in the decoded picture buffer.

In addition, by use of the broken_link_flag, the recovery point SEI message can indicate to the decoder the location of some pictures in the bitstream that can result in serious visual artefacts when displayed, even when the decoding process was begun at the location of a previous IDR access unit in decoding order.

NOTE 1 – The broken_link_flag can be used by encoders to indicate the location of a point after which the decoding process for the decoding of some pictures may cause references to pictures that, though available for use in the decoding process, are not the pictures that were used for reference when the bitstream was originally encoded (e.g., due to a splicing operation performed during the generation of the bitstream).

The recovery point is specified as a count in units of frame_num increments subsequent to the frame_num of the current access unit at the position of the SEI message.

NOTE 2 – When HRD information is present in the bitstream, a buffering period SEI message should be associated with the access unit associated with the recovery point SEI message in order to establish initialisation of the HRD buffer model after a random access.

recovery_frame_cnt specifies the recovery point of output pictures in output order. All decoded pictures in output order are indicated to be correct or approximately correct in content starting at the output order position of the reference picture having the frame_num equal to the frame_num of the VCL NAL units for the current access unit incremented by recovery_frame_cnt in modulo MaxFrameNum arithmetic. recovery_frame_cnt shall be in the range of 0 to MaxFrameNum – 1, inclusive.

exact_match_flag indicates whether decoded pictures at and subsequent to the specified recovery point in output order derived by starting the decoding process at the access unit associated with the recovery point SEI message shall be an exact match to the pictures that would be produced by starting the decoding process at the location of a previous IDR access unit in the NAL unit stream. The value 0 indicates that the match need not be exact and the value 1 indicates that the match shall be exact.

When decoding starts from the location of the recovery point SEI message, all references to not available reference pictures shall be inferred as references to pictures containing only macroblocks coded using Intra macroblock prediction modes and having sample values given by Y samples equal to 128, Cb samples equal to 128, and Cr samples equal to 128 (mid-level grey) for purposes of determining the conformance of the value of exact_match_flag.

NOTE 3 – When performing random access, decoders should infer all references to not available reference pictures as references to pictures containing only intra macroblocks and having sample values given by Y equal to 128, Cb equal to 128, and Cr equal to 128 (mid-level grey), regardless of the value of exact_match_flag.

When exact_match_flag is equal to 0, the quality of the approximation at the recovery point is chosen by the encoding process and is not specified by this Recommendation | International Standard.

broken_link_flag indicates the presence or absence of a broken link in the NAL unit stream at the location of the recovery point SEI message and is assigned further semantics as follows.

- If broken_link_flag is equal to 1, pictures produced by starting the decoding process at the location of a previous IDR access unit may contain undesirable visual artefacts to the extent that decoded pictures at and subsequent to the access unit associated with the recovery point SEI message in decoding order should not be displayed until the specified recovery point in output order.
- Otherwise (broken_link_flag is equal to 0), no indication is given regarding any potential presence of visual artefacts.

Regardless of the value of the broken_link_flag, pictures subsequent to the specified recovery point in output order are specified to be correct or approximately correct in content.

NOTE 4 – When a sub-sequence information SEI message is present in conjunction with a recovery point SEI message in which broken_link_flag is equal to 1 and when sub_seq_layer_num is equal to 0, sub_seq_id should be different from the latest sub_seq_id for sub_seq_layer_num equal to 0 that was decoded prior to the location of the recovery point SEI message. When broken_link_flag is equal to 0, the sub_seq_id in sub-sequence layer 0 should remain unchanged.

changing_slice_group_idc equal to 0 indicates that decoded pictures are correct or approximately correct in content at and subsequent to the recovery point in output order when all macroblocks of the primary coded pictures are decoded within the changing slice group period, i.e., the period between the access unit associated with the recovery point SEI message (inclusive) and the specified recovery point (inclusive) in decoding order. changing_slice_group_idc shall be equal to 0 when num_slice_groups_minus1 is equal to 0 in any primary coded picture within the changing slice group period.

When changing_slice_group_idc is equal to 1 or 2, num_slice_groups_minus1 shall be equal to 1 and the macroblock-to-slice-group map type 3, 4, or 5 shall be applied in each primary coded picture in the changing slice group period.

changing_slice_group_idc equal to 1 indicates that within the changing slice group period no sample values outside the decoded macroblocks covered by slice group 0 are used for inter prediction of any macroblock within slice group 0. In addition, changing_slice_group_idc equal to 1 indicates that when all macroblocks in slice group 0 within the changing slice group period are decoded, decoded pictures will be correct or approximately correct in content at and subsequent to the specified recovery point in output order regardless of whether any macroblock in slice group 1 within the changing slice group period is decoded.

changing_slice_group_idc equal to 2 indicates that within the changing slice group period no sample values outside the decoded macroblocks covered by slice group 1 are used for inter prediction of any macroblock within slice group 1. In addition, changing_slice_group_idc equal to 2 indicates that when all macroblocks in slice group 1 within the changing slice group period are decoded, decoded pictures will be correct or approximately correct in content at and subsequent to the specified recovery point in output order regardless of whether any macroblock in slice group 0 within the changing slice group period is decoded.

changing_slice_group_idc shall be in the range of 0 to 2, inclusive.

D.2.8 Decoded reference picture marking repetition SEI message semantics

The decoded reference picture marking repetition SEI message is used to repeat the decoded reference picture marking syntax structure that was located in the slice header of an earlier picture in the sequence in decoding order.

original_idr_flag shall be equal to 1 when the decoded reference picture marking syntax structure occurred originally in an IDR picture. original_idr_flag shall be equal to 0 when the repeated decoded reference picture marking syntax structure did not occur in an IDR picture originally.

original_frame_num shall be equal to the frame_num of the picture where the repeated decoded reference picture marking syntax structure originally occurred. The picture indicated by original_frame_num is the previous coded picture having the specified value of frame_num. The value of original_frame_num used to refer to a picture having a memory_management_control_operation equal to 5 shall be 0.

original_field_pic_flag shall be equal to the field_pic_flag of the picture where the repeated decoded reference picture marking syntax structure originally occurred.

original_bottom_field_flag shall be equal to the bottom_field_flag of the picture where the repeated decoded reference picture marking syntax structure originally occurred.

dec_ref_pic_marking( ) shall contain a copy of the decoded reference picture marking syntax structure of the picture whose frame_num was original_frame_num. The IdrPicFlag used for specification of the repeated dec_ref_pic_marking( ) syntax structure shall be the IdrPicFlag of the slice header(s) of the picture whose frame_num was original_frame_num (i.e., IdrPicFlag as used in subclause 7.3.3.3 shall be considered equal to original_idr_flag).

D.2.9 Spare picture SEI message semantics

This SEI message indicates that certain slice group map units, called spare slice group map units, in one or more decoded reference pictures resemble the co-located slice group map units in a specified decoded picture called the target picture. A spare slice group map unit may be used to replace a co-located, incorrectly decoded slice group map unit, in the target picture. A decoded picture containing spare slice group map units is called a spare picture.

For all spare pictures identified in a spare picture SEI message, the value of frame_mbs_only_flag shall be equal to the value of frame_mbs_only_flag of the target picture in the same SEI message. The spare pictures in the SEI message are constrained as follows.

- If the target picture is a decoded field, all spare pictures identified in the same SEI message shall be decoded fields.
- Otherwise (the target picture is a decoded frame), all spare pictures identified in the same SEI message shall be decoded frames.

For all spare pictures identified in a spare picture SEI message, the values of pic_width_in_mbs_minus1 and pic_height_in_map_units_minus1 shall be equal to the values of pic_width_in_mbs_minus1 and pic_height_in_map_units_minus1, respectively, of the target picture in the same SEI message. The picture associated (as specified in subclause 7.4.1.2.3) with this message shall appear after the target picture, in decoding order.

target_frame_num indicates the frame_num of the target picture.

spare_field_flag equal to 0 indicates that the target picture and the spare pictures are decoded frames. spare_field_flag equal to 1 indicates that the target picture and the spare pictures are decoded fields.

target_bottom_field_flag equal to 0 indicates that the target picture is a top field. target_bottom_field_flag equal to 1 indicates that the target picture is a bottom field.

A target picture is a decoded reference picture whose corresponding primary coded picture precedes the current picture, in decoding order, and in which the values of frame_num, field_pic_flag (when present) and bottom_field_flag (when present) are equal to target_frame_num, spare_field_flag and target_bottom_field_flag, respectively.

num_spare_pics_minus1 indicates the number of spare pictures for the specified target picture. The number of spare pictures is equal to num_spare_pics_minus1 + 1. The value of num_spare_pics_minus1 shall be in the range of 0 to 15, inclusive.

delta_spare_frame_num[i **]** is used to identify the spare picture that contains the i-th set of spare slice group map units, hereafter called the i-th spare picture, as specified below. The value of delta_spare_frame_num[i] shall be in the range of 0 to MaxFrameNum - 1 - !spare_field_flag, inclusive.

The frame_num of the i-th spare picture, spareFrameNum[i], is derived as follows for all values of i from 0 to num_spare_pics_minus1, inclusive:

```
candidateSpareFrameNum = target_frame_num - !spare_field_flag
for ( i = 0; i <= num_spare_pics_minus1; i++ ) {
    if( candidateSpareFrameNum < 0 )
        candidateSpareFrameNum = MaxFrameNum – 1
    spareFrameNum[ i ] = candidateSpareFrameNum – delta_spare_frame_num[ i ]          (D-3)
    if( spareFrameNum[ i ] < 0 )
        spareFrameNum[ i ] = MaxFrameNum + spareFrameNum[ i ]
    candidateSpareFrameNum = spareFrameNum[ i ] - !spare_field_flag
}
```

spare_bottom_field_flag[i **]** equal to 0 indicates that the i-th spare picture is a top field. spare_bottom_field_flag[i] equal to 1 indicates that the i-th spare picture is a bottom field.

The 0-th spare picture is a decoded reference picture whose corresponding primary coded picture precedes the target picture, in decoding order, and in which the values of frame_num, field_pic_flag (when present) and bottom_field_flag (when present) are equal to spareFrameNum[0], spare_field_flag and spare_bottom_field_flag[0], respectively. The i-th spare picture is a decoded reference picture whose corresponding primary coded picture precedes the (i - 1)-th spare picture, in decoding order, and in which the values of frame_num, field_pic_flag (when present) and bottom_field_flag (when present) are equal to spareFrameNum[i], spare_field_flag and spare_bottom_field_flag[i], respectively.

spare_area_idc[i **]** indicates the method used to identify the spare slice group map units in the i-th spare picture. spare_area_idc[i] shall be in the range of 0 to 2, inclusive. spare_area_idc[i] equal to 0 indicates that all slice group map units in the i-th spare picture are spare units. spare_area_idc[i] equal to 1 indicates that the value of the syntax element spare_unit_flag[i][j] is used to identify the spare slice group map units. spare_area_idc[i] equal to 2 indicates that the zero_run_length[i][j] syntax element is used to derive the values of spareUnitFlagInBoxOutOrder[i][j], as described below.

spare_unit_flag[i **][** j **]** equal to 0 indicates that the j-th slice group map unit in raster scan order in the i-th spare picture is a spare unit. spare_unit_flag[i][j] equal to 1 indicates that the j-th slice group map unit in raster scan order in the i-th spare picture is not a spare unit.

zero_run_length[i **][** j **]** is used to derive the values of spareUnitFlagInBoxOutOrder[i][j] when spare_area_idc[i] is equal to 2. In this case, the spare slice group map units identified in spareUnitFlagInBoxOutOrder[i][j] appear in counter-clockwise box-out order, as specified in subclause 8.2.2.4, for each spare picture. spareUnitFlagInBoxOutOrder[i][j] equal to 0 indicates that the j-th slice group map unit in counter-clockwise box-out order in the i-th spare picture is a spare unit. spareUnitFlagInBoxOutOrder[i][j] equal to 1 indicates that the j-th slice group map unit in counter-clockwise box-out order in the i-th spare picture is not a spare unit.

When spare_area_idc[0] is equal to 2, spareUnitFlagInBoxOutOrder[0][j] is derived as follows:

```
for( j = 0, loop = 0; j < PicSizeInMapUnits; loop++ ) {
    for( k = 0; k < zero_run_length[ 0 ][ loop ]; k++ )
        spareUnitFlagInBoxOutOrder[ 0 ][ j++ ] = 0                                (D-4)
    spareUnitFlagInBoxOutOrder[ 0 ][ j++ ] = 1
}
```

When spare_area_idc[i] is equal to 2 and the value of i is greater than 0, spareUnitFlagInBoxOutOrder[i][j] is derived as follows:

```
for( j = 0, loop = 0; j < PicSizeInMapUnits; loop++ ) {
    for( k = 0; k < zero_run_length[ i ][ loop ]; k++ )
        spareUnitFlagInBoxOutOrder[ i ][ j ] = spareUnitFlagInBoxOutOrder[ i - 1 ][ j++ ]   (D-5)
    spareUnitFlagInBoxOutOrder[ i ][ j ] = !spareUnitFlagInBoxOutOrder[ i - 1 ][ j++ ]
}
```

D.2.10 Scene information SEI message semantics

A scene and a scene transition are herein defined as a set of consecutive pictures in output order.

NOTE 1 – Decoded pictures within one scene generally have similar content. The scene information SEI message is used to label pictures with scene identifiers and to indicate scene changes. The message specifies how the source pictures for the labelled

pictures were created. The decoder may use the information to select an appropriate algorithm to conceal transmission errors. For example, a specific algorithm may be used to conceal transmission errors that occurred in pictures belonging to a gradual scene transition. Furthermore, the scene information SEI message may be used in a manner determined by the application, such as for indexing the scenes of a coded sequence.

A scene information SEI message labels all pictures, in decoding order, from the primary coded picture to which the SEI message is associated (inclusive), as specified in subclause 7.4.1.2.3, to the primary coded picture to which the next scene information SEI message (if present) in decoding order is associated (exclusive) or (otherwise) to the last access unit in the bitstream (inclusive). These pictures are herein referred to as the target pictures.

scene_info_present_flag equal to 0 indicates that the scene or scene transition to which the target pictures belong is unspecified. scene_info_present_flag equal to 1 indicates that the target pictures belong to the same scene or scene transition.

scene_id identifies the scene to which the target pictures belong. When the value of scene_transition_type of the target pictures is less than 4, and the previous picture in output order is marked with a value of scene_transition_type less than 4, and the value of scene_id is the same as the value of scene_id of the previous picture in output order, this indicates that the source scene for the target pictures and the source scene for the previous picture (in output order) are considered by the encoder to have been the same scene. When the value of scene_transition_type of the target pictures is greater than 3, and the previous picture in output order is marked with a value of scene_transition_type less than 4, and the value of scene_id is the same as the value of scene_id of the previous picture in output order, this indicates that one of the source scenes for the target pictures and the source scene for the previous picture (in output order) are considered by the encoder to have been the same scene. When the value of scene_id is not equal to the value of scene_id of the previous picture in output order, this indicates that the target pictures and the previous picture (in output order) are considered by the encoder to have been from different source scenes.

The value of scene_id shall be in the range of 0 to 2^{32}-1, inclusive. Values of scene_id in the range of 0 to 255, inclusive, and in the range of 512 to $2^{31} – 1$, inclusive, may be used as determined by the application. Values of scene_id in the range of 256 to 511, inclusive, and in the range of 2^{31} to $2^{32} – 1$, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of scene_id in the range of 256 to 511, inclusive, or in the range of 2^{31} to 2^{32} - 1, inclusive, shall ignore (remove from the bitstream and discard) it.

scene_transition_type specifies in which type of a scene transition (if any) the target pictures are involved. The valid values of scene_transition_type are specified in Table D-4.

Table D-4 – scene_transition_type values

Value	Description
0	No transition
1	Fade to black
2	Fade from black
3	Unspecified transition from or to constant colour
4	Dissolve
5	Wipe
6	Unspecified mixture of two scenes

When scene_transition_type is greater than 3, the target pictures include contents both from the scene labelled by its scene_id and the next scene, in output order, which is labelled by second_scene_id (see below). The term “the current scene” is used to indicate the scene labelled by scene_id. The term “the next scene” is used to indicate the scene labelled by second_scene_id. It is not required for any following picture, in output order, to be labelled with scene_id equal to second_scene_id of the current SEI message.

Scene transition types are specified as follows.

“No transition” specifies that the target pictures are not involved in a gradual scene transition.

NOTE 2 – When two consecutive pictures in output order have scene_transition_type equal to 0 and different values of scene_id, a scene cut occurred between the two pictures.

“Fade to black” indicates that the target pictures are part of a sequence of pictures, in output order, involved in a fade to black scene transition, i.e., the luma samples of the scene gradually approach zero and the chroma samples of the scene gradually approach 128.

NOTE 3 – When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Fade to black", the later one, in output order, is darker than the previous one.

“Fade from black” indicates that the target pictures are part of a sequence of pictures, in output order, involved in a fade from black scene transition, i.e., the luma samples of the scene gradually diverge from zero and the chroma samples of the scene may gradually diverge from 128.

NOTE 4 – When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Fade from black", the later one in output order is lighter than the previous one.

“Dissolve” indicates that the sample values of each target picture (before encoding) were generated by calculating a sum of co-located weighted sample values of a picture from the current scene and a picture from the next scene. The weight of the current scene gradually decreases from full level to zero level, whereas the weight of the next scene gradually increases from zero level to full level. When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Dissolve", the weight of the current scene for the later one, in output order, is less than the weight of the current scene for the previous one, and the weight of the next scene for the later one, in output order, is greater than the weight of the next scene for the previous one.

"Wipe" indicates that some of the sample values of each target picture (before encoding) were generated by copying co-located sample values of a picture in the current scene and the remaining sample values of each target picture (before encoding) were generated by copying co-located sample values of a picture in the next scene. When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Wipe", the number of samples copied from the next scene to the later picture in output order is greater than the number of samples copied from the next scene to the previous picture.

second_scene_id identifies the next scene in the gradual scene transition in which the target pictures are involved. The value of second_scene_id shall not be equal to the value of scene_id. The value of second_scene_id shall not be equal to the value of scene_id in the previous picture in output order. When the next picture in output order is marked with a value of scene_transition_type less than 4, and the value of second_scene_id is the same as the value of scene_id of the next picture in output order, this indicates that the encoder considers one of the source scenes for the target pictures and the source scene for the next picture (in output order) to have been the same scene. When the value of second_scene_id is not equal to the value of scene_id or second_scene_id (if present) of the next picture in output order, this indicates that the encoder considers the target pictures and the next picture (in output order) to have been from different source scenes.

When the value of scene_id of a picture is equal to the value of scene_id of the following picture in output order and the value of scene_transition_type in both of these pictures is less than 4, this indicates that the encoder considers the two pictures to have been from the same source scene. When the values of scene_id, scene_transition_type and second_scene_id (if present) of a picture are equal to the values of scene_id, scene_transition_type and second_scene_id (respectively) of the following picture in output order and the value of scene_transition_type is greater than 0, this indicates that the encoder considers the two pictures to have been from the same source gradual scene transition.

The value of second_scene_id shall be in the range of 0 to 2^{32}-1, inclusive. Values of second_scene_id in the range of 0 to 255, inclusive, and in the range of 512 to 2^{31}-1, inclusive, may be used as determined by the application. Values of second_scene_id in the range of 256 to 511, inclusive, and in the range of 2^{31} to 2^{32}-1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of second_scene_id in the range of 256 to 511, inclusive, or in the range of 2^{31} to 2^{32}-1, inclusive, shall ignore (remove from the bitstream and discard) it.

D.2.11 Sub-sequence information SEI message semantics

The sub-sequence information SEI message is used to indicate the position of a picture in data dependency hierarchy that consists of sub-sequence layers and sub-sequences.

A sub-sequence layer contains a subset of the coded pictures in a sequence. Sub-sequence layers are numbered with non-negative integers. A layer having a larger layer number is a higher layer than a layer having a smaller layer number. The layers are ordered hierarchically based on their dependency on each other so that any picture in a layer shall not be predicted from any picture on any higher layer.

NOTE 1 – In other words, any picture in layer 0 must not be predicted from any picture in layer 1 or above, pictures in layer 1 may be predicted from layer 0, pictures in layer 2 may be predicted from layers 0 and 1, etc.

NOTE 2 – The subjective quality is expected to increase along with the number of decoded layers.

A sub-sequence is a set of coded pictures within a sub-sequence layer. A picture shall reside in one sub-sequence layer and in one sub-sequence only. Any picture in a sub-sequence shall not be predicted from any picture in another sub-sequence in the same or in a higher sub-sequence layer. A sub-sequence in layer 0 can be decoded independently of any picture that does not belong to the sub-sequence.

The sub-sequence information SEI message concerns the current access unit. The primary coded picture in the access unit is herein referred to as the current picture.

The sub-sequence information SEI message shall not be present unless gaps_in_frame_num_value_allowed_flag in the sequence parameter set referenced by the picture associated with the sub-sequence SEI message is equal to 1.

sub_seq_layer_num specifies the sub-sequence layer number of the current picture. When sub_seq_layer_num is greater than 0, memory management control operations shall not be used in any slice header of the current picture. When the current picture resides in a sub-sequence whose first picture in decoding order is an IDR picture, the value of sub_seq_layer_num shall be equal to 0. For a non-paired reference field, the value of sub_seq_layer_num shall be equal to 0. sub_seq_layer_num shall be in the range of 0 to 255, inclusive.

sub_seq_id identifies the sub-sequence within a layer. When the current picture resides in a sub-sequence whose first picture in decoding order is an IDR picture, the value of sub_seq_id shall be the same as the value of idr_pic_id of the IDR picture. sub_seq_id shall be in the range of 0 to 65535, inclusive.

first_ref_pic_flag equal to 1 specifies that the current picture is the first reference picture of the sub-sequence in decoding order. When the current picture is not the first picture of the sub-sequence in decoding order, the first_ref_pic_flag shall be equal to 0.

leading_non_ref_pic_flag equal to 1 specifies that the current picture is a non-reference picture preceding any reference picture in decoding order within the sub-sequence or that the sub-sequence contains no reference pictures. When the current picture is a reference picture or the current picture is a non-reference picture succeeding at least one reference picture in decoding order within the sub-sequence, the leading_non_ref_pic_flag shall be equal to 0.

last_pic_flag equal to 1 indicates that the current picture is the last picture of the sub-sequence (in decoding order), including all reference and non-reference pictures of the sub-sequence. When the current picture is not the last picture of the sub-sequence (in decoding order), last_pic_flag shall be equal to 0.

The current picture is assigned to a sub-sequence as follows.

- If one or more of the following conditions is true, the current picture is the first picture of a sub-sequence in decoding order.
    - no earlier picture in decoding order is labelled with the same values of sub_seq_id and sub_seq_layer_num as the current picture,
    - the value of leading_non_ref_pic_flag is equal to 1 and the value of leading_non_ref_pic_flag is equal to 0 in the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture,
    - the value of first_ref_pic_flag is equal to 1 and the value of leading_non_ref_pic_flag is equal to 0 in the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture,
    - the value of last_pic_flag is equal to 1 in the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture.
- Otherwise, the current picture belongs to the same sub-sequence as the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture.

sub_seq_frame_num_flag equal to 0 specifies that sub_seq_frame_num is not present. sub_seq_frame_num_flag equal to 1 specifies that sub_seq_frame_num is present.

sub_seq_frame_num shall be equal to 0 for the first reference picture of the sub-sequence and for any non-reference picture preceding the first reference picture of the sub-sequence in decoding order. sub_seq_frame_num is further constrained as follows.

- If the current picture is not the second field of a complementary field pair, sub_seq_frame_num shall be incremented by 1, in modulo MaxFrameNum operation, relative to the previous reference picture, in decoding order, that belongs to the sub-sequence.
- Otherwise (the current picture is the second field of a complementary field pair), the value of sub_seq_frame_num shall be the same as the value of sub_seq_frame_num for the first field of the complementary field pair.

sub_seq_frame_num shall be in the range of 0 to MaxFrameNum – 1, inclusive.

When the current picture is an IDR picture, it shall start a new sub-sequence in sub-sequence layer 0. Thus, the sub_seq_layer_num shall be 0, the sub_seq_id shall be different from the previous sub-sequence in sub-sequence layer 0, first_ref_pic_flag shall be 1, and leading_non_ref_pic_flag shall be equal to 0.

When the sub-sequence information SEI message is present for both coded fields of a complementary field pair, the values of sub_seq_layer_num, sub_seq_id, leading_non_ref_pic_flag and sub_seq_frame_num, when present, shall be identical for both of these pictures.

When the sub-sequence information SEI message is present only for one coded field of a complementary field pair, the values of sub_seq_layer_num, sub_seq_id, leading_non_ref_pic_flag and sub_seq_frame_num, when present, are also applicable to the other coded field of the complementary field pair.

D.2.12 Sub-sequence layer characteristics SEI message semantics

The sub-sequence layer characteristics SEI message specifies the characteristics of sub-sequence layers.

num_sub_seq_layers_minus1 plus 1 specifies the number of sub-sequence layers in the sequence. num_sub_seq_layers_minus1 shall be in the range of 0 to 255, inclusive.

A pair of average_bit_rate and average_frame_rate characterizes each sub-sequence layer. The first pair of average_bit_rate and average_frame_rate specifies the characteristics of sub-sequence layer 0. When present, the second pair specifies the characteristics of sub-sequence layers 0 and 1 jointly. Each pair in decoding order specifies the characteristics for a range of sub-sequence layers from layer number 0 to the layer number specified by the layer loop counter. The values are in effect from the point they are decoded until an update of the values is decoded.

accurate_statistics_flag equal to 1 indicates that the values of average_bit_rate and average_frame_rate are rounded from statistically correct values. accurate_statistics_flag equal to 0 indicates that the average_bit_rate and the average_frame_rate are estimates and may deviate somewhat from the correct values.

When accurate_statistics_flag is equal to 0, the quality of the approximation used in the computation of the values of average_bit_rate and the average_frame_rate is chosen by the encoding process and is not specified by this Recommendation | International Standard.

average_bit_rate indicates the average bit rate in units of 1000 bits per second. All NAL units in the range of sub-sequence layers specified above are taken into account in the calculation. The average bit rate is derived according to the access unit removal time specified in Annex C of the Recommendation | International Standard. In the following, bTotal is the number of bits in all NAL units succeeding a sub-sequence layer characteristics SEI message (including the bits of the NAL units of the current access unit) and preceding the next access unit (in decoding order) including a sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise). t_1 is the removal time (in seconds) of the current access unit, and t_2 is the removal time (in seconds) of the latest access unit (in decoding order) before the next sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If t_1 is not equal to t_2, the following condition shall be true

$$\text{average\_bit\_rate} == \text{Round}(\text{bTotal} \div ((t_2 - t_1) * 1000))) \quad \text{(D-6)}$$

– Otherwise (t_1 is equal to t_2), the following condition shall be true

$$\text{average\_bit\_rate} == 0 \quad \text{(D-7)}$$

average_frame_rate indicates the average frame rate in units of frames/(256 seconds). All NAL units in the range of sub-sequence layers specified above are taken into account in the calculation. In the following, fTotal is the number of frames, complementary field pairs and non-paired fields between the current picture (inclusive) and the next sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise). t_1 is the removal time (in seconds) of the current access unit, and t_2 is the removal time (in seconds) of the latest access unit (in decoding order) before the next sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If t_1 is not equal to t_2, the following condition shall be true

$$\text{average\_frame\_rate} == \text{Round}(\text{fTotal} * 256 \div (t_2 - t_1)) \quad \text{(D-8)}$$

– Otherwise (t_1 is equal to t_2), the following condition shall be true

$$\text{average\_frame\_rate} == 0 \quad \text{(D-9)}$$

D.2.13 Sub-sequence characteristics SEI message semantics

The sub-sequence characteristics SEI message indicates the characteristics of a sub-sequence. It also indicates inter prediction dependencies between sub-sequences. This message shall be contained in the first access unit in decoding

order of the sub-sequence to which the sub-sequence characteristics SEI message applies. This sub-sequence is herein called the target sub-sequence.

sub_seq_layer_num identifies the sub-sequence layer number of the target sub-sequence. sub_seq_layer_num shall be in the range of 0 to 255, inclusive.

sub_seq_id identifies the target sub-sequence. sub_seq_id shall be in the range of 0 to 65535, inclusive.

duration_flag equal to 0 indicates that the duration of the target sub-sequence is not specified.

sub_seq_duration specifies the duration of the target sub-sequence in clock ticks of a 90 kHz clock.

average_rate_flag equal to 0 indicates that the average bit rate and the average frame rate of the target sub-sequence are unspecified.

accurate_statistics_flag indicates how reliable the values of average_bit_rate and average_frame_rate are. accurate_statistics_flag equal to 1, indicates that the average_bit_rate and the average_frame_rate are rounded from statistically correct values. accurate_statistics_flag equal to 0 indicates that the average_bit_rate and the average_frame_rate are estimates and may deviate from the statistically correct values.

average_bit_rate indicates the average bit rate in (1000 bits)/second of the target sub-sequence. All NAL units of the target sub-sequence are taken into account in the calculation. The average bit rate is derived according to the access unit removal time specified in subclause C.1.2. In the following, nB is the number of bits in all NAL units in the sub-sequence. t_1 is the removal time (in seconds) of the first access unit of the sub-sequence (in decoding order), and t_2 is the removal time (in seconds) of the last access unit of the sub-sequence (in decoding order).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If t_1 is not equal to t_2, the following condition shall be true

$$\text{average\_bit\_rate} == \text{Round}(nB \div ((t_2 - t_1) * 1000)) \quad \text{(D-10)}$$

– Otherwise (t_1 is equal to t_2), the following condition shall be true

$$\text{average\_bit\_rate} == 0 \quad \text{(D-11)}$$

average_frame_rate indicates the average frame rate in units of frames/(256 seconds) of the target sub-sequence. All NAL units of the target sub-sequence are taken into account in the calculation. The average frame rate is derived according to the access unit removal time specified in subclause C.1.2. In the following, fC is the number of frames, complementary field pairs and non-paired fields in the sub-sequence. t_1 is the removal time (in seconds) of the first access unit of the sub-sequence (in decoding order), and t_2 is the removal time (in seconds) of the last access unit of the sub-sequence (in decoding order).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If t_1 is not equal to t_2, the following condition shall be true

$$\text{average\_frame\_rate} == \text{Round}(fC * 256 \div (t_2 - t_1)) \quad \text{(D-12)}$$

– Otherwise (t_1 is equal to t_2), the following condition shall be true

$$\text{average\_frame\_rate} == 0 \quad \text{(D-13)}$$

num_referenced_subseqs specifies the number of sub-sequences that contain pictures that are used as reference pictures for inter prediction in the pictures of the target sub-sequence. num_referenced_subseqs shall be in the range of 0 to 255, inclusive.

ref_sub_seq_layer_num, ref_sub_seq_id, and **ref_sub_seq_direction** identify the sub-sequence that contains pictures that are used as reference pictures for inter prediction in the pictures of the target sub-sequence. Depending on ref_sub_seq_direction, the following applies.

– If ref_sub_seq_direction is equal to 0, a set of candidate sub-sequences consists of the sub-sequences whose sub_seq_id is equal to ref_sub_seq_id, which reside in the sub-sequence layer having sub_seq_layer_num equal to ref_sub_seq_layer_num, and whose first picture in decoding order precedes the first picture of the target sub-sequence in decoding order.

– Otherwise (ref_sub_seq_direction is equal to 1), a set of candidate sub-sequences consists of the sub-sequences whose sub_seq_id is equal to ref_sub_seq_id, which reside in the sub-sequence layer having sub_seq_layer_num equal to ref_sub_seq_layer_num, and whose first picture in decoding order succeeds the first picture of the target sub-sequence in decoding order.

The sub-sequence used as a reference for the target sub-sequence is the sub-sequence among the set of candidate sub-sequences whose first picture is the closest to the first picture of the target sub-sequence in decoding order.

D.2.14 Full-frame freeze SEI message semantics

The full-frame freeze SEI message indicates that the current picture and any subsequent pictures in output order that meet specified conditions should not affect the content of the display. No more than one full-frame freeze SEI message shall be present in any access unit.

full_frame_freeze_repetition_period specifies the persistence of the full-frame freeze SEI message and may specify a picture order count interval within which another full-frame freeze SEI message or a full-frame freeze release SEI or the end of the coded video sequence shall be present in the bitstream. The value of full_frame_freeze_repetition_period shall be in the range of 0 to 16 384, inclusive.

full_frame_freeze_repetition_period equal to 0 specifies that the full-frame freeze SEI message applies to the current decoded picture only.

full_frame_freeze_repetition_period equal to 1 specifies that the full-frame freeze SEI message persists in output order until any of the following conditions are true.

- A new coded video sequence begins.
- A picture in an access unit containing a full-frame freeze SEI message or a full-frame freeze release SEI message is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic).

full_frame_freeze_repetition_period greater than 1 specifies that the full-frame freeze SEI message persists until any of the following conditions are true.

- A new coded video sequence begins.
- A picture in an access unit containing a full-frame freeze SEI message or a full-frame freeze release SEI message is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + full_frame_freeze_repetition_period.

full_frame_freeze_repetition_period greater than 1 indicates that another full-frame freeze SEI message or a full-frame freeze release SEI message shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + full_frame_freeze_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

D.2.15 Full-frame freeze release SEI message semantics

The full-frame freeze release SEI message cancels the effect of any full-frame freeze SEI message sent with pictures that precede the current picture in output order. The full-frame freeze release SEI message indicates that the current picture and subsequent pictures in output order should affect the contents of the display.

No more than one full-frame freeze release SEI message shall be present in any access unit. A full-frame freeze release SEI message shall not be present in an access unit containing a full-frame freeze SEI message. When a full-frame freeze SEI message is present in an access unit containing a field of a complementary field pair in which the values of PicOrderCnt(CurrPic) for the two fields of the complementary field pair are equal to each other, a full-frame freeze release SEI message shall not be present in either of the two access units.

D.2.16 Full-frame snapshot SEI message semantics

The full-frame snapshot SEI message indicates that the current frame is labelled for use as determined by the application as a still-image snapshot of the video content.

snapshot_id specifies a snapshot identification number. snapshot_id shall be in the range of 0 to 2^{32} - 1, inclusive.

Values of snapshot_id in the range of 0 to 255, inclusive, and in the range of 512 to 2^{31}-1, inclusive, may be used as determined by the application. Values of snapshot_id in the range of 256 to 511, inclusive, and in the range of 2^{31} to 2^{32}-1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of snapshot_id in the range of 256 to 511, inclusive, or in the range of 2^{31} to 2^{32}-1, inclusive, shall ignore (remove from the bitstream and discard) it.

D.2.17 Progressive refinement segment start SEI message semantics

The progressive refinement segment start SEI message specifies the beginning of a set of consecutive coded pictures that is labelled as the current picture followed by a sequence of one or more pictures of refinement of the quality of the current picture, rather than as a representation of a continually moving scene.

The tagged set of consecutive coded pictures shall continue until one of the following conditions is true. When a condition below becomes true, the next slice to be decoded does not belong to the tagged set of consecutive coded pictures.

1. The next slice to be decoded belongs to an IDR picture.
2. num_refinement_steps_minus1 is greater than 0 and the frame_num of the next slice to be decoded is (currFrameNum + num_refinement_steps_minus1 + 1) % MaxFrameNum, where currFrameNum is the value of frame_num of the picture in the access unit containing the SEI message.
3. num_refinement_steps_minus1 is 0 and a progressive refinement segment end SEI message with the same progressive_refinement_id as the one in this SEI message is decoded.

The decoding order of picture within the tagged set of consecutive pictures should be the same as their output order. **progressive_refinement_id** specifies an identification number for the progressive refinement operation. progressive_refinement_id shall be in the range of 0 to 2^{32} - 1, inclusive.

Values of progressive_refinement_id in the range of 0 to 255, inclusive, and in the range of 512 to 2^{31} - 1, inclusive, may be used as determined by the application. Values of progressive_refinement_id in the range of 256 to 511, inclusive, and in the range of 2^{31} to 2^{32}-1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of progressive_refinement_id in the range of 256 to 511, inclusive, or in the range of 2^{31} to 2^{32} - 1, inclusive, shall ignore (remove from the bitstream and discard) it.

num_refinement_steps_minus1 specifies the number of reference frames in the tagged set of consecutive coded pictures as follows.

– If num_refinement_steps_minus1 is equal to 0, the number of reference frames in the tagged set of consecutive coded pictures is unknown.

– Otherwise, the number of reference frames in the tagged set of consecutive coded pictures is equal to num_refinement_steps_minus1 + 1.

num_refinement_steps_minus1 shall be in the range of 0 to MaxFrameNum - 1, inclusive.

D.2.18 Progressive refinement segment end SEI message semantics

The progressive refinement segment end SEI message specifies the end of a set of consecutive coded pictures that has been labelled by use of a progressive refinement segment start SEI message as an initial picture followed by a sequence of one or more pictures of the refinement of the quality of the initial picture, and ending with the current picture.

progressive_refinement_id specifies an identification number for the progressive refinement operation. progressive_refinement_id shall be in the range of 0 to 2^{32} - 1, inclusive.

The progressive refinement segment end SEI message specifies the end of any progressive refinement segment previously started using a progressive refinement segment start SEI message with the same value of progressive_refinement_id.

Values of progressive_refinement_id in the range of 0 to 255, inclusive, and in the range of 512 to 2^{31} - 1, inclusive, may be used as determined by the application. Values of progressive_refinement_id in the range of 256 to 511, inclusive, and in the range of 2^{31} to 2^{32} - 1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of progressive_refinement_id in the range of 256 to 511, inclusive, or in the range of 2^{31} to 2^{32} - 1, inclusive, shall ignore (remove from the bitstream and discard) it.

D.2.19 Motion-constrained slice group set SEI message semantics

This SEI message indicates that inter prediction over slice group boundaries is constrained as specified below. When present, the message shall only appear where it is associated, as specified in subclause 7.4.1.2.3, with an IDR access unit.

The target picture set for this SEI message contains all consecutive primary coded pictures in decoding order starting with the associated primary coded IDR picture (inclusive) and ending with the following primary coded IDR picture (exclusive) or with the very last primary coded picture in the bitstream (inclusive) in decoding order when there is no following primary coded IDR picture. The slice group set is a collection of one or more slice groups, identified by the slice_group_id[i] syntax element. When separate_colour_plane_flag is equal to 1, the term “primary coded pictures”

represents the parts of the corresponding primary coded pictures that correspond to the NAL units having the same colour_plane_id.

This SEI message indicates that, for each picture in the target picture set, the inter prediction process is constrained as follows: No sample value outside the slice group set, and no sample value at a fractional sample position that is derived using one or more sample values outside the slice group set is used to inter predict any sample within the slice group set.

num_slice_groups_in_set_minus1 + 1 specifies the number of slice groups in the slice group set. The allowed range of num_slice_groups_in_set_minus1 is 0 to num_slice_groups_minus1, inclusive. The allowed range of num_slice_groups_minus1 is specified in Annex A.

slice_group_id[i **]** identifies the slice group(s) contained within the slice group set. The allowed range is from 0 to num_slice_groups_in_set_minus1, inclusive. The size of the slice_group_id[i] syntax element is Ceil(Log2(num_slice_groups_minus1 + 1)) bits.

exact_sample_value_match_flag equal to 0 indicates that, within the target picture set, when the macroblocks that do not belong to the slice group set are not decoded, the value of each sample in the slice group set need not be exactly the same as the value of the same sample when all the macroblocks are decoded. exact_sample_value_match_flag equal to 1 indicates that, within the target picture set, when the macroblocks that do not belong to the slice group set are not decoded, the value of each sample in the slice group set shall be exactly the same as the value of the same sample when all the macroblocks in the target picture set are decoded.

NOTE 1 – When disable_deblocking_filter_idc is equal to 2 in all slices in the target picture set, exact_sample_value_match_flag should be 1.

pan_scan_rect_flag equal to 0 specifies that pan_scan_rect_id is not present. pan_scan_rect_flag equal to 1 specifies that pan_scan_rect_id is present.

pan_scan_rect_id indicates that the specified slice group set covers at least the pan-scan rectangle identified by pan_scan_rect_id within the target picture set.

NOTE 2 – Multiple motion_constrained_slice_group_set SEI messages may be associated with the same IDR picture. Consequently, more than one slice group set may be active within a target picture set.

NOTE 3 – The size, shape, and location of the slice groups in the slice group set may change within the target picture set.

D.2.20 Film grain characteristics SEI message semantics

This SEI message provides the decoder with a parameterised model for film grain synthesis. For example, an encoder may use the film grain characteristics SEI message to characterise film grain that was present in the original source video material and was removed by pre-processing filtering techniques. Synthesis of simulated film grain on the decoded images for the display process is optional and does not affect the decoding process specified in this Recommendation | International Standard. If synthesis of simulated film grain on the decoded images for the display process is performed, there is no requirement that the method by which the synthesis is performed be the same as the parameterised model for the film grain as provided in the film grain characteristics SEI message.

NOTE 1 – The display process is not specified in this Recommendation | International Standard.

film_grain_characteristics_cancel_flag equal to 1 indicates that the SEI message cancels the persistence of any previous film grain characteristics SEI message in output order. film_grain_characteristics_cancel_flag equal to 0 indicates that film grain modelling information follows.

model_id identifies the film grain simulation model as specified in Table D-5. The value of model_id shall be in the range of 0 to 1, inclusive.

Table D-5 – model_id values

Value	Description
0	frequency filtering
1	auto-regression
2	reserved
3	reserved

separate_colour_description_present_flag equal to 1 indicates that a distinct colour space description for the film grain characteristics specified in the SEI message is present in the film grain characteristics SEI message syntax. separate_colour_description_present_flag equal to 0 indicates that the colour description for the film grain characteristics specified in the SEI message is the same as for the coded video sequence as specified in subclause E.2.1.

NOTE 2 – When separate_colour_description_present_flag is equal to 1, the colour space specified for the film grain characteristics specified in the SEI message may differ from the colour space specified for the coded video as specified in subclause E.2.1.

film_grain_bit_depth_luma_minus8 plus 8 specifies the bit depth used for the luma component of the film grain characteristics specified in the SEI message. When film_grain_bit_depth_luma_minus8 is not present in the film grain characteristics SEI message, the value of film_grain_bit_depth_luma_minus8 shall be inferred to be equal to bit_depth_luma_minus8.

The value of filmGrainBitDepth[0] is derived as

$$filmGrainBitDepth[\ 0\ ] = film\_grain\_bit\_depth\_luma\_minus8 + 8 \quad \text{(D-14)}$$

film_grain_bit_depth_chroma_minus8 plus 8 specifies the bit depth used for the Cb and Cr components of the film grain characteristics specified in the SEI message. When film_grain_bit_depth_chroma_minus8 is not present in the film grain characteristics SEI message, the value of film_grain_bit_depth_chroma_minus8 shall be inferred to be equal to bit_depth_chroma_minus8.

The value of filmGrainBitDepth[c] for c = 1 and 2 is derived as

$$filmGrainBitDepth[\ c\ ] = film\_grain\_bit\_depth\_chroma\_minus8 + 8 \quad \text{with } c = 1, 2 \quad \text{(D-15)}$$

film_grain_full_range_flag has the same semantics as specified in subclause E.2.1 for the video_full_range_flag syntax element, except as follows.

– film_grain_full_range_flag specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_full_range_flag is not present in the film grain characteristics SEI message, the value of film_grain_full_range_flag shall be inferred to be equal to video_full_range_flag.

film_grain_colour_primaries has the same semantics as specified in subclause E.2.1 for the colour_primaries syntax element, except as follows.

– film_grain_colour_primaries specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_colour_primaries is not present in the film grain characteristics SEI message, the value of film_grain_colour_primaries shall be inferred to be equal to colour_primaries.

film_grain_transfer_characteristics has the same semantics as specified in subclause E.2.1 for the transfer_characteristics syntax element, except as follows.

– film_grain_transfer_characteristics specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_transfer_characteristics is not present in the film grain characteristics SEI message, the value of film_grain_transfer_characteristics shall be inferred to be equal to transfer_characteristics.

film_grain_matrix_coefficients has the same semantics as specified in subclause E.2.1 for the matrix_coefficients syntax element, except as follows.

– film_grain_matrix_coefficients specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_matrix_coefficients is not present in the film grain characteristics SEI message, the value of film_grain_matrix_coefficients shall be inferred to be equal to matrix_coefficients.

– The values allowed for film_grain_matrix_coefficients are not constrained by the value of chroma_format_idc.

The chroma_format_idc of the film grain characteristics specified in the film grain characteristics SEI message shall be inferred to be equal to 3 (4:4:4).

NOTE 3 – Because the use of a specific method is not required for performing film grain generation function used by the display process, a decoder may, if desired, down-convert the model information for chroma in order to simulate film grain for other chroma formats (4:2:0 or 4:2:2) rather than up-converting the decoded video (using a method not specified by this Recommendation | International Standard) before performing film grain generation.

blending_mode_id identifies the blending mode used to blend the simulated film grain with the decoded images as specified in Table D-6. blending_mode_id shall be in the range of 0 to 1, inclusive.

Table D-6 – blending_mode_id values

Value	Description
0	additive
1	multiplicative
2	reserved
3	reserved

Depending on blending_mode_id, the blending mode is specified as follows

– If blending_mode_id is equal to 0 the blending mode is additive as specified by

$$I_{grain}[x, y, c] = Clip3(0, (1 << filmGrainBitDepth[c]) – 1, I_{decoded}[x, y, c] + G[x, y, c]) \quad \text{(D-16)}$$

– Otherwise (blending_mode_id is equal to 1), the blending mode is multiplicative as specified by

$$I_{grain}[x, y, c] = Clip3(0, (1 << filmGrainBitDepth[c]) – 1, I_{decoded}[x, y, c] * (1 + G[x, y, c])) \quad \text{(D-17)}$$

where $I_{decoded}[x, y, c]$ represents the sample value at coordinates x, y of the colour component c of the decoded image $I_{decoded}$, $G[x, y, c]$ is the simulated film grain value at the same position and colour component, and filmGrainBitDepth[c] is the number of bits used for each sample in a fixed-length unsigned binary representation of the array $I_{grain}[x, y, c]$.

log2_scale_factor specifies a scale factor used in the film grain characterization equations.

comp_model_present_flag[c] equal to 0 indicates that film grain is not modelled on the c-th colour component, where c equal to 0 refers to the luma component, c equal to 1 refers to the Cb component, and c equal to 2 refers to the Cr component. comp_model_present_flag[c] equal to 1 indicates that syntax elements specifying modelling of film grain on colour component c are present in the SEI message.

num_intensity_intervals_minus1[c] plus 1 specifies the number of intensity intervals for which a specific set of model values has been estimated.

NOTE 4 – The intensity intervals may overlap in order to simulate multi-generational film grain.

num_model_values_minus1[c] plus 1 specifies the number of model values present for each intensity interval in which the film grain has been modelled. The value of num_model_values_minus1[c] shall be in the range of 0 to 5, inclusive.

intensity_interval_lower_bound[c][i] specifies the lower bound of the interval i of intensity levels for which the set of model values applies.

intensity_interval_upper_bound[c][i] specifies the upper bound of the interval i of intensity levels for which the set of model values applies.

Depending on model_id, the selection of the sets of model values is specified as follows.

– If model_id is equal to 0, the average value of each block b of 16x16 samples in $I_{decoded}$, referred as b_{avg}, is used to select the sets of model values with index s[j] that apply to all the samples in the block:

```
for( i = 0, j = 0; i <= num_intensity_intervals_minus1; i++ )
   if( b_avg >= intensity_interval_lower_bound[ c ][ i ] && b_avg <= intensity_interval_upper_bound[ c ][ i ] ) {
     s[ j ] = i                                                                                          (D-18)
     j++
   }
```

– Otherwise (model_id is equal to 1), the sets of model values used to generate the film grain are selected for each sample value in $I_{decoded}$ as follows:

```
for( i = 0, j = 0; i <= num_intensity_intervals_minus1; i++ )
   if( I_decoded[ x, y, c ] >= intensity_interval_lower_bound[ c ][ i ] &&
       I_decoded[ x, y, c ] <= intensity_interval_upper_bound[ c ][ i ] ) {
    s[ j ] = i
    j++
   }
```
(D-19)

Samples that do not fall into any of the defined intervals are not modified by the grain generation function. Samples that fall into more than one interval will originate multi-generation grain. Multi-generation grain results from adding the grain computed independently for each intensity interval.

comp_model_value[c][i][j] represents each one of the model values present for the colour component c and the intensity interval i. The set of model values has different meaning depending on the value of model_id. The value of comp_model_value[c][i][j] shall be constrained as follows, and may be additionally constrained as specified elsewhere in this subclause.

– If model_id is equal to 0, comp_model_value[c][i][j] shall be in the range of 0 to $2^{filmGrainBitDepth[\ c\ ]} - 1$, inclusive.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][j] shall be in the range of $-2^{(\ filmGrainBitDepth[\ c\ ] - 1\ )}$ to $2^{(\ filmGrainBitDepth[\ c\ ] - 1\ )} - 1$, inclusive.

Depending on model_id, the synthesis of the film grain is modelled as follows.

– If model_id is equal to 0, a frequency filtering model enables simulating the original film grain for c = 0..2, x = 0..$PicWidthInSamples_L$, and y = 0..$PicHeightInSamples_L$ as specified by:

```
G[ x, y, c ] = ( comp_model_value[ c ][ s ][ 0 ] * Q[ x, y, c ] + comp_model_value[ c ][ s ][ 5 ] *
                                        G[ x, y, c-1 ] ) >> log2_scale_factor
```
(D-20)

where Q[c] is a two-dimensional random process generated by filtering 16x16 blocks gaussRv with random-value elements $gaussRv_{ij}$ generated with a normalized Gaussian distribution (independent and identically distributed Gaussian random variable samples with zero mean and unity variance) and where the value of an element G[x, y, c-1] used in the right-hand side of the equation is inferred to be equal to 0 when c-1 is less than 0.

NOTE 5 – A normalized Gaussian random value can be generated from two independent, uniformly distributed random values over the interval from 0 to 1 (and not equal to 0), denoted as uRv_0 and uRv_1, using the Box-Muller transformation specified by

$$gaussRv_{ij} = \sqrt{-2 * Ln(uRv_0)} * Cos(2 * \pi * uRv_1) \quad \text{(D-21)}$$

where Ln(x) is the natural logarithm of x (the base-e logarithm, where e is natural logarithm base constant 2.718 281 828...), Cos(x) is the trigonometric cosine function operating on an argument x in units of radians, and π is Archimedes' constant 3.141 592 653....

The band-pass filtering of blocks gaussRv may be performed in the discrete cosine transform (DCT) domain as follows:

```
for( y = 0; y < 16; y++ )
    for( x = 0; x < 16; x++ )
        if( ( x < comp_model_value[ c ][ s ][ 3 ]  &&  y < comp_model_value[ c ][ s ][ 4 ] ) ||
          x > comp_model_value[ c ][ s ][ 1 ]  ||  y > comp_model_value[ c ][ s ][ 2 ] )
            gaussRv[ x, y ] = 0
filteredRv = IDCT16x16( gaussRv )
```
(D-22)

where IDCT16x16(z) refers to a unitary inverse discrete cosine transformation (IDCT) operating on a 16x16 matrix argument z as specified by

$$IDCT16x16(z) = r * z * r^T \quad \text{(D-23)}$$

where the superscript T indicates a matrix transposition and r is the 16x16 matrix with elements r_{ij} specified by

$$r_{ij} = \frac{((i == 0)\,?\,1 : \sqrt{2})}{4} \mathrm{Cos}\left(\frac{i*(2*j+1)*\pi}{32}\right) \quad \text{(D-24)}$$

where Cos(x) is the trigonometric cosine function operating on an argument x in units of radians and π is Archimedes' constant 3.141 592 653.

Q[c] is formed by the frequency-filtered blocks filteredRv.

NOTE 6 – Coded model values are based on blocks of 16x16, but a decoder implementation may use other block sizes. For example, decoders implementing the IDCT on 8x8 blocks, should down-convert by a factor of two the set of coded model values comp_model_value[c][s][i] for i equal to 1..4.

NOTE 7 – To reduce the degree of visible blocks that can result from mosaicing the frequency-filtered blocks filteredRv, decoders may apply a low-pass filter to the boundaries between frequency-filtered blocks.

– Otherwise (model_id is equal to 1), an auto-regression model enables simulating the original film grain for c = 0..2, x = 0..$\mathrm{PicWidthInSamples_L}$, and y = 0..$\mathrm{PicHeightInSamples_L}$ as specified by

```
G[ x, y, c ] = ( comp_model_value[ c ][ s ][ 0 ] * n[ x, y, c ] +
    comp_model_value[ c ][ s ][ 1 ] * ( G[ x-1, y, c ] + ( ( comp_model_value[ c ][ s ][ 4 ] * G[ x, y-1, c ] )  >>
        log2_scale_factor ) ) +
    comp_model_value[ c ][ s ][ 3 ] * ( ( ( comp_model_value[ c ][ s ][ 4 ] * G[ x-1, y-1, c ] ) >>
        log2_scale_factor ) + G[ x+1, y-1, c ] ) +
    comp_model_value[ c ][ s ][ 5 ] * ( G[ x-2, y, c ] +
        ( ( comp_model_value[ c ][ s ][ 4 ] * comp_model_value[ c ][ s ][ 4 ] * G[ x, y-2, c ] ) >>
            ( 2 * log2_scale_factor ) ) ) +
    comp_model_value[ c ][ s ][ 2 ] * G[ x, y, c-1 ] ) >> log2_scale_factor                    (D-25)
```

where n[x, y, c] is a random value with normalized Gaussian distribution (independent and identically distributed Gaussian random variable samples with zero mean and unity variance for each value of x, y, and c) and where the value of an element G[x, y, c] used in the right-hand side of the equation is inferred to be equal to 0 when any of the following conditions are true:

– x is less than 0,

– y is less than 0,

– x is greater than or equal to $\mathrm{PicWidthInSamples_L}$,

– c is less than 0.

comp_model_value[c][i][0] provides the first model value for the model as specified by model_id. comp_model_value[c][i][0] corresponds to the standard deviation of the Gaussian noise term in the generation functions specified in Equations D-20 through D-23.

comp_model_value[c][i][1] provides the second model value for the model as specified by model_id. comp_model_value[c][i][1] shall be greater than or equal to 0 and less than 16.

When not present in the film grain characteristics SEI message, comp_model_value[c][i][1] shall be inferred as follows.

– If model_id is equal to 0, comp_model_value[c][i][1] shall be inferred to be equal to 8.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][1] shall be inferred to be equal to 0.

comp_model_value[c][i][1] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[c][i][1] indicates the horizontal high cut frequency to be used to filter the DCT of a block of 16x16 random values.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][1] indicates the first order spatial correlation for neighbouring samples (x-1, y) and (x, y-1).

comp_model_value[c][i][2] provides the third model value for the model as specified by model_id. comp_model_value[c][i][2] shall be greater than or equal to 0 and less than 16.

When not present in the film grain characteristics SEI message, comp_model_value[c][i][2] shall be inferred as follows.

– If model_id is equal to 0, comp_model_value[c][i][2] shall be inferred to be equal to comp_model_value[c][i][1].

– Otherwise (model_id is equal to 0), comp_model_value[c][i][2] shall be inferred to be equal to 0.

comp_model_value[c][i][2] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[c][i][2] indicates the vertical high cut frequency to be used to filter the DCT of a block of 16x16 random values.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][2] indicates the colour correlation between consecutive colour components.

comp_model_value[c][i][3] provides the fourth model value for the model as specified by model_id. comp_model_value[c][i][3] shall be greater than or equal to 0 and less than or equal to comp_model_value[c][i][1].

When not present in the film grain characteristics SEI message, comp_model_value[c][i][3] shall be inferred to be equal to 0.

comp_model_value[c][i][3] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[c][i][3] indicates the horizontal low cut frequency to be used to filter the DCT of a block of 16x16 random values.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][3] indicates the first order spatial correlation for neighbouring samples (x-1, y-1) and (x+1, y-1).

comp_model_value[c][i][4] provides the fifth model value for the model as specified by model_id. comp_model_value[c][i][4] shall be greater than or equal to 0 and less than or equal to comp_model_value[c][i][2].

When not present in the film grain characteristics SEI message, comp_model_value[c][i][4] shall be inferred to be equal to model_id.

comp_model_value[c][i][4] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[c][i][4] indicates the vertical low cut frequency to be used to filter the DCT of a block of 16x16 random values.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][4] indicates the aspect ratio of the modelled grain.

comp_model_value[c][i][5] provides the sixth model value for the model as specified by model_id. When not present in the film grain characteristics SEI message, comp_model_value[c][i][5] shall be inferred to be equal to 0.

comp_model_value[c][i][5] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[c][i][5] indicates the colour correlation between consecutive colour components.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][5] indicates the second order spatial correlation for neighbouring samples (x, y-2) and (x-2, y).

film_grain_characteristics_repetition_period specifies the persistence of the film grain characteristics SEI message and may specify a picture order count interval within which another film grain characteristics SEI message or the end of the coded video sequence shall be present in the bitstream. The value of film_grain_characteristics_repetition_period shall be in the range 0 to 16 384, inclusive.

film_grain_characteristics_repetition_period equal to 0 specifies that the film grain characteristics SEI message applies to the current decoded picture only.

film_grain_characteristics_repetition_period equal to 1 specifies that the film grain characteristics SEI message persists in output order until any of the following conditions are true.

– A new coded video sequence begins, or

– A picture in an access unit containing a film grain characteristics SEI message that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic).

film_grain_characteristics_repetition_period greater than 1 specifies that the film grain characteristics SEI message persists until any of the following conditions are true.

– A new coded video sequence begins, or

– A picture in an access unit containing a film grain characteristics SEI message is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + film_grain_characteristics_repetition_period.

film_grain_characteristics_repetition_period greater than 1 indicates that another film grain characteristics SEI message shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + film_grain_characteristics_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

D.2.21 Deblocking filter display preference SEI message semantics

This SEI message provides the decoder with an indication of whether the display of the cropped result of the deblocking filter process specified in subclause 8.7 or of the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 is preferred by the encoder for the display of each decoded picture that is output.

NOTE 1 – The display process is not specified in this Recommendation | International Standard. The means by which an encoder determines what to indicate as its preference expressed in a deblocking filter display preference SEI message is also not specified in this Recommendation | International Standard, and the expression of an expressed preference in a deblocking filter display preference SEI message does not impose any requirement on the display process.

deblocking_display_preference_cancel_flag equal to 1 indicates that the SEI message cancels the persistence of any previous deblocking filter display preference SEI message in output order. deblocking_display_preference_cancel_flag equal to 0 indicates that a display_prior_to_deblocking_preferred_flag and deblocking_display_preference_repetition_period follow.

NOTE 2 – In the absence of the deblocking filter display preference SEI message, or after the receipt of a deblocking filter display preference SEI message in which deblocking_display_preference_cancel_flag is equal to 1, the decoder should infer that the display of the cropped result of the deblocking filter process specified in subclause 8.7 is preferred over the display of the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 for the display of each decoded picture that is output.

display_prior_to_deblocking_preferred_flag equal to 1 indicates that the encoder preference is for the display process (which is not specified in this Recommendation | International Standard) to display the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 rather than the cropped result of the deblocking filter process specified in subclause 8.7 for each picture that is cropped and output as specified in Annex C. display_prior_to_deblocking_preferred_flag equal to 0 indicates that the encoder preference is for the display process (which is not specified in this Recommendation | International Standard) to display the cropped result of the deblocking filter process specified in subclause 8.7 rather than the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 for each picture that is cropped and output as specified in Annex C.

NOTE 3 – The presence or absence of the deblocking filter display preference SEI message and the value of display_prior_to_deblocking_preferred_flag does not affect the requirements of the decoding process specified in this Recommendation | International Standard. Rather, it only provides an indication of when, in addition to fulfilling the requirements of this Recommendation | International Standard for the decoding process, enhanced visual quality might be obtained by performing the display process (which is not specified in this Recommendation | International Standard) in an alternative fashion. Encoders that use the deblocking filter display preference SEI message should be designed with an awareness that unless the encoder restricts its use of the DPB capacity specified in Annex A for the profile and level in use, some decoders may not have sufficient memory capacity for the storage of the result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 in addition to the storage of the result of the deblocking filter process specified in subclause 8.7 when reordering and delaying pictures for display, and such decoders would therefore not be able to benefit from the preference indication. By restricting its use of the DPB capacity, an encoder can be able to use at least half of the DPB capacity specified in Annex A while allowing the decoder to use the remaining capacity for storage of unfiltered pictures that have been indicated as preferable for display until the output time arrives for those pictures.

dec_frame_buffering_constraint_flag equal to 1 indicates that the use of the frame buffering capacity of the HRD decoded picture buffer (DPB) as specified by max_dec_frame_buffering has been constrained such that the coded video sequence will not require a decoded picture buffer with more than Max(1, max_dec_frame_buffering) frame buffers to enable the output of the decoded filtered or unfiltered pictures, as indicated by the deblocking filter display preference SEI messages, at the output times specified by the dpb_output_delay of the picture timing SEI messages. dec_frame_buffering_constraint_flag equal to 0 indicates that the use of the frame buffering capacity in the HRD may or may not be constrained in the manner that would be indicated by dec_frame_buffering_constraint_flag equal to 1.

For purposes of determining the constraint imposed when dec_frame_buffering_constraint_flag is equal to 1, the quantity of frame buffering capacity used at any given point in time by each frame buffer of the DPB that contains a picture shall be derived as follows:

- If both of the following criteria are satisfied for the frame buffer, the frame buffer is considered to use two frame buffers of capacity for its storage.
- The frame buffer contains a frame or one or more fields that is marked as "used for reference", and
- The frame buffer contains a picture for which both of the following criteria are fulfilled.
  - The HRD output time of the picture is greater than the given point in time, and

– It has been indicated in a deblocking filter display preference SEI message that the encoder preference for the picture is for the display process to display the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 rather than the cropped result of the deblocking filter process specified in subclause 8.7, and

– Otherwise, the frame buffer is considered to use one frame buffer of DPB capacity for its storage.

When dec_frame_buffering_constraint_flag is equal to 1, the frame buffering capacity used by all of the frame buffers in the DPB that contain pictures, as derived in this manner, shall not be greater than Max(1, max_dec_frame_buffering) during the operation of the HRD for the coded video sequence.

The value of dec_frame_buffering_constraint_flag shall be the same in all deblocking filter display preference SEI messages of the coded video sequence.

deblocking_display_preference_repetition_period specifies the persistence of the film grain characteristics SEI message and may specify a picture order count interval within which another film grain characteristics SEI message or the end of the coded video sequence shall be present in the bitstream. The value of deblocking_display_preference_repetition_period shall be in the range 0 to 16 384, inclusive.

deblocking_display_preference_repetition_period equal to 0 specifies that the deblocking filter display preference SEI message applies to the current decoded picture only.

deblocking_display_preference_repetition_period equal to 1 specifies that the deblocking filter display preference SEI message persists in output order until any of the following conditions are true.

– A new coded video sequence begins.

– A picture in an access unit containing a deblocking filter display preference SEI message that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic).

deblocking_display_preference_repetition_period greater than 1 specifies that the deblocking filter display preference SEI message persists until any of the following conditions are true.

– A new coded video sequence begins.

– A picture in an access unit containing a deblocking filter display preference SEI message is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + deblocking_display_preference_repetition_period.

deblocking_display_preference_repetition_period greater than 1 indicates that another deblocking filter display preference SEI message shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + deblocking_display_preference_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

D.2.22 Stereo video information SEI message semantics

This SEI message provides the decoder with an indication that the entire coded video sequence consists of pairs of pictures forming stereo-view content.

The stereo video information SEI message shall not be present in any access unit of a coded video sequence unless a stereo video information SEI message is present in the first access unit of the coded video sequence.

field_views_flag equal to 1 indicates that all pictures in the current coded video sequence are fields and all fields of a particular parity are considered a left view and all fields of the opposite parity are considered a right view for stereo-view content. field_views_flag equal to 0 indicates that all pictures in the current coded video sequence are frames and alternating frames in output order represent a view of a stereo view. The value of field_views_flag shall be the same in all stereo video information SEI messages within a coded video sequence.

When the stereo video information SEI message is present and field_views_flag is equal to 1, the left view and right view of a stereo video pair shall be coded as a complementary field pair, the display time of the first field of the field pair in output order should be delayed to coincide with the display time of the second field of the field pair in output order, and the spatial locations of the samples in each individual field should be interpreted for display purposes as representing complete pictures as shown in Figure 6-1 rather than as spatially-distinct fields within a frame as shown in Figure 6-2.

NOTE – The display process is not specified in this Recommendation | International Standard.

top_field_is_left_view_flag equal to 1 indicates that the top fields in the coded video sequence represent a left view and the bottom fields in the coded video sequence represent a right view. top_field_is_left_view_flag equal to 0 indicates that the bottom fields in the coded video sequence represent a left view and the top fields in the coded video sequence represent a right view. When present, the value of top_field_is_left_view_flag shall be the same in all stereo video information SEI messages within a coded video sequence.

current_frame_is_left_view_flag equal to 1 indicates that the current picture is the left view of a stereo-view pair. current_frame_is_left_view_flag equal to 0 indicates that the current picture is the right view of a stereo-view pair.

next_frame_is_second_view_flag equal to 1 indicates that the current picture and the next picture in output order form a stereo-view pair, and the display time of the current picture should be delayed to coincide with the display time of the next picture in output order. next_frame_is_second_view_flag equal to 0 indicates that the current picture and the previous picture in output order form a stereo-view pair, and the display time of the current picture should not be delayed for purposes of stereo-view pairing.

left_view_self_contained_flag equal to 1 indicates that no inter prediction operations within the decoding process for the left-view pictures of the coded video sequence refer to reference pictures that are right-view pictures. left_view_self_contained_flag equal to 0 indicates that some inter prediction operations within the decoding process for the left-view pictures of the coded video sequence may or may not refer to reference pictures that are right-view pictures. Within a coded video sequence, the value of left_view_self_contained_flag in all stereo video information SEI messages shall be the same.

right_view_self_contained_flag equal to 1 indicates that no inter prediction operations within the decoding process for the right-view pictures of the coded video sequence refer to reference pictures that are left-view pictures. right_view_self_contained_flag equal to 0 indicates that some inter prediction operations within the decoding process for the right-view pictures of the coded video sequence may or may not refer to reference pictures that are left-view pictures. Within a coded video sequence, the value of right_view_self_contained_flag in all stereo video information SEI messages shall be the same.

D.2.23 Post-filter hint SEI message semantics

This SEI message provides the coefficients of a post-filter or correlation information for the design of a post-filter for potential use in post-processing of the output decoded pictures to obtain improved displayed quality.

filter_hint_size_y specifies the vertical size of the filter coefficient or correlation array. The value of filter_hint_size_y shall be in the range of 1 to 15, inclusive.

filter_hint_size_x specifies the horizontal size of the filter coefficient or correlation array. The value of filter_hint_size_x shall be in the range of 1 to 15, inclusive.

filter_hint_type identifies the type of the transmitted filter hints as specified in Table D-7. The value of filter_hint_type shall be in the range of 0 to 2, inclusive. Decoders that conform to this Recommendation | International Standard shall ignore post-filter hint SEI messages having filter_hint_type equal to the reserved value 3.

Table D-7 – filter_hint_type values

Value	Description
0	coefficients of a 2D FIR filter
1	coefficients of two 1D FIR filters
2	cross-correlation matrix
3	Reserved

filter_hint[colour_component **][** cy **][** cx **]** specifies a filter coefficient or an element of a cross-correlation matrix between original and decoded signal with 16-bit precision. colour_component specifies the related colour component. cy represents a counter in vertical direction, cx represents a counter in horizontal direction. Depending on filter_hint_type, the following applies.

– If filter_hint_type is equal to 0, the coefficients of a 2-dimensional FIR filter with the size of filter_hint_size_y * filter_hint_size_x are transmitted.

– Otherwise, if filter_hint_type is equal to 1, the filter coefficients of two 1-dimensional FIR filters are transmitted. In this case, filter_hint_size_y shall be equal to 2. The index cy = 0 specifies the filter coefficients of the horizontal filter and cy = 1 specifies the filter coefficients of the vertical filter. In the filtering process, the horizontal filter shall be applied first and the result shall be filtered by the vertical filter.

– Otherwise (filter_hint_type is equal to 2), the transmitted hints specify a cross-correlation matrix between the original signal s and the decoded signal s'.

NOTE 1 - The cross-correlation matrix for a related colour component with the size of filter_hint_size_y * filter_hint_size_x is defined as follows:

$$\text{filter\_hint}(\text{cy},\text{cx}) = \frac{1}{h \cdot w} \sum_{m=0}^{h-1} \sum_{n=0}^{w-1} s(m,n) \cdot s'(m + \text{cy} - offset\_y, n + \text{cx} - offset\_x) \quad \text{(D-26)}$$

where *s* denotes the original frame, *s'* denotes the decoded frame, *h* denotes the vertical height of the related colour component, *w* denotes the horizontal width of the related colour component, *offset_y* is equal to (filter_hint_size_y >> 1), *offset_x* is equal to (filter_hint_size_x >> 1), 0 <= cy < filter_hint_size_y and 0 <= cx < filter_hint_size_x.

NOTE 2 - A decoder can derive a Wiener post-filter from the cross-correlation matrix of original and decoded signal and the auto-correlation matrix of the decoded signal.

additional_extension_flag equal to 0 indicates that no additional data follows within the post-filter hint SEI message. The value of additional_extension_flag shall be equal to 0. The value of 1 for additional_extension_flag is reserved for future use by ITU-T | ISO/IEC. Decoders that conform to this Recommendation | International Standard shall ignore all data that follows the value of 1 for additional_extension_flag in a post-filter hint SEI message.

D.2.24 Tone mapping information SEI message semantics

This SEI message provides information to enable remapping of the colour samples of the output decoded pictures for customization to particular display environments. The remapping process maps coded sample values in the RGB colour space (specified in Annex E) to target sample values. All mappings are expressed in the RGB colour space and should be applied to each RGB component separately.

tone_map_id contains an identifying number that may be used to identify the purpose of the tone mapping model. The value of tone_map_id shall be in the range of 0 to $2^{32} - 1$, inclusive.

Values of tone_map_id from 0 to 255 and from 512 to $2^{31} - 1$ may be used as determined by the application. Values of tone_map_id from 256 to 511 and from 2^{31} to $2^{32} - 1$ are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping information SEI messages containing a value of tone_map_id in the range of 256 to 511 or in the range of 2^{31} to $2^{32} - 1$, and bitstreams shall not contain such values.

NOTE 1 – The tone_map_id can be used to support tone mapping operations that are suitable for different display scenarios. For example, different values of tone_map_id may correspond to different display bit depths.

tone_map_cancel_flag equal to 1 indicates that the tone mapping information SEI message cancels the persistence of any previous tone mapping information SEI message in output order. tone_map_cancel_flag equal to 0 indicates that tone mapping information follows.

tone_map_repetition_period specifies the persistence of the tone mapping information SEI message and may specify a picture order count interval within which another tone mapping information SEI message with the same value of tone_map _id or the end of the coded video sequence shall be present in the bitstream. The value of tone_map_repetition_period shall be in the range of 0 to 16 384, inclusive.

tone_map_repetition_period equal to 0 specifies that the tone map information applies to the current decoded picture only.

tone_map_repetition_period equal to 1 specifies that the tone map information persists in output order until any of the following conditions are true.

– A new coded video sequence begins.

– A picture in an access unit containing a tone mapping information SEI message with the same value of tone_map_id is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic).

tone_map_repetition_period equal to 0 or equal to 1 indicates that another tone mapping information SEI message with the same value of tone_map_id may or may not be present.

tone_map_repetition_period greater than 1 specifies that the tone map information persists until any of the following conditions are true.

– A new coded video sequence begins.

– A picture in an access unit containing a tone mapping information SEI message with the same value of tone_map_id is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + tone_map_repetition_period.

tone_map_repetition_period greater than 1 indicates that another tone mapping information SEI message with the same value of tone_map_id shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + tone_map_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

coded_data_bit_depth specifies the $BitDepth_Y$ of the luma component of the coded video sequence. It is used to identify the tone mapping information SEI message that is intended for use with the coded video sequence. If tone mapping information SEI messages are present that have coded_data_bit_depth that is not equal to $BitDepth_Y$, these refer to the hypothetical result of a transcoding operation performed to convert the coded video to the $BitDepth_Y$ corresponding to the value of coded_data_bit_depth.

The value of coded_data_bit_depth shall be in the range of 8 to 14, inclusive. Values of coded_data_bit_depth from 0 to 7 and from 15 to 255 are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping SEI messages that contain a coded_data_bit_depth in the range of 0 to 7 or in the range of 15 to 255, and bitstreams shall not contain such values.

target_bit_depth specifies the bit depth of the output of the dynamic range mapping function (or tone mapping function) described by the tone mapping information SEI message. The tone mapping function specified with a particular target_bit_depth is suggested to be reasonable for all display bit depths that are equal to or less than the target_bit_depth.

The value of target_bit_depth shall be in the range of 1 to 16, inclusive. Values of target_bit_depth equal to 0 and in the range of 17 to 255 are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping SEI messages that contain a value of target_bit_depth equal to 0 or in the range of 17 to 255, and bitstreams shall not contain such values.

model_id specifies the model utilized for mapping the coded data into the target_bit_depth range. Values greater than 3 are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping SEI messages that contain a value of model_id greater than 3, and bitstreams shall not contain such values.

NOTE 2 – A model_id of 0 corresponds to a linear mapping with clipping; a model_id of 1 corresponds to a sigmoidal mapping; a model_id of 2 corresponds to a user-defined table mapping, and a model_id of 3 corresponds to a piece-wise linear mapping.

min_value specifies the RGB sample value in the coded data that maps to the minimum value in the signalled target_bit_depth. It is used in combination with the max_value parameter. All values in the coded data that are less than or equal to min_value are mapped to this minimum value in the target_bit_depth representation.

max_value specifies the RGB sample value in the coded data that maps to the maximum value in the signalled target_bit_depth. It is used in combination with the min_value parameter. All values in the coded data that are larger than or equal to max_value are mapped to this maximum value in the target_bit_depth representation.

sigmoid_midpoint specifies the RGB sample value of the coded data that is mapped to the center point of the target_bit_depth representation. It is used in combination with the sigmoid_width parameter.

sigmoid_width specifies the distance between two coded data values that approximately correspond to the 5% and 95% values of the target_bit_depth representation, respectively. It is used in combination with the sigmoid_midpoint parameter and is interpreted according to the following function:

$$f(i) = Round\left(\frac{2^{target\_bit\_depth} - 1}{1 + \exp\left(\frac{-6 * (i - sigmoid\_midpoint)}{sigmoid\_width} \right)} \right) \quad for\ i = 0, \cdots, (2^{coded\_bit\_depth} - 1) \tag{D-27}$$

where *f*(i) denotes the function that maps an RGB sample value i from the coded data to a resulting RGB sample value in the target_bit_depth representation.

start_of_coded_interval[i] specifies the beginning point of an interval in the coded data such that all RGB sample values that are greater than or equal to start_of_coded_interval[i] and less than start_of_coded_interval[i + 1] are mapped to i in the target bit depth representation. The value of start_of_coded_interval[$2^{target\_bit\_depth}$] is equal to $2^{coded\_bit\_depth}$. The number of bits used for the representation of the start_of_coded_interval is ((coded_data_bit_depth + 7) >> 3) << 3.

num_pivots specifies the number of pivot points in the piece-wise linear mapping function without counting the two default end points, (0, 0) and ($2^{coded\_data\_bit\_depth} - 1$, $2^{target\_bit\_depth} - 1$) .

coded_pivot_value[i] specifies the value in the coded_bit_depth corresponding to the i-th pivot point. The number of bits used for the representation of the coded_pivot_value is ((coded_data_bit_depth + 7) >> 3) << 3.

target_pivot_value[i] specifies the value in the reference target_bit_depth corresponding to the i-th pivot point. The number of bits used for the representation of the target_pivot_value is ((target_bit_depth + 7) >> 3) << 3.

D.2.25 Reserved SEI message semantics

This message consists of data reserved for future backward-compatible use by ITU-T | ISO/IEC. Encoders conforming to this Recommendation | International Standard shall not send reserved SEI messages until and unless the use of such messages has been specified by ITU-T | ISO/IEC. Decoders conforming to this Recommendation | International Standard that encounter reserved SEI messages shall discard their content without effect on the decoding process, except as specified in future Recommendations | International Standards specified by ITU-T | ISO/IEC.

reserved_sei_message_payload_byte is a byte reserved for future use by ITU-T | ISO/IEC.

Annex E
Video usability information

(This annex forms an integral part of this Recommendation | International Standard)

This Annex specifies syntax and semantics of the VUI parameters of the sequence parameter sets.

VUI parameters are not required for constructing the luma or chroma samples by the decoding process. Conforming decoders are not required to process this information for output order conformance to this Recommendation | International Standard (see Annex C for the specification of conformance). Some VUI parameters are required to check bitstream conformance and for output timing decoder conformance.

In Annex E, specification for presence of VUI parameters is also satisfied when those parameters (or some subset of them) are conveyed to decoders (or to the HRD) by other means not specified by this Recommendation | International Standard. When present in the bitstream, VUI parameters shall follow the syntax and semantics specified in subclauses 7.3.2.1 and 7.4.2.1 and this annex. When the content of VUI parameters is conveyed for the application by some means other than presence within the bitstream, the representation of the content of the VUI parameters is not required to use the same syntax specified in this annex. For the purpose of counting bits, only the appropriate bits that are actually present in the bitstream are counted.

E.1 VUI syntax

E.1.1 VUI parameters syntax

vui_parameters( ) {	C	Descriptor
aspect_ratio_info_present_flag	0	u(1)
if(aspect_ratio_info_present_flag) {		
aspect_ratio_idc	0	u(8)
if(aspect_ratio_idc = = Extended_SAR) {		
sar_width	0	u(16)
sar_height	0	u(16)
}		
}		
overscan_info_present_flag	0	u(1)
if(overscan_info_present_flag)		
overscan_appropriate_flag	0	u(1)
video_signal_type_present_flag	0	u(1)
if(video_signal_type_present_flag) {		
video_format	0	u(3)
video_full_range_flag	0	u(1)
colour_description_present_flag	0	u(1)
if(colour_description_present_flag) {		
colour_primaries	0	u(8)
transfer_characteristics	0	u(8)
matrix_coefficients	0	u(8)
}		
}		
chroma_loc_info_present_flag	0	u(1)
if(chroma_loc_info_present_flag) {		
chroma_sample_loc_type_top_field	0	ue(v)
chroma_sample_loc_type_bottom_field	0	ue(v)
}		

timing_info_present_flag	0	u(1)
if(timing_info_present_flag) {		
num_units_in_tick	0	u(32)
time_scale	0	u(32)
fixed_frame_rate_flag	0	u(1)
}		
nal_hrd_parameters_present_flag	0	u(1)
if(nal_hrd_parameters_present_flag)		
hrd_parameters( )		
vcl_hrd_parameters_present_flag	0	u(1)
if(vcl_hrd_parameters_present_flag)		
hrd_parameters( )		
if(nal_hrd_parameters_present_flag || vcl_hrd_parameters_present_flag)		
low_delay_hrd_flag	0	u(1)
pic_struct_present_flag	0	u(1)
bitstream_restriction_flag	0	u(1)
if(bitstream_restriction_flag) {		
motion_vectors_over_pic_boundaries_flag	0	u(1)
max_bytes_per_pic_denom	0	ue(v)
max_bits_per_mb_denom	0	ue(v)
log2_max_mv_length_horizontal	0	ue(v)
log2_max_mv_length_vertical	0	ue(v)
num_reorder_frames	0	ue(v)
max_dec_frame_buffering	0	ue(v)
}		
}		

E.1.2 HRD parameters syntax

hrd_parameters( ) {	**C**	**Descriptor**
cpb_cnt_minus1	0	ue(v)
bit_rate_scale	0	u(4)
cpb_size_scale	0	u(4)
for(SchedSelIdx = 0; SchedSelIdx <= cpb_cnt_minus1; SchedSelIdx++) {		
bit_rate_value_minus1[SchedSelIdx **]**	0	ue(v)
cpb_size_value_minus1[SchedSelIdx **]**	0	ue(v)
cbr_flag[SchedSelIdx **]**	0	u(1)
}		
initial_cpb_removal_delay_length_minus1	0	u(5)
cpb_removal_delay_length_minus1	0	u(5)
dpb_output_delay_length_minus1	0	u(5)
time_offset_length	0	u(5)
}		

E.2 VUI semantics

E.2.1 VUI parameters semantics

aspect_ratio_info_present_flag equal to 1 specifies that aspect_ratio_idc is present. aspect_ratio_info_present_flag equal to 0 specifies that aspect_ratio_idc is not present.

aspect_ratio_idc specifies the value of the sample aspect ratio of the luma samples. Table E-1 shows the meaning of the code. When aspect_ratio_idc indicates Extended_SAR, the sample aspect ratio is represented by sar_width and sar_height. When the aspect_ratio_idc syntax element is not present, aspect_ratio_idc value shall be inferred to be equal to 0.

Table E-1 – Meaning of sample aspect ratio indicator

aspect_ratio_idc	Sample aspect ratio	(informative) Examples of use
0	Unspecified	
1	1:1 ("square")	1280x720 16:9 frame without horizontal overscan 1920x1080 16:9 frame without horizontal overscan (cropped from 1920x1088) 640x480 4:3 frame without horizontal overscan
2	12:11	720x576 4:3 frame with horizontal overscan 352x288 4:3 frame without horizontal overscan
3	10:11	720x480 4:3 frame with horizontal overscan 352x240 4:3 frame without horizontal overscan
4	16:11	720x576 16:9 frame with horizontal overscan 528x576 4:3 frame without horizontal overscan
5	40:33	720x480 16:9 frame with horizontal overscan 528x480 4:3 frame without horizontal overscan
6	24:11	352x576 4:3 frame without horizontal overscan 480x576 16:9 frame with horizontal overscan
7	20:11	352x480 4:3 frame without horizontal overscan 480x480 16:9 frame with horizontal overscan
8	32:11	352x576 16:9 frame without horizontal overscan
9	80:33	352x480 16:9 frame without horizontal overscan
10	18:11	480x576 4:3 frame with horizontal overscan
11	15:11	480x480 4:3 frame with horizontal overscan
12	64:33	528x576 16:9 frame without horizontal overscan
13	160:99	528x480 16:9 frame without horizontal overscan
14	4:3	1440x1080 16:9 frame without horizontal overscan
15	3:2	1280x1080 16:9 frame without horizontal overscan
16	2:1	960x1080 16:9 frame without horizontal overscan
17..254	Reserved	
255	Extended_SAR	

sar_width indicates the horizontal size of the sample aspect ratio (in arbitrary units).

sar_height indicates the vertical size of the sample aspect ratio (in the same arbitrary units as sar_width).

sar_width and sar_height shall be relatively prime or equal to 0. When aspect_ratio_idc is equal to 0 or sar_width is equal to 0 or sar_height is equal to 0, the sample aspect ratio shall be considered unspecified by this Recommendation | International Standard.

overscan_info_present_flag equal to 1 specifies that the overscan_appropriate_flag is present. When overscan_info_present_flag is equal to 0 or is not present, the preferred display method for the video signal is unspecified.

overscan_appropriate_flag equal to 1 indicates that the cropped decoded pictures output are suitable for display using overscan. overscan_appropriate_flag equal to 0 indicates that the cropped decoded pictures output contain visually important information in the entire region out to the edges of the cropping rectangle of the picture, such that the cropped decoded pictures output should not be displayed using overscan. Instead, they should be displayed using either an exact match between the display area and the cropping rectangle, or using underscan.

NOTE 1 – For example, overscan_appropriate_flag equal to 1 might be used for entertainment television programming, or for a live view of people in a videoconference, and overscan_appropriate_flag equal to 0 might be used for computer screen capture or security camera content.

video_signal_type_present_flag equal to 1 specifies that video_format, video_full_range_flag and colour_description_present_flag are present. video_signal_type_present_flag equal to 0, specify that video_format, video_full_range_flag and colour_description_present_flag are not present.

video_format indicates the representation of the pictures as specified in Table E-2, before being coded in accordance with this Recommendation | International Standard. When the video_format syntax element is not present, video_format value shall be inferred to be equal to 5.

Table E-2 – Meaning of video_format

video_format	Meaning
0	Component
1	PAL
2	NTSC
3	SECAM
4	MAC
5	Unspecified video format
6	Reserved
7	Reserved

video_full_range_flag indicates the black level and range of the luma and chroma signals as derived from E'_Y, E'_{PB}, and E'_{PR} or E'_R, E'_G, and E'_B analogue component signals.

When the video_full_range_flag syntax element is not present, the value of video_full_range_flag shall be inferred to be equal to 0.

colour_description_present_flag equal to 1 specifies that colour_primaries, transfer_characteristics and matrix_coefficients are present. colour_description_present_flag equal to 0 specifies that colour_primaries, transfer_characteristics and matrix_coefficients are not present.

colour_primaries indicates the chromaticity coordinates of the source primaries as specified in Table E-3 in terms of the CIE 1931 definition of x and y as specified by ISO/CIE 10527.

When the colour_primaries syntax element is not present, the value of colour_primaries shall be inferred to be equal to 2 (the chromaticity is unspecified or is determined by the application).

Table E-3 – Colour primaries

Value	Primaries			Informative Remark
0	Reserved			For future use by ITU-T | ISO/IEC
1	primary green blue red white D65	x 0.300 0.150 0.640 0.3127	y 0.600 0.060 0.330 0.3290	ITU-R Rec. BT.709-5 ITU-R Rec. BT.1361 conventional colour gamut system and extended colour gamut system IEC 61966-2-4 Society of Motion Picture and Television Engineers RP 177 (1993) Annex B
2	Unspecified			Image characteristics are unknown or are determined by the application.
3	Reserved			For future use by ITU-T | ISO/IEC
4	primary green blue red white C	x 0.21 0.14 0.67 0.310	y 0.71 0.08 0.33 0.316	ITU-R Rec. BT.470-6 System M (historical) United States National Television System Committee 1953 Recommendation for transmission standards for colour television United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20)
5	primary green blue red white D65	x 0.29 0.15 0.64 0.3127	y 0.60 0.06 0.33 0.3290	ITU-R Rec. BT.470-6 System B, G (historical) ITU-R Rec. BT.601-6 625 ITU-R Rec. BT.1358 625 ITU-R Rec. BT.1700 625 PAL and 625 SECAM
6	primary green blue red white D65	x 0.310 0.155 0.630 0.3127	y 0.595 0.070 0.340 0.3290	ITU-R Rec. BT.601-6 525 ITU-R Rec. BT.1358 525 ITU-R Rec. BT.1700 NTSC Society of Motion Picture and Television Engineers 170M (2004) (functionally the same as the value 7)
7	primary green blue red white D65	x 0.310 0.155 0.630 0.3127	y 0.595 0.070 0.340 0.3290	Society of Motion Picture and Television Engineers 240M (1999) (functionally the same as the value 6)
8	primary green blue red white C	x 0.243 0.145 0.681 0.310	y 0.692 (Wratten 58) 0.049 (Wratten 47) 0.319 (Wratten 25) 0.316	Generic film (colour filters using Illuminant C)
9-255	Reserved			For future use by ITU-T | ISO/IEC

transfer_characteristics indicates the opto-electronic transfer characteristic of the source picture as specified in Table E-4 as a function of a linear optical intensity input L_c with an analogue range of 0 to 1.

When the transfer_characteristics syntax element is not present, the value of transfer_characteristics shall be inferred to be equal to 2 (the transfer characteristics are unspecified or are determined by the application).

Table E-4 – Transfer characteristics

Value	Transfer Characteristic		Informative Remark
0	Reserved		For future use by ITU-T | ISO/IEC
1	$V = 1.099 * L_c^{0.45} - 0.099$ $V = 4.500 * L_c$	for $1 >= L_c >= 0.018$ for $0.018 > L_c >= 0$	ITU-R Rec. BT.709-5 ITU-R Rec. BT.1361 conventional colour gamut system (functionally the same as the value 6)
2	Unspecified		Image characteristics are unknown or are determined by the application.
3	Reserved		For future use by ITU-T | ISO/IEC
4	Assumed display gamma 2.2		ITU-R Rec. BT.470-6 System M (historical) United States National Television System Committee 1953 Recommendation for transmission standards for colour television United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20) ITU-R Rec. BT.1700 (2007 revision) 625 PAL and 625 SECAM
5	Assumed display gamma 2.8		ITU-R Rec. BT.470-6 System B, G (historical)
6	$V = 1.099 * L_c^{0.45} - 0.099$ $V = 4.500 * L_c$	for $1 >= L_c >= 0.018$ for $0.018 > L_c >= 0$	ITU-R Rec. BT.601-6 525 or 625 ITU-R Rec. BT.1358 525 or 625 ITU-R Rec. BT.1700 NTSC Society of Motion Picture and Television Engineers 170M (2004) (functionally the same as the value 1)
7	$V = 1.1115 * L_c^{0.45} - 0.1115$ $V = 4.0 * L_c$	for $1 >= L_c >= 0.0228$ for $0.0228 > L_c >= 0$	Society of Motion Picture and Television Engineers 240M (1999)
8	$V = L_c$	for $1 > L_c >= 0$	Linear transfer characteristics
9	$V = 1.0 - \text{Log10}(L_c) \div 2$ $V = 0.0$	for $1 >= L_c >= 0.01$ for $0.01 > L_c >= 0$	Logarithmic transfer characteristic (100:1 range)
10	$V = 1.0 - \text{Log10}(L_c) \div 2.5$ $V = 0.0$	for $1 >= L_c >= 0.0031622777$ for $0.0031622777 > L_c >= 0$	Logarithmic transfer characteristic (316.22777:1 range)
11	$V = 1.099 * L_c^{0.45} - 0.099$ $V = 4.500 * L_c$ $V = -1.099 * (-L_c)^{0.45} + 0.099$	for $L_c >= 0.018$ for $0.018 > L_c > -0.018$ for $-0.018 >= L_c$	IEC 61966-2-4
12	$V = 1.099 * L_c^{0.45} - 0.099$ $V = 4.500 * L_c$ $V = -(1.099 * (-4 * L_c)^{0.45} - 0.099) \div 4$	for $1.33 > L_c >= 0.018$ for $0.018 > L_c >= -0.0045$ for $-0.0045 > L_c >= -0.25$	ITU-R Rec. BT.1361 extended colour gamut system
13..255	Reserved		For future use by ITU-T | ISO/IEC

matrix_coefficients describes the matrix coefficients used in deriving luma and chroma signals from the green, blue, and red primaries, as specified in Table E-5.

matrix_coefficients shall not be equal to 0 unless both of the following conditions are true

– BitDepth_C is equal to BitDepth_Y

– chroma_format_idc is equal to 3 (4:4:4)

The specification of the use of matrix_coefficients equal to 0 under all other conditions is reserved for future use by ITU-T | ISO/IEC.

matrix_coefficients shall not be equal to 8 unless one of the following conditions are true

– $BitDepth_C$ is equal to $BitDepth_Y$

– $BitDepth_C$ is equal to $BitDepth_Y + 1$ and chroma_format_idc is equal to 3 (4:4:4)

The specification of the use of matrix_coefficients equal to 8 under all other conditions is reserved for future use by ITU-T | ISO/IEC.

When the matrix_coefficients syntax element is not present, the value of matrix_coefficients shall be inferred to be equal to 2 (unspecified).

The interpretation of matrix_coefficients is specified as follows.

– If transfer_characteristics is not equal to 11 or 12, E'_R, E'_G, and E'_B are analog with values in the range of 0 to 1.

– Otherwise (transfer_characteristics is equal to 11 (IEC 61966-2-4) or 12 (ITU-R BT.1361 extended colour gamut system)), E'_R, E'_G and E'_B are analog with a larger range not specified in this Recommendation.

– Nominal white is specified as having E'_R equal to 1, E'_G equal to 1, and E'_B equal to 1.

– Nominal black is specified as having E'_R equal to 0, E'_G equal to 0, and E'_B equal to 0.

– If video_full_range_flag is equal to 0, the following equations apply.

  – If matrix_coefficients is equal to 1, 4, 5, 6, or 7, the following equations apply.

$$Y = Clip1_Y(Round((1 << (BitDepth_Y - 8)) * (219 * E'_Y + 16))) \quad (E\text{-}1)$$

$$Cb = Clip1_C(Round((1 << (BitDepth_C - 8)) * (224 * E'_{PB} + 128))) \quad (E\text{-}2)$$

$$Cr = Clip1_C(Round((1 << (BitDepth_C - 8)) * (224 * E'_{PR} + 128))) \quad (E\text{-}3)$$

  – Otherwise, if matrix_coefficients is equal to 0 or 8, the following equations apply.

$$R = Clip1_Y((1 << (BitDepth_Y - 8)) * (219 * E'_R + 16)) \quad (E\text{-}4)$$

$$G = Clip1_Y((1 << (BitDepth_Y - 8)) * (219 * E'_G + 16)) \quad (E\text{-}5)$$

$$B = Clip1_Y((1 << (BitDepth_Y - 8)) * (219 * E'_B + 16)) \quad (E\text{-}6)$$

  – Otherwise, if matrix_coefficients is equal to 2, the interpretation of the matrix_coefficients syntax element is unknown or is determined by the application.

  – Otherwise (matrix_coefficients is not equal to 0, 1, 2, 4, 5, 6, 7, or 8), the interpretation of the matrix_coefficients syntax element is reserved for future definition by ITU-T | ISO/IEC.

– Otherwise (video_full_range_flag is equal to 1), the following equations apply.

  – If matrix_coefficients is equal to 1, 4, 5, 6, or 7, the following equations apply.

$$Y = Clip1_Y(Round(((1 << BitDepth_Y) - 1) * E'_Y)) \quad (E\text{-}7)$$

$$Cb = Clip1_C(Round(((1 << BitDepth_C) - 1) * E'_{PB} + (1 << (BitDepth_C - 1)))) \quad (E\text{-}8)$$

$$Cr = Clip1_C(Round(((1 << BitDepth_C) - 1) * E'_{PR} + (1 << (BitDepth_C - 1)))) \quad (E\text{-}9)$$

  – Otherwise, if matrix_coefficients is equal to 0 or 8, the following equations apply.

$$R = Clip1_Y(((1 << BitDepth_Y) - 1) * E'_R) \quad (E\text{-}10)$$

$$G = Clip1_Y(((1 << BitDepth_Y) - 1) * E'_G) \quad (E\text{-}11)$$

$$B = Clip1_Y(((1 << BitDepth_Y) - 1) * E'_B) \quad (E\text{-}12)$$

– Otherwise, if matrix_coefficients is equal to 2, the interpretation of the matrix_coefficients syntax element is unknown or is determined by the application.
– Otherwise (matrix_coefficients is not equal to 0, 1, 2, 4, 5, 6, 7, or 8), the interpretation of the matrix_coefficients syntax element is reserved for future definition by ITU-T | ISO/IEC.

– If matrix_coefficients is not equal to 0 or 8, the following equations apply.

$$E'_Y = K_R * E'_R + (1 - K_R - K_B) * E'_G + K_B * E'_B \quad \text{(E-13)}$$

$$E'_{PB} = 0.5 * (E'_B - E'_Y) \div (1 - K_B) \quad \text{(E-14)}$$

$$E'_{PR} = 0.5 * (E'_R - E'_Y) \div (1 - K_R) \quad \text{(E-15)}$$

NOTE 2 – E'_Y is analog with the value 0 associated with nominal black and the value 1 associated with nominal white. E'_{PB} and E'_{PR} are analog with the value 0 associated with both nominal black and nominal white. When transfer_characteristics is not equal to 11 or 12, E'_Y is analog with values in the range of 0 to 1. When transfer_characteristics is not equal to 11 or 12, E'_{PB} and E'_{PR} are analog with values in the range of –0.5 to 0.5. When transfer_characteristics is equal to 11 (IEC 61966-2-4), or 12 (ITU-R BT.1361 extended colour gamut system), E'_Y, E'_{PB} and E'_{PR} are analog with a larger range not specified in this Recommendation.

– Otherwise, if matrix_coefficients is equal to 0, the following equations apply.

$$Y = \text{Round}(G) \quad \text{(E-16)}$$

$$Cb = \text{Round}(B) \quad \text{(E-17)}$$

$$Cr = \text{Round}(R) \quad \text{(E-18)}$$

– Otherwise (matrix_coefficients is equal to 8), the following applies.
  – If BitDepth_C is equal to BitDepth_Y, the following equations apply.

$$Y = \text{Round}(0.5 * G + 0.25 * (R + B)) \quad \text{(E-19)}$$

$$Cb = \text{Round}(0.5 * G - 0.25 * (R + B)) + (1 << (\text{BitDepth}_C - 1)) \quad \text{(E-20)}$$

$$Cr = \text{Round}(0.5 * (R - B)) + (1 << (\text{BitDepth}_C - 1)) \quad \text{(E-21)}$$

NOTE 3 – For purposes of the YCgCo nomenclature used in Table E-5, Cb and Cr of Equations E-20 and E-21 may be referred to as Cg and Co, respectively. The inverse conversion for the above three equations should be computed as.

$$t = Y - (Cb - (1 << (\text{BitDepth}_C - 1))) \quad \text{(E-22)}$$

$$G = \text{Clip1}_Y(Y + (Cb - (1 << (\text{BitDepth}_C - 1)))) \quad \text{(E-23)}$$

$$B = \text{Clip1}_Y(t - (Cr - (1 << (\text{BitDepth}_C - 1)))) \quad \text{(E-24)}$$

$$R = \text{Clip1}_Y(t + (Cr - (1 << (\text{BitDepth}_C - 1)))) \quad \text{(E-25)}$$

  – Otherwise (BitDepth_C is not equal to BitDepth_Y), the following equations apply.

$$Cr = \text{Round}(R) - \text{Round}(B) + (1 << (\text{BitDepth}_C - 1)) \quad \text{(E-26)}$$

$$t = \text{Round}(B) + ((Cr - (1 << (\text{BitDepth}_C - 1))) >> 1) \quad \text{(E-27)}$$

$$Cb = Round(G) – t + (1 << (BitDepth_C – 1)) \quad \text{(E-28)}$$

$$Y = t + ((Cb – (1 << (BitDepth_C – 1))) >> 1) \quad \text{(E-29)}$$

NOTE 4 – For purposes of the YCgCo nomenclature used in Table E-5, Cb and Cr of Equations E-28 and E-26 may be referred to as Cg and Co, respectively. The inverse conversion for the above four equations should be computed as.

$$t = Y – ((Cb – (1 << (BitDepth_C – 1))) >> 1) \quad \text{(E-30)}$$

$$G = Clip1_Y(t + (Cb – (1 << (BitDepth_C – 1)))) \quad \text{(E-31)}$$

$$B = Clip1_Y(t– ((Cr – (1 << (BitDepth_C – 1))) >> 1)) \quad \text{(E-32)}$$

$$R = Clip1_Y(B + (Cr – (1 << (BitDepth_C – 1)))) \quad \text{(E-33)}$$

Table E-5 – Matrix coefficients

Value	Matrix	Informative remark
0	GBR	Typically referred to as RGB; see Equations E-16 to E-18
1	$K_R = 0.2126$; $K_B = 0.0722$	ITU-R Rec. BT.709-5 ITU-R Rec. BT.1361 conventional colour gamut system and extended colour gamut system IEC 61966-2-4 xvYCC$_{709}$ Society of Motion Picture and Television Engineers RP 177 (1993) Annex B
2	Unspecified	Image characteristics are unknown or are determined by the application.
3	Reserved	For future use by ITU-T | ISO/IEC
4	$K_R = 0.30$; $K_B = 0.11$	United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20)
5	$K_R = 0.299$; $K_B = 0.114$	ITU-R Rec. BT.470-6 System B, G (historical) ITU-R Rec. BT.601-6 625 ITU-R Rec. BT.1358 625 ITU-R Rec. BT.1700 625 PAL and 625 SECAM IEC 61966-2-4 xvYCC$_{601}$ (functionally the same as the value 6)
6	$K_R = 0.299$; $K_B = 0.114$	ITU-R Rec. BT.601-6 525 ITU-R Rec. BT.1358 525 ITU-R Rec. BT.1700 NTSC Society of Motion Picture and Television Engineers 170M (2004) (functionally the same as the value 5)
7	$K_R = 0.212$; $K_B = 0.087$	Society of Motion Picture and Television Engineers 240M (1999)
8	YCgCo	See Equations E-19 to E-33
9-255	Reserved	For future use by ITU-T | ISO/IEC

chroma_loc_info_present_flag equal to 1 specifies that chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are present. chroma_loc_info_present_flag equal to 0 specifies that chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are not present.

chroma_sample_loc_type_top_field and **chroma_sample_loc_type_bottom_field** specify the location of chroma samples for the top field and the bottom field as shown in Figure E-1. The value of chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall be in the range of 0 to 5, inclusive. When the

chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are not present, the values of chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall be inferred to be equal to 0.

NOTE 5 – When coding progressive source material, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should have the same value.

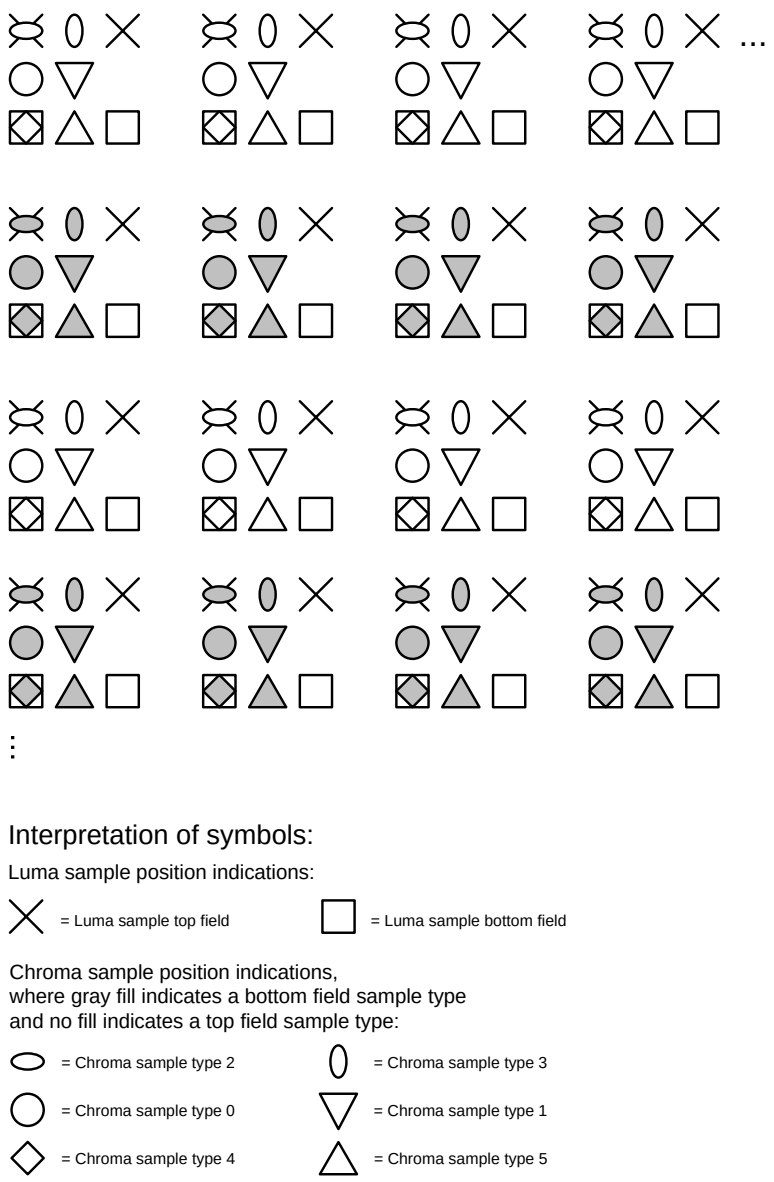


Figure E-1 – Location of chroma samples for top and bottom fields as a function of chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field

timing_info_present_flag equal to 1 specifies that num_units_in_tick, time_scale and fixed_frame_rate_flag are present in the bitstream. timing_info_present_flag equal to 0 specifies that num_units_in_tick, time_scale and fixed_frame_rate_flag are not present in the bitstream.

num_units_in_tick is the number of time units of a clock operating at the frequency time_scale Hz that corresponds to one increment (called a clock tick) of a clock tick counter. num_units_in_tick shall be greater than 0. A clock tick is the minimum interval of time that can be represented in the coded data. For example, when the clock frequency of a video signal is 60 000 ÷ 1001 Hz, time_scale may be equal to 60 000 and num_units_in_tick may be equal to 1001. See Equation C-1.

time_scale is the number of time units that pass in one second. For example, a time coordinate system that measures time using a 27 MHz clock has a time_scale of 27 000 000. time_scale shall be greater than 0.

fixed_frame_rate_flag equal to 1 indicates that the temporal distance between the HRD output times of any two consecutive pictures in output order is constrained as follows. fixed_frame_rate_flag equal to 0 indicates that no such constraints apply to the temporal distance between the HRD output times of any two consecutive pictures in output order.

For each picture n where n indicates the n-th picture (in output order) that is output and picture n is not the last picture in the bitstream (in output order) that is output, the value of $\Delta t_{fi,dpb}(n)$ is specified by

$$\Delta t_{fi,dpb}(n) = \Delta t_{o,dpb}(n) \div \text{DeltaTfiDivisor} \quad \text{(E-34)}$$

where $\Delta t_{o,dpb}(n)$ is specified in Equation C-13 and DeltaTfiDivisor is specified by Table E-6 based on the value of pic_struct_present_flag, field_pic_flag, and pic_struct for the coded video sequence containing picture n. Entries marked "-" in Table E-6 indicate a lack of dependence of DeltaTfiDivisor on the corresponding syntax element.

When fixed_frame_rate_flag is equal to 1 for a coded video sequence containing picture n, the value computed for $\Delta t_{fi,dpb}(n)$ shall be equal to t_c as specified in Equation C-1 (using the value of t_c for the coded video sequence containing picture n) when either or both of the following conditions are true for the following picture n_n that is specified for use in Equation C-13.

– picture n_n is in the same coded video sequence as picture n.

– picture n_n is in a different coded video sequence and fixed_frame_rate_flag is equal to 1 in the coded video sequence containing picture n_n and the value of num_units_in_tick ÷ time_scale is the same for both coded video sequences.

Table E-6 – Divisor for computation of $\Delta t_{fi,dpb}(n)$

pic_struct_present_flag	field_pic_flag	pic_struct	DeltaTfiDivisor
0	1	-	1
1	-	1	1
1	-	2	1
0	0	-	2
1	-	0	2
1	-	3	2
1	-	4	2
1	-	5	3
1	-	6	3
1	-	7	4
1	-	8	6

nal_hrd_parameters_present_flag equal to 1 specifies that NAL HRD parameters (pertaining to Type II bitstream conformance) are present. nal_hrd_parameters_present_flag equal to 0 specifies that NAL HRD parameters are not present.

NOTE 6 – When nal_hrd_parameters_present_flag is equal to 0, the conformance of the bitstream cannot be verified without provision of the NAL HRD parameters, including the NAL sequence HRD parameter information and all buffering period and picture timing SEI messages, by some means not specified in this Recommendation | International Standard.

When nal_hrd_parameters_present_flag is equal to 1, NAL HRD parameters (subclauses E.1.2 and E.2.2) immediately follow the flag.

The variable NalHrdBpPresentFlag is derived as follows.

– If any of the following is true, the value of NalHrdBpPresentFlag shall be set equal to 1.
  – nal_hrd_parameters_present_flag is present in the bitstream and is equal to 1,
  – the need for presence of buffering periods for NAL HRD operation to be present in the bitstream in buffering period SEI messages is determined by the application, by some means not specified in this Recommendation | International Standard.

- Otherwise, the value of NalHrdBpPresentFlag shall be set equal to 0.

vcl_hrd_parameters_present_flag equal to 1 specifies that VCL HRD parameters (pertaining to all bitstream conformance) are present. vcl_hrd_parameters_present_flag equal to 0 specifies that VCL HRD parameters are not present.

NOTE 7 – When vcl_hrd_parameters_present_flag is equal to 0, the conformance of the bitstream cannot be verified without provision of the VCL HRD parameters and all buffering period and picture timing SEI messages, by some means not specified in this Recommendation | International Standard.

When vcl_hrd_parameters_present_flag is equal to 1, VCL HRD parameters (subclauses E.1.2 and E.2.2) immediately follow the flag.

The variable VclHrdBpPresentFlag is derived as follows.

– If any of the following is true, the value of VclHrdBpPresentFlag shall be set equal to 1.
  – vcl_hrd_parameters_present_flag is present in the bitstream and is equal to 1,
  – the need for presence of buffering periods for VCL HRD operation to be present in the bitstream in buffering period SEI messages is determined by the application, by some means not specified in this Recommendation | International Standard.
– Otherwise, the value of VclHrdBpPresentFlag shall be set equal to 0.

The variable CpbDpbDelaysPresentFlag is derived as follows.

– If any of the following is true, the value of CpbDpbDelaysPresentFlag shall be set equal to 1.
  – nal_hrd_parameters_present_flag is present in the bitstream and is equal to 1,
  – vcl_hrd_parameters_present_flag is present in the bitstream and is equal to 1,
  – the need for presence of CPB and DPB output delays to be present in the bitstream in picture timing SEI messages is determined by the application, by some means not specified in this Recommendation | International Standard.
– Otherwise, the value of CpbDpbDelaysPresentFlag shall be set equal to 0.

low_delay_hrd_flag specifies the HRD operational mode as specified in Annex C. When fixed_frame_rate_flag is equal to 1, low_delay_hrd_flag shall be equal to 0.

NOTE 8 – When low_delay_hrd_flag is equal to 1, "big pictures" that violate the nominal CPB removal times due to the number of bits used by an access unit are permitted. It is expected, but not required, that such "big pictures" occur only occasionally.

pic_struct_present_flag equal to 1 specifies that picture timing SEI messages (subclause D.2.2) are present that include the pic_struct syntax element. pic_struct_present_flag equal to 0 specifies that the pic_struct syntax element is not present in picture timing SEI messages. When pic_struct_present_flag is not present, its value shall be inferred to be equal to 0.

bitstream_restriction_flag equal to 1, specifies that the following coded video sequence bitstream restriction parameters are present. bitstream_restriction_flag equal to 0, specifies that the following coded video sequence bitstream restriction parameters are not present.

motion_vectors_over_pic_boundaries_flag equal to 0 indicates that no sample outside the picture boundaries and no sample at a fractional sample position whose value is derived using one or more samples outside the picture boundaries is used to inter predict any sample. motion_vectors_over_pic_boundaries_flag equal to 1 indicates that one or more samples outside picture boundaries may be used in inter prediction. When the motion_vectors_over_pic_boundaries_flag syntax element is not present, motion_vectors_over_pic_boundaries_flag value shall be inferred to be equal to 1.

max_bytes_per_pic_denom indicates a number of bytes not exceeded by the sum of the sizes of the VCL NAL units associated with any coded picture in the coded video sequence.

The number of bytes that represent a picture in the NAL unit stream is specified for this purpose as the total number of bytes of VCL NAL unit data (i.e., the total of the NumBytesInNALunit variables for the VCL NAL units) for the picture. The value of max_bytes_per_pic_denom shall be in the range of 0 to 16, inclusive.

Depending on max_bytes_per_pic_denom the following applies.

– If max_bytes_per_pic_denom is equal to 0, no limits are indicated.
– Otherwise (max_bytes_per_pic_denom is not equal to 0), no coded picture shall be represented in the coded video sequence by more than the following number of bytes.

$$(PicSizeInMbs * RawMbBits) \div (8 * max\_bytes\_per\_pic\_denom) \quad \text{(E-35)}$$

When the max_bytes_per_pic_denom syntax element is not present, the value of max_bytes_per_pic_denom shall be inferred to be equal to 2.

max_bits_per_mb_denom indicates the maximum number of coded bits of macroblock_layer( ) data for any macroblock in any picture of the coded video sequence. The value of max_bits_per_mb_denom shall be in the range of 0 to 16, inclusive.

Depending on max_bits_per_mb_denom the following applies.

– If max_bits_per_mb_denom is equal to 0, no limit is specified.

– Otherwise (max_bits_per_mb_denom is not equal to 0), no coded macroblock_layer( ) shall be represented in the bitstream by more than the following number of bits.

$$(128 + \text{RawMbBits}) \div \text{max\_bits\_per\_mb\_denom} \quad \text{(E-36)}$$

Depending on entropy_coding_mode_flag, the bits of macroblock_layer( ) data are counted as follows.

– If entropy_coding_mode_flag is equal to 0, the number of bits of macroblock_layer( ) data is given by the number of bits in the macroblock_layer( ) syntax structure for a macroblock.

– Otherwise (entropy_coding_mode_flag is equal to 1), the number of bits of macroblock_layer( ) data for a macroblock is given by the number of times read_bits(1) is called in subclauses 9.3.3.2.2 and 9.3.3.2.3 when parsing the macroblock_layer( ) associated with the macroblock.

When the max_bits_per_mb_denom is not present, the value of max_bits_per_mb_denom shall be inferred to be equal to 1.

log2_max_mv_length_horizontal and **log2_max_mv_length_vertical** indicate the maximum absolute value of a decoded horizontal and vertical motion vector component, respectively, in ¼ luma sample units, for all pictures in the coded video sequence. A value of n asserts that no value of a motion vector component shall exceed the range from -2^n to 2^n-1, inclusive, in units of ¼ luma sample displacement. The value of log2_max_mv_length_horizontal shall be in the range of 0 to 16, inclusive. The value of log2_max_mv_length_vertical shall be in the range of 0 to 16, inclusive. When log2_max_mv_length_horizontal is not present, the values of log2_max_mv_length_horizontal and log2_max_mv_length_vertical shall be inferred to be equal to 16.

NOTE 9 – The maximum absolute value of a decoded vertical or horizontal motion vector component is also constrained by profile and level limits as specified in Annex A.

num_reorder_frames indicates the maximum number of frames, complementary field pairs, or non-paired fields that precede any frame, complementary field pair, or non-paired field in the coded video sequence in decoding order and follow it in output order. The value of num_reorder_frames shall be in the range of 0 to max_dec_frame_buffering, inclusive. When the num_reorder_frames syntax element is not present, the value of num_reorder_frames value shall be inferred as follows.

– If profile_idc is equal to 44, 86, 100, 110, 122, or 244 and constraint_set3_flag is equal to 1, the value of num_reorder_frames shall be inferred to be equal to 0.

– Otherwise (profile_idc is not equal to 44, 86, 100, 110, 122, or 244 or constraint_set3_flag is equal to 0), the value of num_reorder_frames shall be inferred to be equal to MaxDpbSize.

max_dec_frame_buffering specifies the required size of the HRD decoded picture buffer (DPB) in units of frame buffers. The coded video sequence shall not require a decoded picture buffer with size of more than Max(1, max_dec_frame_buffering) frame buffers to enable the output of decoded pictures at the output times specified by dpb_output_delay of the picture timing SEI messages. The value of max_dec_frame_buffering shall be in the range of num_ref_frames to MaxDpbSize (as specified in subclause A.3.1 or A.3.2), inclusive. When the max_dec_frame_buffering syntax element is not present, the value of max_dec_frame_buffering shall be inferred as follows.

– If profile_idc is equal to 44 or 244 and constraint_set3_flag is equal to 1, the value of max_dec_frame_buffering shall be inferred to be equal to 0.

– Otherwise (profile_idc is not equal to 44 or 244 or constraint_set3_flag is equal to 0), the value of max_dec_frame_buffering shall be inferred to be equal to MaxDpbSize.

E.2.2 HRD parameters semantics

cpb_cnt_minus1 plus 1 specifies the number of alternative CPB specifications in the bitstream. The value of cpb_cnt_minus1 shall be in the range of 0 to 31, inclusive. When low_delay_hrd_flag is equal to 1, cpb_cnt_minus1 shall be equal to 0. When cpb_cnt_minus1 is not present, it shall be inferred to be equal to 0.

bit_rate_scale (together with bit_rate_value_minus1[SchedSelIdx]) specifies the maximum input bit rate of the SchedSelIdx-th CPB.

cpb_size_scale (together with cpb_size_value_minus1[SchedSelIdx]) specifies the CPB size of the SchedSelIdx-th CPB.

bit_rate_value_minus1[SchedSelIdx **]** (together with bit_rate_scale) specifies the maximum input bit rate for the SchedSelIdx-th CPB. bit_rate_value_minus1[SchedSelIdx] shall be in the range of 0 to 2^{32} - 2, inclusive. For any SchedSelIdx > 0, bit_rate_value_minus1[SchedSelIdx] shall be greater than bit_rate_value_minus1[SchedSelIdx - 1]. The bit rate in bits per second is given by

$$BitRate[SchedSelIdx] = (bit\_rate\_value\_minus1[SchedSelIdx] + 1) * 2^{(6 + bit\_rate\_scale)} \quad \text{(E-37)}$$

When the bit_rate_value_minus1[SchedSelIdx] syntax element is not present, the value of BitRate[SchedSelIdx] shall be inferred as follows.

– If profile_idc is equal to 66, 77, or 88, BitRate[SchedSelIdx] shall be inferred to be equal to 1000 * MaxBR for VCL HRD parameters and to be equal to 1200 * MaxBR for NAL HRD parameters, where MaxBR is specified in subclause A.3.1.

– Otherwise, BitRate[SchedSelIdx] shall be inferred to be equal to cpbBrVclFactor * MaxBR for VCL HRD parameters and to be equal to cpbBrNalFactor * MaxBR for NAL HRD parameters, where cpbBrVclFactor, cpbBrNalFactor, and MaxBR are specified in subclause A.3.3.

cpb_size_value_minus1[SchedSelIdx **]** is used together with cpb_size_scale to specify the SchedSelIdx-th CPB size. cpb_size_value_minus1[SchedSelIdx] shall be in the range of 0 to 2^{32} - 2, inclusive. For any SchedSelIdx greater than 0, cpb_size_value_minus1[SchedSelIdx] shall be less than or equal to cpb_size_value_minus1[SchedSelIdx -1].

The CPB size in bits is given by

$$CpbSize[SchedSelIdx] = (cpb\_size\_value\_minus1[SchedSelIdx] + 1) * 2^{(4 + cpb\_size\_scale)} \quad \text{(E-38)}$$

When the cpb_size_value_minus1[SchedSelIdx] syntax element is not present, the value of CpbSize[SchedSelIdx] shall be inferred as follows.

– If profile_idc is equal to 66, 77, or 88, CpbSize[SchedSelIdx] shall be inferred to be equal to 1000 * MaxCPB for VCL HRD parameters and to be equal to 1200 * MaxCPB for NAL HRD parameters, where MaxCPB is specified in subclause A.3.1.

– Otherwise, CpbSize[SchedSelIdx] shall be inferred to be equal to cpbBrVclFactor * MaxCPB for VCL HRD parameters and to be equal to cpbBrNalFactor * MaxCPB for NAL HRD parameters, where cpbBrVclFactor, cpbBrNalFactor, and MaxCPB are specified in subclause A.3.3.

cbr_flag[SchedSelIdx **]** equal to 0 specifies that to decode this bitstream by the HRD using the SchedSelIdx-th CPB specification, the hypothetical stream delivery scheduler (HSS) operates in an intermittent bit rate mode. cbr_flag[SchedSelIdx] equal to 1 specifies that the HSS operates in a constant bit rate (CBR) mode. When the cbr_flag[SchedSelIdx] syntax element is not present, the value of cbr_flag shall be inferred to be equal to 0.

initial_cpb_removal_delay_length_minus1 specifies the length in bits of the initial_cpb_removal_delay[SchedSelIdx] and initial_cpb_removal_delay_offset[SchedSelIdx] syntax elements of the buffering period SEI message. The length of initial_cpb_removal_delay[SchedSelIdx] and of initial_cpb_removal_delay_offset[SchedSelIdx] is initial_cpb_removal_delay_length_minus1 + 1. When the initial_cpb_removal_delay_length_minus1 syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the initial_cpb_removal_delay_length_minus1 parameters shall be equal in both hrd_parameters( ) syntax structures. When the initial_cpb_removal_delay_length_minus1 syntax element is not present, it shall be inferred to be equal to 23.

cpb_removal_delay_length_minus1 specifies the length in bits of the cpb_removal_delay syntax element. The length of the cpb_removal_delay syntax element of the picture timing SEI message is cpb_removal_delay_length_minus1 + 1. When the cpb_removal_delay_length_minus1 syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the cpb_removal_delay_length_minus1 parameters

shall be equal in both hrd_parameters( ) syntax structures. When the cpb_removal_delay_length_minus1 syntax element is not present, it shall be inferred to be equal to 23.

dpb_output_delay_length_minus1 specifies the length in bits of the dpb_output_delay syntax element. The length of the dpb_output_delay syntax element of the picture timing SEI message is dpb_output_delay_length_minus1 + 1. When the dpb_output_delay_length_minus1 syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the dpb_output_delay_length_minus1 parameters shall be equal in both hrd_parameters( ) syntax structures. When the dpb_output_delay_length_minus1 syntax element is not present, it shall be inferred to be equal to 23.

time_offset_length greater than 0 specifies the length in bits of the time_offset syntax element. time_offset_length equal to 0 specifies that the time_offset syntax element is not present. When the time_offset_length syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the time_offset_length parameters shall be equal in both hrd_parameters( ) syntax structures. When the time_offset_length syntax element is not present, it shall be inferred to be equal to 24.

Annex G
Scalable video coding

(This annex forms an integral part of this Recommendation | International Standard)

This annex specifies scalable video coding, referred to as SVC.

G.1 Scope

Bitstreams and decoders conforming to one or more of the profiles specified in this annex are completely specified in this annex with reference made to clauses 2-9 and Annexes A-E.

G.2 Normative References

The specifications in clause 2 apply with the following additions.

- ISO/IEC 10646:2003, Information technology − Universal Multiple-Octet Coded Character Set (UCS).
- IETF RFC 3986 (2005), Uniform Resource Identifiers (URI): Generic Syntax.

G.3 Definitions

For the purpose of this annex, the following definitions apply in addition to the definitions in clause 3. These definitions are either not present in clause 3 or replace definitions in clause 3.

G.3.1 arbitrary slice order (ASO): A *decoding order* of *slices* in which the *macroblock address* of the first *macroblock* of some *slice* of a *slice group* within a *layer representation* may be less than the *macroblock address* of the first *macroblock* of some other preceding *slice* of the same *slice group* within the same *layer representation* or in which the *slices* of a *slice group* within a *layer representation* may be interleaved with the *slices* of one or more other *slices groups* within the same *layer representation*.

G.3.2 associated NAL unit: A *NAL unit* that directly succeeds a *prefix NAL unit* in *decoding order*.

G.3.3 B slice: A *slice* that may be decoded using *intra-layer intra prediction* or *inter prediction* using at most two *motion vectors* and *reference indices* to *predict* the sample values of each *block*.

G.3.4 base layer: A *bitstream subset* that contains all the *NAL units* with the nal_unit_type *syntax element* equal to 1 and 5 of the *bitstream* and does not contain any *NAL unit* with the nal_unit_type *syntax element* equal to 14, 15, or 20 and conforms to one or more of the profiles specified in Annex A.

G.3.5 base quality layer representation: The *layer representation* of the *target dependency representation* of an *access unit* that is associated with the quality_id *syntax element* equal to 0.

G.3.6 bitstream subset: A *bitstream* that is derived as a *subset* from a *bitstream* by discarding zero or more *NAL units*. A *bitstream subset* is also referred to as *sub-bitstream*.

G.3.7 bottom macroblock (of a macroblock pair): The *macroblock* within a *macroblock pair* that contains the samples in the bottom row of samples for the *macroblock pair*. For a *field macroblock pair*, the bottom macroblock represents the samples from the region of the *bottom field* or *layer bottom field* of the *frame* or *layer frame*, respectively, that lie within the spatial region of the *macroblock pair*. For a *frame macroblock pair*, the bottom macroblock represents the samples of the *frame* or *layer frame* that lie within the bottom half of the spatial region of the *macroblock pair*.

G.3.8 coded slice in scalable extension NAL unit: A *coded slice NAL unit* that contains an *EI slice*, *EP slice*, or an *EB slice*.

G.3.9 complementary reference field pair: A collective term for two *reference fields* that are in consecutive *access units* in *decoding order* as two *coded fields*, where the *target dependency representations* of the *access units* share the same value of the frame_num *syntax element* and where the second *field* in *decoding order* is not an *IDR picture* and the *target dependency representation* of the second *access unit* does not include a memory_management_control_operation *syntax element* equal to 5, or a *complementary reference base field pair*.

G.3.10 complementary reference base field pair: Two *reference base fields* that are constructed from consecutive *access units* in *decoding order*, where the *target dependency representations* of the *access units* share the same value of the frame_num *syntax element* and where the second *access unit* in *decoding order* is not an *IDR*

access unit and the *target dependency representation* of the second *access unit* does not include a memory_management_control_operation *syntax element* equal to 5. A *complementary reference base field pair* is a *complementary reference field pair*.

G.3.11 dependency representation: A *subset* of *VCL NAL units* within an *access unit* that are associated with the same value of the dependency_id *syntax element*, which is provided as part of the *NAL unit* header or by an associated *prefix NAL unit*. A *dependency representation* consist of one or more *layer representations*.

G.3.12 EB slice: A *slice* that may be decoded using *intra prediction* or *inter prediction* or *inter-layer prediction* from *syntax elements* and derived variables of the *reference layer representation*. For *inter-prediction* of EB slices at most two *motion vectors* and *reference indices* are used to *predict* the sample values of each *block*.

G.3.13 EI slice: A *slice* that is not an *I slice* or *SI slice* that is decoded using *intra prediction* only.

G.3.14 EP slice: A *slice* that may be decoded using *intra prediction* or *inter prediction* or *inter-layer prediction* from *syntax elements* and derived variables of the *reference layer representation*. For *inter-prediction* of EP slices at most one *motion vector* and *reference index* is used to *predict* the sample values of each *block.*

G.3.15 field macroblock: A *macroblock* containing samples from a single *field* or *layer field*.

G.3.16 filler prefix NAL unit: A *prefix NAL unit* with an *associated NAL unit* that is a filler data *NAL unit*.

G.3.17 frame macroblock: A *macroblock* containing samples from the two *fields* or *layer fields* of a *frame* or *layer frame*, respectively.

G.3.18 I slice: A *slice* that is decoded using *intra-layer intra prediction* only.

G.3.19 instantaneous decoding refresh (IDR) picture: A *coded picture* in which all *slices* of the *target dependency representation* within the access unit are *I or EI slices* that causes the *decoding process* to mark all *reference pictures* as "unused for reference" immediately after decoding the IDR picture. After the decoding of an IDR picture all following *coded pictures* in *decoding order* can be decoded without *inter prediction* from any *picture* decoded prior to the IDR picture. The first *picture* of each *coded video sequence* is an IDR picture.

G.3.20 inter-layer intra prediction: An *inter-layer prediction* derived from decoded samples of *intra-coded macroblocks* of the *reference layer representation*.

G.3.21 inter-layer prediction: A *prediction* derived from *syntax elements*, derived variables, or decoded samples of the *reference layer representation*.

G.3.22 intra-layer intra prediction: A *prediction* derived from decoded samples of the same decoded *slice*.

G.3.23 intra prediction: A collective term for *intra-layer intra prediction* or *inter-layer intra prediction* or a combination of *intra-layer intra prediction* together with *inter-layer prediction* from *syntax elements* and derived variables of the *reference layer representation.*

G.3.24 intra slice: A collective term for *I slice* or *EI slice*.

G.3.25 layer bottom field: One of two *layer fields* that comprise a *layer frame*. Each row of a layer bottom field is spatially located immediately below a corresponding row of a *layer top field*.

G.3.26 layer field: An assembly of alternate rows of a *layer frame*. A *layer frame* is composed of two *layer fields*, a *layer top field* and a *layer bottom field*.

G.3.27 layer frame: A *layer frame* contains an array of *luma* samples that represents an intermediate decoding result for a *field* or a *frame* in monochrome format or an array of *luma* samples and two corresponding arrays of *chroma* samples that represent an intermediate decoding result for a *field* or a *frame* in 4:2:0, 4:2:2, and 4:4:4 colour format. A *layer frame* consists of two *layer fields*, a *layer top field* and a *layer bottom field*.

G.3.28 layer picture: A collective term for a *layer field* or a *layer frame*.

G.3.29 layer top field: One of two *layer fields* that comprise a *layer frame*. Each row of a *layer top field* is spatially located immediately above a corresponding row of a *layer bottom field*.

G.3.30 layer representation: A subset of *VCL NAL units* within an *access unit* that are associated with the same values of the dependency_id and quality_id *syntax elements*, which are provided as part of the *VCL NAL unit* header or by an associated *prefix NAL unit*. One or more *layer representations* represent a *dependency representation*.

G.3.31 layer representation identifier: An integer value by which a particular *layer representation* inside an *access unit* is uniquely identified.

G.3.32 macroblock: A 16x16 *block* of *luma* samples and two corresponding *blocks* of *chroma* samples of a *picture* or *layer picture* that has three sample arrays, or a 16x16 *block* of samples of a monochrome *picture* or *layer picture*. The division of a *slice* or a *macroblock pair* into macroblocks is a *partitioning*.

G.3.33 macroblock-adaptive frame/field decoding: A *decoding process* for *coded frames* or *layer representations* in which some *macroblocks* may be decoded as *frame macroblocks* and others may be decoded as *field macroblocks.*

G.3.34 macroblock address: When *macroblock-adaptive frame/field decoding* is not in use, a macroblock address is the index of a macroblock in a *macroblock raster scan* of the *picture* or *layer picture* starting with zero for the top-left *macroblock* in a *picture* or *layer picture*. When *macroblock-adaptive frame/field decoding* is in use, the macroblock address of the *top macroblock* of a *macroblock pair* is two times the index of the *macroblock pair* in a *macroblock pair raster scan* of the *picture* or *layer picture*, and the macroblock address of the *bottom macroblock* of a *macroblock pair* is the macroblock address of the corresponding *top macroblock* plus 1. The macroblock address of the *top macroblock* of each *macroblock pair* is an even number and the macroblock address of the *bottom macroblock* of each *macroblock pair* is an odd number.

G.3.35 macroblock location: The two-dimensional coordinates of a *macroblock* in a *picture* or *layer picture* denoted by (x, y). For the top left *macroblock* of the *picture* or *layer picture* (x, y) is equal to (0, 0). x is incremented by 1 for each *macroblock* column from left to right. When *macroblock-adaptive frame/field decoding* is not in use, y is incremented by 1 for each *macroblock* row from top to bottom. When *macroblock-adaptive frame/field decoding* is in use, y is incremented by 2 for each *macroblock pair* row from top to bottom, and is incremented by an additional 1 when a macroblock is a *bottom macroblock.*

G.3.36 macroblock pair: A pair of vertically contiguous *macroblocks* in a *frame* or *layer frame* that is coupled for use in *macroblock-adaptive frame/field decoding*. The division of a *slice* into macroblock pairs is a *partitioning*.

G.3.37 macroblock to slice group map: A means of mapping *macroblocks* of a *picture* or *layer picture* into *slice groups*. The macroblock to slice group map consists of a list of numbers, one for each coded *macroblock*, specifying the *slice group* to which each coded *macroblock* belongs.

G.3.38 map unit to slice group map: A means of mapping *slice group map units* of a *picture* or *layer picture* into *slice groups*. The map unit to slice group map consists of a list of numbers, one for each *slice group map unit*, specifying the *slice group* to which each coded *slice group map unit* belongs to.

G.3.39 non-paired reference base field: A *reference base field* that is not part of a *complementary reference base field pair*. A *non-paired reference base field* is a *non-paired reference field.*

G.3.40 P slice: A *slice* that may be decoded using *intra-layer intra prediction* or inter *prediction* using at most one *motion vector* and *reference index* to *predict* the sample values of each *block.*

G.3.41 parameter: A *syntax element* of an *SVC sequence parameter set* or a *picture parameter set*. Parameter is also used as part of the defined term *quantisation parameter*.

G.3.42 picture parameter set: A *syntax structure* containing *syntax elements* that apply to zero or more *layer representations* as determined by the pic_parameter_set_id *syntax element* found in each *slice header.*

G.3.43 prefix NAL unit: A *NAL unit* with nal_unit_type equal to 14 that immediately precedes in *decoding order* a *NAL unit* with nal_unit_type equal to 1, 5, or 12. The *NAL unit* that immediately succeeds in *decoding order* the *prefix NAL unit* is referred to as the *associated NAL unit*. The *prefix NAL unit* contains data associated with the *associated NAL unit*, which are considered to be part of the *associated NAL unit*.

G.3.44 reference base field: A *reference field* that is obtained by decoding a *base quality layer representation* with the nal_ref_idc *syntax element* not equal to 0, the store_ref_base_pic_flag *syntax element* equal to 1, and the field_pic_flag *syntax element* equal to 1 of an access unit and all *layer representations* of the *access unit* that are referred to by *inter-layer prediction* of the *base quality layer representation*. A *reference base field* is not an output of the *decoding process*, but may be used for *inter prediction* when *P*, *B*, *EP*, and *EB slices* of a *coded field* or *field macroblock* of a *coded frame* are decoded. See also *reference base picture*.

G.3.45 reference base frame: A *reference frame* that is obtained by decoding a *base quality layer representation* with the nal_ref_idc *syntax element* not equal to 0, the store_ref_base_pic_flag *syntax element* equal to 1, and the field_pic_flag *syntax element* equal to 0 of an access unit and all *layer representations* of the *access unit* that are referred to by *inter-layer prediction* of the *base quality layer representation*. A *reference base frame* is not an output of the *decoding process*, but may be used for *inter prediction* when *P*, *B*, *EP*, and *EB slices* of a *coded frame* are decoded. See also *reference base picture*.

G.3.46 reference base picture: A *reference picture* that is obtained by decoding a *base quality layer representation* with the nal_ref_idc *syntax element* not equal to 0 and the store_ref_base_pic_flag *syntax element* equal to 1 of

an access unit and all *layer representations* of the *access unit* that are referred to by *inter-layer prediction* of the *base quality layer representation*. A *reference base picture* is not an output of the *decoding process*, but the samples of a *reference base picture* may be used for *inter prediction* in the *decoding process* of subsequent *pictures* in *decoding order*. *Reference base picture* is a collective term for a *reference base field* or a *reference base frame*.

G.3.47 reference field: A *reference field* may be used for *inter prediction* when *P, B, EP,* or *EB slices* of a *coded field* or *field macroblocks* of a *coded frame* are decoded. See also *reference picture*.

G.3.48 reference frame: A *reference frame* may be used for *inter prediction* when *P, B, EP,* or *EB slices* of a *coded frame* are decoded. See also *reference picture*.

G.3.49 reference layer macroblock: A *macroblock* of a *reference layer representation*.

G.3.50 reference layer representation: A *reference layer representation* for a particular *layer representation* of an *access unit* is the *layer representation* that is used for *inter-layer prediction* of the particular *layer representation*. The *reference layer representation* is in the same *access unit* as the *layer representation* that uses the *reference layer representation* for *inter-layer prediction*.

G.3.51 reference picture: A collective term for a *decoded picture* that is obtained by decoding an *access unit* for that the nal_ref_idc *syntax element* that is associated with the *target dependency representation* is not equal to 0 or a *reference base picture*. A *reference picture* contains samples that may be used for *inter prediction* in the *decoding process* of subsequent *pictures* in *decoding order*.

G.3.52 reference picture list: A list of *reference pictures* that is used for *inter prediction* of a *P, B, EP,* or *EB slice*. For the *decoding process* of a *P* or *EP slice*, there is one reference picture list. For the *decoding process* of a *B* or *EB slice*, there are two reference picture lists.

G.3.53 reference picture list 0: A *reference picture list* used for *inter prediction* of a *P, B, EP,* or *EB slice*. All *inter prediction* used for *P* and *EP slices* uses reference picture list 0. Reference picture list 0 is one of two *reference picture lists* used for *inter prediction* for a *B* or *EB slice*, with the other being *reference picture list 1*.

G.3.54 reference picture list 1: A *reference picture list* used for *inter prediction* of a *B* or *EB slice*. Reference picture list 1 is one of two *reference picture lists* used for *inter prediction* for a *B* or *EB slice*, with the other being *reference picture list 0*.

G.3.55 scalable bitstream: A *bitstream* with the property that one or more *bitstream subsets* that are not identical to the *scalable bitstream* form another *bitstream* that conforms to this specification.

G.3.56 sequence parameter set: A *syntax structure* containing *syntax elements* that apply to zero or more *layer representations* with the dependency_id *syntax element* equal to 0 and the quality_id *syntax element* equal to 0 as determined by the content of a seq_parameter_set_id *syntax element* found in the *picture parameter set* referred to by the pic_parameter_set_id *syntax element* found in each *slice header* of *I, P*, and *B slices*.

G.3.57 slice: An integer number of *macroblocks* or *macroblock pairs* ordered consecutively in the *raster scan* within a particular *slice group*. For a *picture* or *layer picture*, the division of each *slice group* into slices is a partitioning. Although a slice contains *macroblocks* or *macroblock pairs* that are consecutive in the *raster scan* within a *slice group*, these *macroblocks* or *macroblock pairs* are not necessarily consecutive in the *raster scan* within the *picture* or *layer picture*. The *macroblock addresses* are derived from the first *macroblock address* in a slice (as represented in the *slice header*) and the *macroblock to slice group map*.

G.3.58 slice group: A subset of the *macroblocks* or *macroblock pairs* of a *picture* or *layer picture*. The division of the *picture* or *layer picture* into slice groups is a *partitioning* of the *picture* or *layer picture*. The partitioning is specified by the *macroblock to slice group map*.

G.3.59 spatial intra prediction: See *intra-layer intra prediction*.

G.3.60 sub-bitstream: A *subset* of a *bitstream*. A *sub-bitstream* is also referred to as *bitstream subset*.

G.3.61 subset: A subset contains only elements that are also contained in the set from which the subset is derived. The subset may be identical to the set from which it is derived.

G.3.62 subset sequence parameter set: A *syntax structure* containing *syntax elements* that apply to zero or more *layer representations* with the dependency_id *syntax element* not equal to 0 or the quality_id *syntax element* not equal to 0 as determined by the content of a seq_parameter_set_id *syntax element* found in the *picture parameter set* referred to by the pic_parameter_set_id *syntax element* found in each *slice header* of *EI, EP*, and *EB slices*.

G.3.63 SVC sequence parameter set: A collective term for *sequence parameter set* or *subset sequence parameter set*.

G.3.64 SVC sequence parameter set RBSP: A collective term for sequence parameter set RBSP or subset sequence parameter set RBSP.

G.3.65 target dependency representation: The *dependency representation* of an *access unit* that is associated with the largest value of the dependency_id *syntax element* for all *dependency representations* of the *access unit*.

G.3.66 target layer representation: The *layer representation* of the *target dependency representation* of an *access unit* that is associated with the largest value of the quality_id *syntax element* for all *layer representations* of the *target dependency representation* of the *access unit*.

G.3.67 top macroblock (of a macroblock pair): The *macroblock* within a *macroblock pair* that contains the samples in the top row of samples for the *macroblock pair*. For a *field macroblock pair*, the top macroblock represents the samples from the region of the *top field* or *layer top field* of the *frame* or *layer frame* that lie within the spatial region of the *macroblock pair*. For a *frame macroblock pair*, the top macroblock represents the samples of the *frame* or *layer frame* that lie within the top half of the spatial region of the *macroblock pair*.

G.3.68 VCL NAL unit: A collective term for *coded slice NAL units* and *VCL prefix NAL units*.

G.3.69 VCL prefix NAL unit: A *prefix NAL unit* with an *associated NAL unit* that has nal_unit_type equal to 1 or 5.

G.4 Abbreviations

The specifications in clause 4 apply.

G.5 Conventions

The specifications in clause 5 apply.

G.6 Source, coded, decoded and output data formats, scanning processes, neighbouring and reference layer relationships

The specifications in clause 6 apply with substituting SVC sequence parameter set for sequence parameter set. Additionally, the following process is specified.

G.6.1 Derivation process for reference layer macroblocks

This process is only invoked when no_inter_layer_pred_flag is equal to 0.

Inputs to this process are

– a luma location (xP, yP) relative to the upper-left luma sample of the current macroblock,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation.

Outputs of this process are

– the macroblock address mbAddrRefLayer specifying the reference layer macroblock,

– a luma location (xB, yB) relative to the upper-left luma sample of the reference layer macroblock.

The variables shiftX, shiftY, scaleX, scaleY, offsetX, and offsetY are derived as specified in the following ordered steps.

NOTE 1 – These variables do not depend on the luma location (xP, yP), the variable fieldMbFlag, or the current macroblock.

1. The variables refW, refH, scaledW, scaledH, offsetX, and offsetY are derived by

$$refW = RefLayerPicWidthInSamples_L \quad (G\text{-}1)$$
$$refH = RefLayerPicHeightInSamples_L \quad (G\text{-}2)$$
$$scaledW = ScaledRefLayerPicWidthInSamples_L \quad (G\text{-}3)$$
$$scaledH = ScaledRefLayerPicHeightInSamples_L \quad (G\text{-}4)$$
$$offsetX = ScaledRefLayerLeftOffset \quad (G\text{-}5)$$
$$offsetY = ScaledRefLayerTopOffset / (1 + field\_pic\_flag) \quad (G\text{-}6)$$

2. The variables shiftX and shiftY are derived by

$$shiftX = ((level\_idc <= 30) \ ? \ 16 \ : \ (31 - Ceil(Log2(refW)))) \quad \text{(G-7)}$$
$$shiftY = ((level\_idc <= 30) \ ? \ 16 \ : \ (31 - Ceil(Log2(refH)))) \quad \text{(G-8)}$$

3. The variables scaleX and scaleY are derived by

$$scaleX = ((refW << shiftX) + (scaledW >> 1)) / scaledW \quad \text{(G-9)}$$
$$scaleY = ((refH << shiftY) + (scaledH >> 1)) / scaledH \quad \text{(G-10)}$$

The reference layer luma location (xRef, yRef) relative to the upper-left sample of the reference layer picture is derived as specified by the following ordered steps.

1. The inverse macroblock scanning process as specified in subclause 6.4.1 is invoked with CurrMbAddr as the input and the output is assigned to (xM, yM). For this invocation of the process in subclause 6.4.1, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1, and it is treated as frame macroblock when fieldMbFlag is equal to 0.
2. The luma location (xC, yC) is derived by

$$xC = xM + xP \quad \text{(G-11)}$$
$$yC = yM + yP * (1 + fieldMbFlag - field\_pic\_flag) \quad \text{(G-12)}$$

3. The reference layer luma location is derived by

$$xRef = ((xC - offsetX) * scaleX + (1 << (shiftX - 1))) >> shiftX \quad \text{(G-13)}$$
$$yRef = ((yC - offsetY) * scaleY + (1 << (shiftY - 1))) >> shiftY \quad \text{(G-14)}$$

The reference layer macroblock address mbAddrRefLayer and a luma location (xB, yB) relative to the upper-left sample of the reference layer macroblock mbAddrRefLayer are derived as follows.

– If MbaffFrameFlag is equal to 0 and RefLayerMbaffFrameFlag is equal to 0, the following ordered steps are specified.

1. The reference layer macroblock address mbAddrRefLayer is derived as follows.
   – If any of the following conditions is true, mbAddrRefLayer is marked as not available.
     – xRef is less than 0 or xRef is greater than or equal to $RefLayerPicWidthInSamples_L$
     – yRef is less than 0 or yRef is greater than or equal to $RefLayerPicHeightInSamples_L$
   – Otherwise, the macroblock address mbAddrRefLayer is derived by

$$mbAddrRefLayer = (yRef / 16) * RefLayerPicWidthInMbs + (xRef / 16) \quad \text{(G-15)}$$

2. The luma location (xB, yB) is derived as follows.
   – If mbAddrRefLayer is not available, (xB, yB) is marked as not available.
   – Otherwise (mbAddrRefLayer is available), (xB, yB) is set equal to (xRef % 16, yRef % 16).

– Otherwise (MbaffFrameFlag is equal to 1 or RefLayerMbaffFrameFlag is equal to 1), the following ordered steps are specified.

NOTE 2 – When MbaffFrameFlag is equal to 1 or RefLayerMbaffFrameFlag is equal to 1, field_pic_flag and RefLayerFieldPicFlag are both equal to 0 (see subclause G.7.4.3.4).

1. A virtual reference layer macroblock address virtMbAddrRefLayer is derived as follows.
   – If any of the following conditions is true, virtMbAddrRefLayer is marked as not available.
     – xRef is less than 0 or xRef is greater than or equal to $RefLayerPicWidthInSamples_L$
     – yRef is less than 0 or yRef is greater than or equal to $RefLayerPicHeightInSamples_L$
   – Otherwise, the following applies.

– If RefLayerMbaffFrameFlag is equal to 1, virtMbAddrRefLayer is derived by

$$virtMbAddrRefLayer = 2 * ((yRef / 32) * RefLayerPicWidthInMbs + (xRef / 16)) + (yRef \% 32) / 16 \quad \text{(G-16)}$$

– Otherwise (RefLayerMbaffFrameFlag is equal to 0), virtMbAddrRefLayer is derived by

$$virtMbAddrRefLayer = (yRef / 16) * RefLayerPicWidthInMbs + (xRef / 16) \quad \text{(G-17)}$$

2. The reference layer macroblock address mbAddrRefLayer and the luma location (xB, yB) are derived as follows.

– If virtMbAddrRefLayer is not available, the reference layer macroblock address mbAddrRefLayer and the luma location (xB, yB) are marked as not available.

– Otherwise, if fieldMbFlag is equal to 0 and refLayerFieldMbRef[virtMbAddrRefLayer] is equal to 1, the field-to-frame reference layer macroblock conversion process as specified in subclause G.6.1.1 is invoked with virtMbAddrRefLayer, (xRef, yRef), and refLayerMbType as the inputs and the outputs are assigned to mbAddrRefLayer and (xB, yB).

– Otherwise, if fieldMbFlag is equal to 1 and refLayerFieldMbRef[virtMbAddrRefLayer] is equal to 0, the frame-to-field reference layer macroblock conversion process as specified in subclause G.6.1.2 is invoked with virtMbAddrRefLayer and (xRef, yRef) as the inputs and the outputs are assigned to mbAddrRefLayer and (xB, yB).

– Otherwise (virtMbAddrRefLayer is available and fieldMbFlag is equal to refLayerFieldMbRef[virtMbAddrRefLayer]), mbAddrRefLayer and (xB, yB) are derived as follows.

$$mbAddrRefLayer = ((virtMbAddrRefLayer >> fieldMbFlag) << fieldMbFlag) + (CurrMbAddr \% 2) * fieldMbFlag \quad \text{(G-18)}$$
$$xB = (xRef \% 16) \quad \text{(G-19)}$$
$$yB = (yRef \% (16 << fieldMbFlag)) >> fieldMbFlag \quad \text{(G-20)}$$

G.6.1.1 Field-to-frame reference layer macroblock conversion process

Inputs to this process are

– a virtual reference layer macroblock address virtMbAddrRefLayer,

– a reference layer luma location (xRef, yRef) relative to the upper-left luma sample of the reference layer picture,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation.

Outputs of this process are

– the macroblock address mbAddrRefLayer of the reference layer macroblock,

– a luma location (xB, yB) relative to the upper-left luma sample of the reference layer macroblock.

The macroblock addresses mbAddrRefLayerTop and mbAddrRefLayerBot are derived by

$$mbAddrRefLayerTop = virtMbAddrRefLayer – (virtMbAddrRefLayer \% 2) \quad \text{(G-21)}$$
$$mbAddrRefLayerBot = mbAddrRefLayerTop + 1 \quad \text{(G-22)}$$

The reference layer macroblock address mbAddrRefLayer is derived as follows.

– If refLayerMbType[mbAddrRefLayerTop] is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL, mbAddrRefLayer is set equal to mbAddrRefLayerBot.

– Otherwise (refLayerMbType[mbAddrRefLayerTop] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL), mbAddrRefLayer is set equal to mbAddrRefLayerTop.

The luma location (xB, yB) is derived by

$$xB = xRef \% 16 \quad \text{(G-23)}$$
$$yB = 8 * ((yRef / 16) \% 2) + 4 * ((yRef \% 16) / 8) \quad \text{(G-24)}$$

G.6.1.2 Frame-to-field reference layer macroblock conversion process

Inputs to this process are

– a virtual reference layer macroblock address virtMbAddrRefLayer,

– a virtual reference layer luma location (xRef, yRef) relative to the upper-left luma sample of the reference layer picture.

Outputs of this process are

– the macroblock address mbAddrRefLayer of the reference layer macroblock,

– a luma location (xB, yB) relative to the upper-left luma sample of the reference layer macroblock.

The macroblock addresses mbAddrRefLayerTop and mbAddrRefLayerBot are derived as follows.

– If RefLayerMbaffFrameFlag is equal to 1, mbAddrRefLayerTop and mbAddrRefLayerBot are derived by

$$mbAddrRefLayerTop = virtMbAddrRefLayer - (virtMbAddrRefLayer \% 2) \quad (G\text{-}25)$$
$$mbAddrRefLayerBot = mbAddrRefLayerTop + 1 \quad (G\text{-}26)$$

– Otherwise (RefLayerMbaffFrameFlag is equal to 0), mbAddrRefLayerTop and mbAddrRefLayerBot are derived by

$$mbAddrRefLayerTop = virtMbAddrRefLayer - ((yRef / 16) \% 2) * RefLayerPicWidthInMbs \quad (G\text{-}27)$$
$$mbAddrRefLayerBot = mbAddrRefLayerTop + RefLayerPicWidthInMbs \quad (G\text{-}28)$$

The reference layer macroblock address is derived as follows.

– If (yRef % 16) is less than 8, mbAddrRefLayer is set equal to mbAddrRefLayerTop.

– Otherwise ((yRef % 16) is greater than or equal to 8), mbAddrRefLayer is set equal to mbAddRefLayerBot.

The luma location (xB, yB) is derived by

$$xB = xRef \% 16 \quad (G\text{-}29)$$
$$yB = 8 * (((yRef \% 16) / 4) \% 2) + 4 * ((yRef / 16) \% 2) \quad (G\text{-}30)$$

G.6.2 Derivation process for reference layer partitions

This process is only invoked when no_inter_layer_pred_flag is equal to 0.

Inputs to this process are

– a luma location (xP, yP) relative to the upper-left luma sample of the current macroblock,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation,

– a (RefLayerPicSizeInMbs)x4 array refLayerSubMbType specifying the sub-macroblock types for the macroblocks of the reference layer representation.

Outputs of this process are

– the macroblock address mbAddrRefLayer specifying the reference layer macroblock,

– the macroblock partition index mbPartIdxRefLayer specifying the reference layer macroblock partition inside the reference layer macroblock mbAddrRefLayer,

– the sub-macroblock partition index subMbPartIdxRefLayer specifying the reference layer sub-macroblock partition inside the macroblock partition mbPartIdxRefLayer of the reference layer macroblock mbAddrRefLayer.

The derivation process for reference layer macroblocks as specified in subclause G.6.1 is invoked with the luma location (xP, yP), fieldMbFlag, refLayerFieldMbFlag, and refLayerMbType as the input and the outputs are assigned to mbAddrRefLayer and (xB, yB).

The reference layer macroblock partition index mbPartIdxRefLayer and the reference layer sub-macroblock partition index subMbPartIdxRefLayer are derived as follows.

– If mbAddrRefLayer is not available, mbPartIdxRefLayer and subMbPartIdxRefLayer are marked as not available.

– Otherwise, if refLayerMbType[mbAddrRefLayer] is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL, mbPartIdxRefLayer and subMbPartIdxRefLayer are set equal to 0.

– Otherwise, if refLayerMbType[mbAddrRefLayer] is equal to B_Skip or B_Direct_16x16, the following applies.

  – If ref_layer_dq_id is greater than 0, mbPartIdxRefLayer and subMbPartIdxRefLayer are set equal to 0.

  – Otherwise (ref_layer_dq_id is equal to 0), mbPartIdxRefLayer and subMbPartIdxRefLayer are derived by

$$\text{mbPartIdxRefLayer} = 2 * (yB / 8) + (xB / 8) \quad \text{(G-31)}$$
$$\text{subMbPartIdxRefLayer} = 2 * ((yB \% 8) / 4) + ((xB \% 8) / 4) \quad \text{(G-32)}$$

– Otherwise (mbAddrRefLayer is available and refLayerMbType[mbAddrRefLayer] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, I_BL, B_Skip, or B_Direct_16x16), the following ordered steps are specified.

  1. The reference layer macroblock partition index mbPartIdxRefLayer is set equal to the macroblock partition index of the macroblock partition inside the reference layer macroblock mbAddrRefLayer that covers the luma location (xB, yB). The macroblock partitioning of the reference layer macroblock mbAddrRefLayer is given by the macroblock type refLayerMbType[mbAddrRefLayer] and the specification in subclause G.8.4.1.

  2. The reference layer sub-macroblock partition index subMbPartIdxRefLayer is derived as follows.

     – If NumMbPart(refLayerMbType[mbAddrRefLayer]) is less than 4, subMbPartIdxRefLayer is set equal to 0.

     – Otherwise (NumMbPart(refLayerMbType[mbAddrRefLayer]) is equal to 4), the following applies.

       – If refLayerSubMbType[mbAddrRefLayer][mbPartIdxRefLayer] is equal to B_Direct_8x8, the following applies.

         – If ref_layer_dq_id is greater than 0, subMbPartIdxRefLayer is set equal to 0.

         – Otherwise (ref_layer_dq_id is equal to 0), subMbPartIdxRefLayer is derived by

$$\text{subMbPartIdxRefLayer} = 2 * ((yB \% 8) / 4) + ((xB \% 8) / 4) \quad \text{(G-33)}$$

       – Otherwise (refLayerSubMbType[mbAddrRefLayer][mbPartIdxRefLayer] is not equal to B_Direct_8x8), the reference layer sub-macroblock partition index subMbPartIdxRefLayer is set equal to the sub-macroblock partition index of the sub-macroblock partition inside the macroblock partition mbPartIdxRefLayer of the reference layer macroblock mbAddrRefLayer that covers the luma location (xB, yB). The sub-macroblock partitioning of the reference layer macroblock partition mbPartIdxRefLayer inside the reference layer macroblock mbAddrRefLayer is given by the sub-macroblock type refLayerSubMbType[mbAddrRefLayer][mbPartIdxRefLayer] and the specification in subclause G.8.4.1.

G.6.3 Derivation process for reference layer sample locations in resampling

Inputs to this process are

– a variable chromaFlag specifying whether the luma or a chroma component is subject to the resampling process,

– a sample location (xP, yP) relative to the upper-left sample of the current macroblock,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable botFieldFlag specifying whether a top or a bottom field is subject to the resampling process (when RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0).

Output of this process is a reference layer sample location (xRef16, yRef16), which specifies the following.

– If RefLayerFrameMbsOnlyFlag is equal to 1 or RefLayerFieldPicFlag is equal to 1, (xRef16, yRef16) specifies the reference layer sample location in units of 1/16-th sample relative to the upper-left sample of the reference layer picture.

– Otherwise (RefLayerFrameMbsOnlyFlag is equal to 0 and RefLayerFieldPicFlag is equal to 0), (xRef16, yRef16) specifies the reference layer sample location in units of 1/16-th field sample relative to the upper-left sample of the field specified by botFieldFlag of the reference layer picture.

The variables subW, subH, shiftX, shiftY, scaleX, scaleY, offsetX, offsetY, addX, addY, deltaX, and deltaY are derived as specified in the following ordered steps.

NOTE – These variables do not depend on the input sample location (xP, yP), the input variable fieldMbFlag, or the current macroblock address CurrMbAddr.

1. With Z being replaced by L for chromaFlag equal to 0 and C for chromaFlag equal to 1, the variables refW, refH, scaledW, and scaledH are derived by

$$refW = RefLayerPicWidthInSamples_Z \quad \text{(G-34)}$$
$$refH = RefLayerPicHeightInSamples_Z * (1 + RefLayerFieldPicFlag) \quad \text{(G-35)}$$
$$scaledW = ScaledRefLayerPicWidthInSamples_Z \quad \text{(G-36)}$$
$$scaledH = ScaledRefLayerPicHeightInSamples_Z * (1 + field\_pic\_flag) \quad \text{(G-37)}$$

2. When frame_mbs_only_flag is equal to 0 and RefLayerFrameMbsOnlyFlag is equal to 1, the variable scaledH is modified by

$$scaledH = scaledH / 2 \quad \text{(G-38)}$$

3. The variables refPhaseX, refPhaseY, phaseX, phaseY, subW, and subH are derived by

$$refPhaseX = ((chromaFlag == 0) ? 0 : (ref\_layer\_chroma\_phase\_x\_plus1\_flag - 1)) \quad \text{(G-39)}$$
$$refPhaseY = ((chromaFlag == 0) ? 0 : (ref\_layer\_chroma\_phase\_y\_plus1 - 1)) \quad \text{(G-40)}$$
$$phaseX = ((chromaFlag == 0) ? 0 : (chroma\_phase\_x\_plus1\_flag - 1)) \quad \text{(G-41)}$$
$$phaseY = ((chromaFlag == 0) ? 0 : (chroma\_phase\_y\_plus1 - 1)) \quad \text{(G-42)}$$
$$subW = ((chromaFlag == 0) ? 1 : SubWidthC) \quad \text{(G-43)}$$
$$subH = ((chromaFlag == 0) ? 1 : SubHeightC) \quad \text{(G-44)}$$

4. When RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0, the following applies.
   – The variable phaseY is modified by

$$phaseY = phaseY + 4 * botFieldFlag \quad \text{(G-45)}$$

   – The variable refPhaseY is modified as follows.
     – If RefLayerFrameMbsOnlyFlag is equal to 1, the variable refPhaseY is modified by

$$refPhaseY = 2 * refPhaseY + 2 \quad \text{(G-46)}$$

     – Otherwise (RefLayerFrameMbsOnlyFlag is equal to 0), the variable refPhaseY is modified by

$$refPhaseY = refPhaseY + 4 * botFieldFlag \quad \text{(G-47)}$$

5. The variables shiftX and shiftY are derived by

$$shiftX = ((level\_idc <= 30) ? 16 : (31 - Ceil(Log2(refW)))) \quad \text{(G-48)}$$
$$shiftY = ((level\_idc <= 30) ? 16 : (31 - Ceil(Log2(refH)))) \quad \text{(G-49)}$$

6. The variables scaleX and scaleY are derived by

$$scaleX = ((refW << shiftX) + (scaledW >> 1)) / scaledW \quad \text{(G-50)}$$
$$scaleY = ((refH << shiftY) + (scaledH >> 1)) / scaledH \quad \text{(G-51)}$$

7. The variables offsetX, addX, and deltaX are derived by

$$offsetX = ScaledRefLayerLeftOffset / subW \quad \text{(G-52)}$$
$$addX = (((refW * (2 + phaseX)) << (shiftX – 2)) + (scaledW >> 1)) / scaledW + (1 << (shiftX – 5)) \quad \text{(G-53)}$$
$$deltaX = 4 * (2 + refPhaseX) \quad \text{(G-54)}$$

8. The variables offsetY, addY, and deltaY are derived as follows.

   – If RefLayerFrameMbsOnlyFlag is equal to 1 and frame_mbs_only_flag is equal to 1, the variables offsetY, addY, and deltaY are derived by

$$offsetY = ScaledRefLayerTopOffset / subH \quad \text{(G-55)}$$
$$addY = (((refH * (2 + phaseY)) << (shiftY – 2)) + (scaledH >> 1)) / scaledH + (1 << (shiftY – 5)) \quad \text{(G-56)}$$
$$deltaY = 4 * (2 + refPhaseY) \quad \text{(G-57)}$$

   – Otherwise (RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0), the variables offsetY, addY, and deltaY are derived by

$$offsetY = ScaledRefLayerTopOffset / (2 * subH) \quad \text{(G-58)}$$
$$addY = (((refH * (2 + phaseY)) << (shiftY – 3)) + (scaledH >> 1)) / scaledH + (1 << (shiftY – 5)) \quad \text{(G-59)}$$
$$deltaY = 2 * (2 + refPhaseY) \quad \text{(G-60)}$$

The sample location (xC, yC) is derived as specified in the following ordered steps.

1. The inverse macroblock scanning process as specified in subclause 6.4.1 is invoked with CurrMbAddr as input and the output is assigned to (xM, yM). For this invocation of the process in subclause 6.4.1, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1 and it is treated as frame macroblock when fieldMbFlag is equal to 0.
2. The sample location (xC, yC) is derived by

$$xC = xP + (xM >> (subW – 1)) \quad \text{(G-61)}$$
$$yC = yP + (yM >> (subH – 1 + fieldMbFlag – field_pic_flag)) \quad \text{(G-62)}$$

3. When RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0, the vertical component of the sample location (xC, yC) is modified by

$$yC = yC >> (1 – fieldMbFlag) \quad \text{(G-63)}$$

The reference layer sample location (xRef16 yRef16) is derived by

$$xRef16 = (((xC – offsetX) * scaleX + addX) >> (shiftX – 4)) – deltaX \quad \text{(G-64)}$$
$$yRef16 = (((yC – offsetY) * scaleY + addY) >> (shiftY – 4)) – deltaY \quad \text{(G-65)}$$

G.7 Syntax and semantics

This clause specifies syntax and semantics for coded video sequences that conform to one or more of the profiles specified in this Annex.

G.7.1 Method of specifying syntax in tabular form

The specifications in subclause 7.1 apply.

G.7.2 Specification of syntax functions, categories, and descriptors

The specifications in subclauses 7.2 apply. Additionally, the following syntax function is specified.

in_crop_window(mbAddr) is specified by the following ordered steps.

1. The variables mbX is set equal to (mbAddr % PicWidthInMbs).

2. The variables mbY0 and mbY1 are derived as follows.
   - If MbaffFrameFlag is equal to 0, mbY0 and mbY1 are set equal to (mbAddr / PicWidthInMbs).
   - Otherwise (MbaffFrameFlag is equal to 1), mbY0 is set equal to (2 * ((mbAddr / PicWidthInMbs) / 2)) and mbIdxY1 is set equal to (mbIdxY0 + 1).
3. The variable scalMbH is set equal to (16 * (1 + field_pic_flag)).
4. The return value of in_crop_window (mbAddr) is derived as follows.
   - If all of the following conditions are true, the return value of in_crop_window(mbAddr) is equal to TRUE.
     - no_inter_layer_pred_flag is equal to 0
     - mbX is greater than or equal to ((ScaledRefLayerLeftOffset + 15) / 16)
     - mbX is less than ((ScaledRefLayerLeftOffset + $ScaledRefLayerPicWidthInSamples_L$) / 16)
     - mbY0 is greater than or equal to ((ScaledRefLayerTopOffset + scalMbH – 1) / scalMbH)
     - mbY1 is less than ((ScaledRefLayerTopOffset + $ScaledRefLayerPicHeightInSamples_L$) / scalMbH)
   - Otherwise, the return value of in_crop_window(mbAddr) is equal to FALSE.

G.7.3 Syntax in tabular form

G.7.3.1 NAL unit syntax

The syntax table is specified in subclause 7.3.1.

G.7.3.1.1 NAL unit header SVC extension syntax

nal_unit_header_svc_extension( ) {	C	Descriptor
reserved_one_bit	All	u(1)
idr_flag	All	u(1)
priority_id	All	u(6)
no_inter_layer_pred_flag	All	u(1)
dependency_id	All	u(3)
quality_id	All	u(4)
temporal_id	All	u(3)
use_ref_base_pic_flag	All	u(1)
discardable_flag	All	u(1)
output_flag	All	u(1)
reserved_three_2bits	All	u(2)
}		

G.7.3.2 Raw byte sequence payloads and RBSP trailing bits syntax

G.7.3.2.1 Sequence parameter set RBSP syntax

The syntax table is specified in subclause 7.3.2.1.

G.7.3.2.1.1 Sequence parameter set data syntax

The syntax table is specified in subclause 7.3.2.1.1.

G.7.3.2.1.1.1 Scaling list syntax

The syntax table is specified in subclause 7.3.2.1.1.1.

G.7.3.2.1.2 Sequence parameter set extension RBSP syntax

The syntax table is specified in subclause 7.3.2.1.2.

G.7.3.2.1.3 Subset sequence parameter set RBSP syntax

subset_seq_parameter_set_rbsp( ) {	C	Descriptor
seq_parameter_set_data( )	0	
if(profile_idc = = 83 || profile_idc = = 86) {		
seq_parameter_set_svc_extension( )	0	
svc_vui_parameters_present_flag	0	u(1)
if(svc_vui_parameters_present_flag = = 1)		
svc_vui_parameters_extension( )	0	
}		
additional_extension2_flag	0	u(1)
if(additional_extension2_flag = = 1)		
while(more_rbsp_data( ))		
additional_extension2_data_flag	0	u(1)
rbsp_trailing_bits( )	0	
}		

G.7.3.2.1.4 Sequence parameter set SVC extension syntax

seq_parameter_set_svc_extension( ) {	C	Descriptor
inter_layer_deblocking_filter_control_present_flag	0	u(1)
extended_spatial_scalability	0	u(2)
if(ChromaArrayType = = 1 || ChromaArrayType = = 2)		
chroma_phase_x_plus1_flag	0	u(1)
if(ChromaArrayType = = 1)		
chroma_phase_y_plus1	0	u(2)
if(extended_spatial_scalability = = 1) {		
if(ChromaArrayType > 0) {		
seq_ref_layer_chroma_phase_x_plus1_flag	0	u(1)
seq_ref_layer_chroma_phase_y_plus1	0	u(2)
}		
seq_scaled_ref_layer_left_offset	0	se(v)
seq_scaled_ref_layer_top_offset	0	se(v)
seq_scaled_ref_layer_right_offset	0	se(v)
seq_scaled_ref_layer_bottom_offset	0	se(v)
}		
seq_tcoeff_level_prediction_flag	0	u(1)
if(seq_tcoeff_level_prediction_flag) {		
adaptive_tcoeff_level_prediction_flag	0	u(1)
}		
slice_header_restriction_flag	0	u(1)
}		

G.7.3.2.2 Picture parameter set RBSP syntax

The syntax table is specified in subclause 7.3.2.2.

G.7.3.2.3 Supplemental enhancement information RBSP syntax

The syntax table is specified in subclause 7.3.2.3.

G.7.3.2.3.1 Supplemental enhancement information message syntax

The syntax table is specified in subclause 7.3.2.3.1.

G.7.3.2.4 Access unit delimiter RBSP syntax

The syntax table is specified in subclause 7.3.2.4.

G.7.3.2.5 End of sequence RBSP syntax

The syntax table is specified in subclause 7.3.2.5.

G.7.3.2.6 End of stream RBSP syntax

The syntax table is specified in subclause 7.3.2.6.

G.7.3.2.7 Filler data RBSP syntax

The syntax table is specified in subclause 7.3.2.7.

G.7.3.2.8 Slice layer without partitioning RBSP syntax

The syntax table is specified in subclause 7.3.2.8.

G.7.3.2.9 Slice data partition RBSP syntax

Slice data partition syntax is not present in coded video sequences conforming to one or more of the profiles specified in this Annex.

G.7.3.2.10 RBSP slice trailing bits syntax

The syntax table is specified in subclause 7.3.2.10.

G.7.3.2.11 RBSP trailing bits syntax

The syntax table is specified in subclause 7.3.2.11.

G.7.3.2.12 Prefix NAL unit RBSP syntax

prefix_nal_unit_rbsp( ) {	C	Descriptor
if(nal_ref_idc != 0) {		
store_ref_base_pic_flag	2	u(1)
if((use_ref_base_pic_flag || store_ref_base_pic_flag) && !idr_flag)		
dec_ref_base_pic_marking( )	2	
prefix_nal_unit_additional_extension_flag	2	u(1)
if(prefix_nal_unit_additional_extension_flag == 1)		
while(more_rbsp_data( ))		
prefix_nal_unit_extension_flag	2	u(1)
rbsp_trailing_bits( )	2	
}		
}		

G.7.3.2.13 Slice layer in scalable extension RBSP syntax

slice_layer_in_scalable_extension_rbsp( ) {	C	Descriptor
slice_header_in_scalable_extension( )	2	
if(!slice_skip_flag)		
slice_data_in_scalable_extension( )	2 | 3 | 4	
rbsp_slice_trailing_bits( )	2	
}		

G.7.3.3 Slice header syntax

The syntax table is specified in subclause 7.3.3.

G.7.3.3.1 Reference picture list reordering syntax

The syntax table is specified in subclause 7.3.3.1.

G.7.3.3.2 Prediction weight table syntax

The syntax table is specified in subclause 7.3.3.2.

G.7.3.3.3 Decoded reference picture marking syntax

The syntax table is specified in subclause 7.3.3.3.

G.7.3.3.4 Slice header in scalable extension syntax

slice_header_in_scalable_extension( ) {	C	Descriptor
first_mb_in_slice	2	ue(v)
slice_type	2	ue(v)
pic_parameter_set_id	2	ue(v)
if(separate_colour_plane_flag = = 1)		
colour_plane_id	2	u(2)
frame_num	2	u(v)
if(!frame_mbs_only_flag) {		
field_pic_flag	2	u(1)
if(field_pic_flag)		
bottom_field_flag	2	u(1)
}		
if(idr_flag = = 1)		
idr_pic_id	2	ue(v)
if(pic_order_cnt_type = = 0) {		
pic_order_cnt_lsb	2	u(v)
if(pic_order_present_flag && !field_pic_flag)		
delta_pic_order_cnt_bottom	2	se(v)
}		
if(pic_order_cnt_type = = 1 && !delta_pic_order_always_zero_flag) {		
delta_pic_order_cnt[0 **]**	2	se(v)
if(pic_order_present_flag && !field_pic_flag)		
delta_pic_order_cnt[1 **]**	2	se(v)
}		
if(redundant_pic_cnt_present_flag)		
redundant_pic_cnt	2	ue(v)

if(quality_id = = 0) {		
if(slice_type = = EB)		
direct_spatial_mv_pred_flag	2	u(1)
if(slice_type = = EP || slice_type = = EB) {		
num_ref_idx_active_override_flag	2	u(1)
if(num_ref_idx_active_override_flag) {		
num_ref_idx_l0_active_minus1	2	ue(v)
if(slice_type = = EB)		
num_ref_idx_l1_active_minus1	2	ue(v)
}		
}		
ref_pic_list_reordering( )	2	
if((weighted_pred_flag && slice_type = = EP) || (weighted_bipred_idc = = 1 && slice_type = = EB)) {		
if(!no_inter_layer_pred_flag)		
base_pred_weight_table_flag	2	u(1)
if(no_inter_layer_pred_flag || !base_pred_weight_table_flag)		
pred_weight_table( )	2	
}		
if(nal_ref_idc != 0) {		
dec_ref_pic_marking( )	2	
if(!slice_header_restriction_flag) {		
store_ref_base_pic_flag	2	u(1)
if ((use_ref_base_pic_flag || store_ref_base_pic_flag) && !idr_flag)		
dec_ref_base_pic_marking( )	2	
}		
}		
}		
if(entropy_coding_mode_flag && slice_type != EI)		
cabac_init_idc	2	ue(v)
slice_qp_delta	2	se(v)
if(deblocking_filter_control_present_flag) {		
disable_deblocking_filter_idc	2	ue(v)
if(disable_deblocking_filter_idc != 1) {		
slice_alpha_c0_offset_div2	2	se(v)
slice_beta_offset_div2	2	se(v)
}		
}		
if(quality_id = = 0 && num_slice_groups_minus1 > 0 && slice_group_map_type >= 3 && slice_group_map_type <= 5)		
slice_group_change_cycle	2	u(v)
if(!no_inter_layer_pred_flag && quality_id = = 0) {		
ref_layer_dq_id	2	ue(v)
if(inter_layer_deblocking_filter_control_present_flag) {		
disable_inter_layer_deblocking_filter_idc	2	ue(v)
if(disable_inter_layer_deblocking_filter_idc != 1) {		
inter_layer_slice_alpha_c0_offset_div2	2	se(v)
inter_layer_slice_beta_offset_div2	2	se(v)

}		
}		
constrained_intra_resampling_flag	2	u(1)
if(extended_spatial_scalability = = 2) {		
if(ChromaArrayType > 0) {		
ref_layer_chroma_phase_x_plus1_flag	2	u(1)
ref_layer_chroma_phase_y_plus1	2	u(2)
}		
scaled_ref_layer_left_offset	2	se(v)
scaled_ref_layer_top_offset	2	se(v)
scaled_ref_layer_right_offset	2	se(v)
scaled_ref_layer_bottom_offset	2	se(v)
}		
}		
if(!no_inter_layer_pred_flag) {		
slice_skip_flag	2	u(1)
if(slice_skip_flag)		
num_mbs_in_slice_minus1	2	ue(v)
else {		
adaptive_base_mode_flag	2	u(1)
if(!adaptive_base_mode_flag)		
default_base_mode_flag	2	u(1)
if(!default_base_mode_flag) {		
adaptive_motion_prediction_flag	2	u(1)
if(!adaptive_motion_prediction_flag)		
default_motion_prediction_flag	2	u(1)
}		
adaptive_residual_prediction_flag	2	u(1)
if(adaptive_residual_prediction_flag)		
default_residual_prediction_flag	2	u(1)
}		
if(adaptive_tcoeff_level_prediction_flag = = 1)		
tcoeff_level_prediction_flag	2	u(1)
}		
if(!slice_header_restriction_flag) {		
scan_idx_start	2	u(4)
scan_idx_end	2	u(4)
}		
}		

G.7.3.3.5 Decoded reference base picture marking syntax

dec_ref_base_pic_marking( ) {	C	Descriptor
adaptive_ref_base_pic_marking_mode_flag	2 | 5	u(1)
if(adaptive_ref_base_pic_marking_mode_flag)		
do {		
memory_management_control_operation	2 | 5	ue(v)
if(memory_management_control_operation = = 1)		
difference_of_pic_nums_minus1	2 | 5	ue(v)
if(memory_management_control_operation = = 2)		
long_term_pic_num	2 | 5	ue(v)
} while(memory_management_control_operation != 0)		
}		

G.7.3.4 Slice data syntax

The syntax table is specified in subclause 7.3.4.

G.7.3.4.1 Slice data in scalable extension syntax

slice_data_in_scalable_extension( ) {	C	Descriptor
if(entropy_coding_mode_flag)		
while(!byte_aligned( ))		
cabac_alignment_one_bit	2	f(1)
CurrMbAddr = first_mb_in_slice * (1 + MbaffFrameFlag)		
moreDataFlag = 1		
prevMbSkipped = 0		
do {		
if(slice_type != EI)		
if(!entropy_coding_mode_flag) {		
mb_skip_run	2	ue(v)
prevMbSkipped = (mb_skip_run > 0)		
for(i = 0; i < mb_skip_run; i++)		
CurrMbAddr = NextMbAddress(CurrMbAddr)		
moreDataFlag = more_rbsp_data( )		
} else {		
mb_skip_flag	2	ae(v)
moreDataFlag = !mb_skip_flag		
}		
if(moreDataFlag) {		
if(MbaffFrameFlag && ((CurrMbAddr % 2) = = 0 || ((CurrMbAddr % 2) = = 1 && prevMbSkipped)))		
mb_field_decoding_flag	2	u(1) | ae(v)
macroblock_layer_in_scalable_extension( )	2 | 3 | 4	
}		
if(!entropy_coding_mode_flag)		
moreDataFlag = more_rbsp_data( )		
else {		
if(slice_type != EI)		

prevMbSkipped = mb_skip_flag		
if(MbaffFrameFlag && (CurrMbAddr % 2) = = 0)		
moreDataFlag = 1		
else {		
end_of_slice_flag	2	ae(v)
moreDataFlag = !end_of_slice_flag		
}		
}		
CurrMbAddr = NextMbAddress(CurrMbAddr)		
} while(moreDataFlag)		
}		

G.7.3.5 Macroblock layer syntax

The syntax table is specified in subclause 7.3.5.

G.7.3.5.1 Macroblock prediction syntax

The syntax table is specified in subclause 7.3.5.1.

G.7.3.5.2 Sub-macroblock prediction syntax

The syntax table is specified in subclause 7.3.5.2.

G.7.3.5.3 Residual data syntax

The syntax table is specified in subclause 7.3.5.3.

G.7.3.5.3.1 Residual luma syntax

The syntax table is specified in subclause 7.3.5.3.1.

G.7.3.5.3.2 Residual block CAVLC syntax

The syntax table is specified in subclause 7.3.5.3.2.

G.7.3.5.3.3 Residual block CABAC syntax

The syntax table is specified in subclause 7.3.5.3.3.

G.7.3.6 Macroblock layer in scalable extension syntax

macroblock_layer_in_scalable_extension( ) {	C	Descriptor
if(in_crop_window(CurrMbAddr) && adaptive_base_mode_flag)		
base_mode_flag	2	u(1) | ae(v)
if(!base_mode_flag)		
mb_type	2	ue(v) | ae(v)
if(!base_mode_flag && mb_type = = I_PCM) {		
while(!byte_aligned( ))		
pcm_alignment_zero_bit	3	f(1)
for(i = 0; i < 256; i++)		
pcm_sample_luma[i **]**	3	u(v)
for(i = 0; i < 2 * MbWidthC * MbHeightC; i++)		
pcm_sample_chroma[i **]**	3	u(v)
} else {		
if(! base_mode_flag) {		
noSubMbPartSizeLessThan8x8Flag = 1		

if(mb_type != I_NxN && MbPartPredMode(mb_type, 0) != Intra_16x16 && NumMbPart(mb_type) = = 4) {		
sub_mb_pred_in_scalable_extension(mb_type)	2	
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if(sub_mb_type[mbPartIdx] != B_Direct_8x8) {		
if(NumSubMbPart(sub_mb_type [mbPartIdx]) > 1)		
noSubMbPartSizeLessThan8x8Flag = 0		
} else if(!direct_8x8_inference_flag)		
noSubMbPartSizeLessThan8x8Flag = 0		
} else {		
if(transform_8x8_mode_flag && mb_type = = I_NxN)		
transform_size_8x8_flag	2	u(1) | ae(v)
mb_pred_in_scalable_extension(mb_type)	2	
}		
}		
if(adaptive_residual_prediction_flag && slice_type != EI && (base_mode_flag || (MbPartPredMode(mb_type, 0) != Intra_16x16 && MbPartPredMode(mb_type, 0) != Intra_8x8 && MbPartPredMode(mb_type, 0) != Intra_4x4 && mb_type != I_PCM && in_crop_window(CurrMbAddr))))		
residual_prediction_flag	2	u(1) | ae(v)
if(scan_idx_end >= scan_idx_start) {		
if(base_mode_flag || MbPartPredMode(mb_type, 0) != Intra_16x16) {		
coded_block_pattern	2	me(v) | ae(v)
if(CodedBlockPatternLuma > 0 && transform_8x8_mode_flag && (base_mode_flag || (mb_type != I_NxN && noSubMbPartSizeLessThan8x8Flag && (mb_type != B_Direct_16x16 || direct_8x8_inference_flag))))		
transform_size_8x8_flag	2	u(1) | ae(v)
}		
if(CodedBlockPatternLuma > 0 || CodedBlockPatternChroma > 0 || (!base_mode_flag && MbPartPredMode(mb_type, 0) = = Intra_16x16)) {		
mb_qp_delta	2	se(v) | ae(v)
residual(base_mode_flag, scan_idx_start, scan_idx_end)	3 | 4	
}		
}		
}		
}		

G.7.3.6.1 Macroblock prediction in scalable extension syntax

mb_pred_in_scalable_extension(mb_type) {	C	Descriptor
if(MbPartPredMode(mb_type, 0) = = Intra_4x4 || MbPartPredMode(mb_type, 0) = = Intra_8x8 || MbPartPredMode(mb_type, 0) = = Intra_16x16) {		
if(MbPartPredMode(mb_type, 0) = = Intra_4x4)		
for(luma4x4BlkIdx = 0; luma4x4BlkIdx < 16; luma4x4BlkIdx++) {		
prev_intra4x4_pred_mode_flag[luma4x4BlkIdx **]**	2	u(1) | ae(v)
if(!prev_intra4x4_pred_mode_flag**[** luma4x4BlkIdx **]**)		
rem_intra4x4_pred_mode[luma4x4BlkIdx **]**	2	u(3) | ae(v)
}		
if(MbPartPredMode(mb_type, 0) = = Intra_8x8)		
for(luma8x8BlkIdx = 0; luma8x8BlkIdx < 4; luma8x8BlkIdx++) {		
prev_intra8x8_pred_mode_flag[luma8x8BlkIdx **]**	2	u(1) | ae(v)
if(!prev_intra8x8_pred_mode_flag[luma8x8BlkIdx])		
rem_intra8x8_pred_mode[luma8x8BlkIdx **]**	2	u(3) | ae(v)
}		
if(ChromaArrayType != 0)		
intra_chroma_pred_mode	2	ue(v) | ae(v)
} else if(MbPartPredMode(mb_type, 0) != Direct) {		
if(in_crop_window(CurrMbAddr) && adaptive_motion_prediction_flag) {		
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if(MbPartPredMode(mb_type, mbPartIdx) != Pred_L1)		
motion_prediction_flag_l0[mbPartIdx **]**	2	u(1) | ae(v)
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if(MbPartPredMode(mb_type, mbPartIdx) != Pred_L0)		
motion_prediction_flag_l1[mbPartIdx **]**	2	u(1) | ae(v)
}		
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if((num_ref_idx_l0_active_minus1 > 0 || mb_field_decoding_flag) && MbPartPredMode(mb_type, mbPartIdx) != Pred_L1 && !motion_prediction_flag_l0[mbPartIdx])		
ref_idx_l0[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if((num_ref_idx_l1_active_minus1 > 0 || mb_field_decoding_flag) && MbPartPredMode(mb_type, mbPartIdx) != Pred_L0 && !motion_prediction_flag_l1[mbPartIdx])		
ref_idx_l1[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if(MbPartPredMode (mb_type, mbPartIdx) != Pred_L1)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l0[mbPartIdx **][** 0 **][** compIdx **]**	2	se(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if(MbPartPredMode(mb_type, mbPartIdx) != Pred_L0)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l1[mbPartIdx **][** 0 **][** compIdx **]**	2	se(v) | ae(v)
}		
}		

G.7.3.6.2 Sub-macroblock prediction in scalable extension syntax

sub_mb_pred_in_scalable_extension(mb_type) {	C	Descriptor
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
sub_mb_type[mbPartIdx **]**	2	ue(v) | ae(v)
if(in_crop_window(CurrMbAddr) && adaptive_motion_prediction_flag) {		
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if(SubMbPredMode(sub_mb_type[mbPartIdx]) != Direct && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L1)		
motion_prediction_flag_l0[mbPartIdx]	2	u(1) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if(SubMbPredMode(sub_mb_type[mbPartIdx]) != Direct && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L0)		
motion_prediction_flag_l1[mbPartIdx]	2	u(1) | ae(v)
}		
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if((num_ref_idx_l0_active_minus1 > 0 || mb_field_decoding_flag) && mb_type != P_8x8ref0 && sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L1 && !motion_prediction_flag_l0[mbPartIdx])		
ref_idx_l0[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if((num_ref_idx_l1_active_minus1 > 0 || mb_field_decoding_flag) && sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L0 && !motion_prediction_flag_l1[mbPartIdx])		
ref_idx_l1[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if(sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L1)		
for(subMbPartIdx = 0; subMbPartIdx < NumSubMbPart(sub_mb_type[mbPartIdx]); subMbPartIdx++)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l0[mbPartIdx **][** subMbPartIdx **][** compIdx **]**	2	se(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if(sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L0)		
for(subMbPartIdx = 0; subMbPartIdx < NumSubMbPart(sub_mb_type[mbPartIdx]); subMbPartIdx++)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l1[mbPartIdx **][** subMbPartIdx **][** compIdx **]**	2	se(v) | ae(v)
}		

G.7.4 Semantics

Semantics associated with the syntax structures and syntax elements within these structures (in subclause G.7.3 and in subclause 7.3 by reference in G.7.3) are specified in this subclause and by reference to subclause 7.4. When the semantics of a syntax element are specified using a table or a set of tables, any values that are not specified in the table(s) shall not be present in the bitstream unless otherwise specified in this Recommendation | International Standard.

One or more sub-bitstreams may be derived from a bitstream conforming to one or more of the profiles specified in this annex. Sub-bitstreams that are derived according to the process specified in subclause G.8.8.1 conform to one or more of the profiles specified in Annex A or one or more of the profiles specified in this annex.

One or more sub-bitstreams conform to the profiles specified in Annex A. The decoding for these sub-bitstreams is specified in clauses 2-9 and Annexes B-E.

The decoding for bitstreams conforming to one or more of the profiles specified in this Annex is completely specified in this Annex with reference made to clauses 2-9 and Annexes B-E.

A specification or a process in clauses 2-9 and Annexes B-E may be used as is or by specifying assignments or alternative meanings of certain parts.

G.7.4.1 NAL unit semantics

The semantics for the syntax elements in subclause G.7.3.1 are specified in subclause 7.4.1. The following specifications additionally apply.

For NAL units with nal_unit_type equal to 14, nal_ref_idc shall be identical to nal_ref_idc of the associated NAL unit, which succeeds the NAL unit with nal_unit_type equal to 14 in decoding order.

The value of nal_ref_idc shall be identical for all VCL NAL units of a dependency representation.

The variable refNalRefIdc is derived as follows.

– When nal_unit_type is not equal to 20 or dependency_id is equal to the minimum value of dependency_id for all VCL NAL units of the access unit, refNalRefIdc is set equal to 0.

– Otherwise, refNalRefIdc is set equal to the maximum value of nal_ref_idc for all VCL NAL units of the access unit with a value of dependency_id less than the current value of dependency_id.

When refNalRefIdc is greater than 0, the value of nal_ref_idc shall not be equal to 0.

nal_ref_idc equal to 0 for a NAL unit containing a slice and having a value of dependency_id that is equal to the maximum value of dependency_id in the access unit indicates that all coded slice NAL units of the access unit are coded slice NAL units of a non-reference picture.

nal_ref_idc greater than 0 for a NAL unit containing a slice and having a value of dependency_id that is equal to the maximum value of dependency_id in the access unit indicates that all coded slice NAL units of the access unit are coded slice NAL units of a non-reference picture.

G.7.4.1.1 NAL unit header SVC extension semantics

The syntax elements idr_flag, priority_id, no_inter_layer_pred_flag, dependency_id, quality_id, temporal_id, use_ref_base_pic_flag, discardable_flag, and output_flag, when present in a prefix NAL unit, are considered to apply to the associated NAL unit.

reserved_one_bit shall be equal to 1. The value of reserved_one_bit may be specified by future extension of this Recommendation | International Standard. Decoders shall ignore the value of reserved_one_bit.

idr_flag equal to 1 specifies that the current access unit is an IDR access unit when the value of dependency_id for the NAL unit is equal to the maximum value of dependency_id for the access unit.

The value of idr_flag shall be the same for all NAL units of a dependency representation. For filler prefix NAL units, idr_flag shall be equal to 0. When idr_flag is equal to 1 for a VCL prefix NAL unit, the associated NAL unit shall have nal_unit_type equal to 5. When idr_flag is equal to 0 for a VCL prefix NAL unit, the associated NAL unit shall have nal_unit_type equal to 1.

When nal_ref_idc is equal to 0, the value of idr_flag shall be equal to 0.

For NAL units, in which idr_flag is present, the variable IdrPicFlag derived in subclause 7.4.1 is modified by setting it equal to idr_flag.

Let dIdMax be the maximum value of dependency_id in the NAL units of an access unit. An access unit is referred to as an IDR access unit when IdrPicFlag is equal to 1 for any NAL unit with dependency_id equal to dIdMax.

NOTE 1 – The classification of an access unit as IDR access unit and the partitioning of a sequence of access units in coded video sequences depends on the maximum present value of dependency_id in the associated NAL units. When NAL units are removed from a bitstream, e.g. in order to adjust the bitstream to the capabilities of a receiving device, the classification of access units as IDR access units and the partitioning of the sequence of access units into coded video sequences may change.

priority_id specifies a priority identifier for the NAL unit.

NOTE 2 – The syntax element priority_id is not required by the decoding process specified in this Recommendation | International Standard. The syntax element priority_id may be used as determined by the application within the specified constraints.

no_inter_layer_pred_flag specifies, when present in a coded slice NAL unit, whether inter-layer prediction may be used for decoding the coded slice. When no_inter_layer_pred_flag is equal to 1, inter-layer prediction is not used for

decoding the coded slice. When no_inter_layer_pred_flag is equal to 0, inter-layer prediction may or may not be used for decoding the coded slice as signalled in the macroblock layer.

For prefix NAL units, no_inter_layer_pred_flag shall be equal to 1. When nal_unit_type is equal to 20 and quality_id is greater than 0, no_inter_layer_pred_flag shall be equal to 0.

dependency_id specifies a dependency identifier for the NAL unit. dependency_id shall be equal to 0 in VCL prefix NAL units.

quality_id specifies a quality identifier for the NAL unit. quality_id shall be equal to 0 in VCL prefix NAL units.

The variable DQId is derived by

$$DQId = (dependency\_id << 4) + quality\_id \quad \text{(G-66)}$$

temporal_id specifies a temporal identifier for the NAL unit.

The value of temporal_id shall be the same for all prefix and coded slice in scalable extension NAL units of an access unit. When an access unit contains any NAL unit with nal_unit_type equal to 5 or idr_flag equal to 1, temporal_id shall be equal to 0.

The bitstream that would be obtained by invoking the bitstream extraction process as specified in subclause G.8.8.1 with pIdTarget equal to any value in the range of 0 to 63, inclusive, tIdTarget equal to any value in the range of 0 to 7, inclusive, dIdTarget equal to any value in the range of 0 to 7, inclusive, and qIdTarget equal to any value in the range of 0 to 15, inclusive, shall be conforming to this Recommendation | International Standard.

NOTE 3 – A conforming bitstream contains one or more coded slice NAL units with priority_id equal to 0, dependency_id equal to 0, quality_id equal to 0, and temporal_id equal to 0.

use_ref_base_pic_flag equal to 1 specifies that reference base pictures are used as reference pictures for the inter prediction process. use_ref_base_pic_flag equal to 0 specifies that decoded pictures are used as reference pictures during the inter prediction process.

The values of use_ref_base_pic_flag shall be the same for all NAL units of a dependency representation. use_ref_base_pic_flag shall be equal to 0 in filler prefix NAL units.

discardable_flag equal to 1 specifies that the current NAL unit is not used for decoding NAL units of the current access unit and all subsequent access units that have a greater value of dependency_id than the current NAL unit. discardable_flag equal to 0 specifies that the current NAL unit may be used for decoding NAL units of the current access unit and all subsequent access units that have a greater value of dependency_id than the current NAL unit.

discardable_flag shall be equal to 1 in filler prefix NAL units.

output_flag affects the decoded picture output and removal processes as specified in Annex C. The value of output_flag shall be the same for all NAL units of a dependency representation. The value of output_flag shall be the same for both fields of a complementary field pair.

output_flag shall be equal to 0 in filler prefix NAL units.

reserved_three_2bits shall be equal to 3. The values of reserved_three_2bits may be specified by future extension of this Recommendation | International Standard. Decoders shall ignore the value of reserved_three_2bits.

G.7.4.1.2 Order of NAL units and association to coded pictures, access units, and video sequences

This subclause specifies constraints on the order of NAL units in the bitstream. Any order of NAL units in the bitstream obeying these constraints is referred to in the text as the decoding order of NAL units. Within a NAL unit, the syntax in subclauses 7.3, D.1, E.1, G.7.3, G.13.1, and G.14.1 specifies the decoding order of syntax elements. Decoders conforming to this Recommendation | International Standard shall be capable of receiving NAL units and their syntax elements in decoding order.

G.7.4.1.2.1 Order of SVC sequence parameter set RBSPs and picture parameter set RBSPs and their activation

NOTE 1 – The sequence and picture parameter set mechanism decouples the transmission of infrequently changing information from the transmission of coded macroblock data. Sequence and picture parameter sets may, in some applications, be conveyed "out-of-band" using a reliable transport mechanism.

A picture parameter set RBSP includes parameters that can be referred to by the coded slice NAL units of one or more layer representations of one or more coded pictures.

Each picture parameter set RBSP is initially considered not active at the start of the operation of the decoding process. At most one picture parameter set RBSP is considered as the active picture parameter set RBSP at any given moment during the operation of the decoding process, and when any particular picture parameter set RBSP becomes the active picture parameter set RBSP, the previously-active picture parameter set RBSP (if any) is deactivated.

In addition to the active picture parameter set RBSP, zero or more picture parameter set RBSPs may be specifically active for layer representations (with a particular value of DQId less than DQIdMax) that are referred to through inter-layer prediction in decoding the target layer representation. Such a picture parameter set RBSP is referred to as active layer picture parameter set RBSP for the particular value of DQId (less than DQIdMax). The restrictions on active picture parameter set RBSPs also apply to active layer picture parameter set RBSPs with a particular value of DQId.

When a picture parameter set RBSP (with a particular value of pic_parameter_set_id) is not the active picture parameter set RBSP and it is referred to by a coded slice NAL unit with DQId equal to DQIdMax (using that value of pic_parameter_set_id), it is activated. This picture parameter set RBSP is called the active picture parameter set RBSP until it is deactivated when another picture parameter set RBSP becomes the active picture parameter set RBSP. A picture parameter set RBSP, with that particular value of pic_parameter_set_id, shall be available to the decoding process prior to its activation.

When a picture parameter set RBSP (with a particular value of pic_parameter_set_id) is not the active layer picture parameter set for a particular value of DQId less than DQIdMax and it is referred to by a coded slice NAL unit with the particular value of DQId (using that value of pic_parameter_set_id), it is activated for layer representations with the particular value of DQId. This picture parameter set RBSP is called the active layer picture parameter set RBSP for the particular value of DQId until it is deactivated when another picture parameter set RBSP becomes the active layer picture parameter set RBSP for the particular value of DQId or when decoding an access unit with DQIdMax less than or equal to the particular value of DQId. A picture parameter set RBSP, with that particular value of pic_parameter_set_id, shall be available to the decoding process prior to its activation.

Any picture parameter set NAL unit containing the value of pic_parameter_set_id for the active picture parameter set RBSP shall have the same content as that of the active picture parameter set RBSP unless it follows the last VCL NAL unit of a coded picture and precedes the first VCL NAL unit of another coded picture. Any picture parameter set NAL unit containing the value of pic_parameter_set_id for the active layer picture parameter set RBSP for a particular value of DQId less than DQIdMax shall have the same content as that of the active layer picture parameter set RBSP for the particular value of DQId unless it follows the last VCL NAL unit of a coded picture and precedes the first VCL NAL unit of another coded picture.

An SVC sequence parameter set RBSP includes parameters that can be referred to by one or more picture parameter set RBSPs or one or more SEI NAL units containing a buffering period SEI message.

Each SVC sequence parameter set RBSP is initially considered not active at the start of the operation of the decoding process. At most one SVC sequence parameter set RBSP is considered as the active SVC sequence parameter set RBSP at any given moment during the operation of the decoding process, and when any particular SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP, the previously-active SVC sequence parameter set RBSP (if any) is deactivated.

In addition to the active SVC sequence parameter set RBSP, zero or more SVC sequence parameter set RBSPs may be specifically active for layer representations (with a particular value of DQId less than DQIdMax) that are referred to through inter-layer prediction in decoding the target layer representation. Such an SVC sequence parameter set RBSP is referred to as active layer SVC sequence parameter set RBSP for the particular value of DQId (less than DQIdMax). The restrictions on active SVC sequence parameter set RBSPs also apply to active layer SVC sequence parameter set RBSPs with a particular value of DQId.

When a sequence parameter set RBSP (nal_unit_type is equal to 7) with a particular value of seq_parameter_set_id is not already the active SVC sequence parameter set RBSP and it is referred to by activation of a picture parameter set RBSP (using that value of seq_parameter_set_id) and the picture parameter set RBSP is activated by a coded slice NAL unit with DQId equal to DQIdMax (the picture parameter set RBSP becomes the active picture parameter set RBSP) and nal_unit_type equal to 1 or 5, it is activated. This sequence parameter set RBSP, is called the active SVC sequence parameter set RBSP until it is deactivated when another SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP. A sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

When a sequence parameter set RBSP (nal_unit_type is equal to 7) with a particular value of seq_parameter_set_id is not already the active SVC sequence parameter set RBSP and it is referred to by an SEI NAL unit containing a buffering period SEI message (using that value of seq_parameter_set_id) that is not included in a scalable nesting SEI message and represents the last buffering period SEI message in decoding order in the access unit and DQIdMax is equal to 0, it is activated. This sequence parameter set RBSP is called the active SVC sequence parameter set RBSP until it is deactivated when another SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP. A sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

When a subset sequence parameter set RBSP (nal_unit_type is equal to 15) with a particular value of seq_parameter_set_id is not already the active SVC sequence parameter set RBSP and it is referred to by activation of a picture parameter set RBSP (using that value of seq_parameter_set_id) and the picture parameter set RBSP is activated

by a coded slice in scalable extension NAL unit (nal_unit_type is equal to 20) with DQId equal to DQIdMax (the picture parameter set RBSP becomes the active picture parameter set RBSP), it is activated. This subset sequence parameter set RBSP is called the active SVC sequence parameter set RBSP until it is deactivated when another SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP. A subset sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

When a subset sequence parameter set RBSP (nal_unit_type is equal to 15) with a particular value of seq_parameter_set_id is not already the active SVC sequence parameter set RBSP and it is referred to by an SEI NAL unit containing a buffering period SEI message (using that value of seq_parameter_set_id) that is included in a scalable nesting SEI message and represents the last buffering period SEI message in decoding order in the access unit that is associated with a value of DQId in the range of ((DQIdMax >> 4) << 4) to (((DQIdMax >> 4) << 4) + 15), inclusive, it is activated. This subset sequence parameter set RBSP, is called the active SVC sequence parameter set RBSP until it is deactivated when another SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP. A subset sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

NOTE 2 – The active SVC sequence parameter set RBSP is either a sequence parameter set RBSP or a subset sequence parameter set RBSP. Sequence parameter set RBSPs are activated by coded slice NAL units with nal_unit_type equal to 1 or 5 or buffering period SEI messages that are not included in a scalable nesting SEI message. Subset sequence parameter sets are activated by coded slice in scalable extension NAL units (nal_unit_type equal to 20) or buffering period SEI messages that are included in a scalable nesting SEI message. A sequence parameter set RBSP and a subset sequence parameter set RBSP may have the same value of seq_parameter_set_id.

For the following specification, the activating buffering period SEI message is specified as follows.

– If DQIdMax is less than 16 and the access unit contains one or more buffering period SEI messages and the last of these buffering period SEI messages in decoding order is not included in a scalable nesting SEI message, then this last buffering period SEI message is the activating buffering period SEI message.

– Otherwise, if the access unit contains one or more buffering period SEI messages that are included in a scalable nesting SEI message and are associated with a values of DQId in the range of ((DQIdMax >> 4) << 4) to (((DQIdMax >> 4) << 4) + 15), inclusive, then the last of these buffering period SEI messages in decoding order is the activating buffering period SEI message.

– Otherwise, the access unit does not contain an activating buffering period SEI message.

When an SVC sequence parameter set RBSP is referred to by activation of a picture parameter set RBSP inside a particular access unit and this picture parameter set RBSP is activated by a coded slice NAL unit with DQId equal to DQIdMax (the picture parameter set RBSP becomes the active picture parameter set RBSP) and this particular access unit also contains an activating buffering period SEI message that refers to an SVC sequence parameter set RBSP that is different then the SVC sequence parameter set RBSP referred to by the activation of the picture parameter set RBSP, then the SVC sequence parameter set RBSP that is referred to by the activating buffering period SEI message becomes the active SVC sequence parameter set.

NOTE 3 – Buffering period SEI messages have a higher priority for activating SVC sequence parameter sets then coded slice NAL units.

NOTE 4 – Compared to the specifications for profiles specified in Annex A, where an activated sequence parameter set RBSP must remain active for the entire coded video sequence, the specification for profiles specified in this annex differs. When an SVC sequence parameter set RBSP is already active (as the active SVC sequence parameter set RBSP), another SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP in a non-IDR access unit when it is referred to by an activating buffering period SEI message or by the activation of a picture parameter set RBSP (as the active picture parameter set RBSP). In this case, the contents of the de-activated and activated SVC sequence parameter set RBSP are mutually restricted as described below. Hence, within a coded video sequence, multiple successively activated/de-activated SVC sequence parameter set RBSPs can be present.

When a sequence parameter set RBSP (nal_unit_type is equal to 7) with a particular value of seq_parameter_set_id is not already the active layer SVC sequence parameter set RBSP for a particular value of DQId and it is referred to by activation of a picture parameter set RBSP (using that value of seq_parameter_set_id) and the picture parameter set RBSP is activated by a coded slice NAL unit with DQId less than DQIdMax (the picture parameter set RBSP becomes the active layer picture parameter set RBSP for the particular value of DQId) and nal_unit_type equal to 1 or 5, it is activated for the layer representation with the particular value of DQId. This sequence parameter set RBSP is called the active layer SVC sequence parameter set RBSP for the particular value of DQId until it is deactivated when another SVC sequence parameter set RBSP becomes the active layer SVC sequence parameter set RBSP for the particular value of DQId or when decoding an access unit with DQIdMax less than or equal to the particular value of DQId. A sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

When a subset sequence parameter set RBSP (nal_unit_type is equal to 15) with a particular value of seq_parameter_set_id is not already the active layer SVC sequence parameter set RBSP for a particular value of DQId and it is referred to by activation of a picture parameter set RBSP (using that value of seq_parameter_set_id) and the picture parameter set RBSP is activated by a coded slice NAL unit with DQId less than DQIdMax (the picture parameter set RBSP becomes the active layer picture parameter set RBSP for the particular value of DQId) and nal_unit_type equal to 20, it is activated for the layer representation with the particular value of DQId. This subset sequence parameter set RBSP is called the active layer SVC sequence parameter set RBSP for the particular value of DQId until it is deactivated when another SVC sequence parameter set RBSP becomes the active layer SVC sequence parameter set RBSP for the particular value of DQId or when decoding an access unit with DQIdMax less than or equal to the particular value of DQId. A subset sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

A sequence parameter set RBSP or a subset sequence parameter set RBSP that includes a value of profile_idc not specified in Annex A or Annex G shall not be referred to by activation of a picture parameter set RBSP as the active picture parameter set RBSP or as active layer picture parameter set RBSP (using that value of seq_parameter_set_id) or referred to by an SEI NAL unit containing a buffering period SEI message (using that value of seq_parameter_set_id). A sequence parameter set RBSP or a subset sequence parameter set RBSP including a value of profile_idc not specified in Annex A or Annex G is ignored in the decoding for profiles specified in Annex A or Annex G.

An SVC sequence parameter set RBSP (SPSB) that becomes the active SVC sequence parameter set RBSP in a non-IDR access unit is restricted with regards to its contents compared to the SVC sequence parameter set RBSP that it deactivates (SPSA) as specified in the following.

– The values of the syntax elements in the seq_parameter_set_data( ) syntax structure of SPSA and SPSB may only differ for the syntax elements profile_idc, constraint_setX_flag (with X being equal to 0 to 3, inclusive), level_idc, seq_parameter_set_id, and the hrd_parameters( ) syntax structure and shall be the same otherwise.

– When the seq_parameter_set_svc_extension( ) syntax structure is present in both SPSA and SPSB, the values of all syntax elements in the seq_parameter_set_svc_extension( ) syntax structure shall be the same.

For each particular value of DQId, the SVC sequence parameter set RBSPs that are active layer SVC sequence parameter set RBPSs for the particular value of DQId in any access unit inside a coded video sequence are restricted with regards to their contents. The values of the syntax elements in these SVC sequence parameter set RBSPs (for the particular value of DQId) may only differ for the syntax elements profile_idc, constraint_setX_flag (with X being equal to 0 to 3, inclusive), level_idc, and the hrd_parameters( ) syntax structure and shall be the same otherwise.

The active layer SVC sequence parameter set RBSPs for different values of DQId may be the same SVC sequence parameter set RBSP. The active SVC sequence parameter set RBSP and an active layer SVC sequence parameter set RBSP for a particular value of DQId may be the same SVC sequence parameter set RBSP.

When the active SVC sequence parameter set RBSP is a sequence parameter set RBSP, any sequence parameter set RBSP with the value of seq_parameter_set_id for the active SVC sequence parameter set RBSP shall have the same content as that of the active SVC sequence parameter set RBSP unless it follows the last access unit of a coded video sequence and precedes the first VCL NAL unit and the first SEI NAL unit containing a buffering period SEI message (when present) of another coded video sequence.

When the active SVC sequence parameter set RBSP is a subset sequence parameter set RBSP, any subset sequence parameter set RBSP with the value of seq_parameter_set_id for the active SVC sequence parameter set RBSP shall have the same content as that of the active SVC sequence parameter set RBSP unless it follows the last access unit of a coded video sequence and precedes the first VCL NAL unit and the first SEI NAL unit containing a buffering period SEI message (when present) of another coded video sequence.

For each particular value of DQId, the following applies.

– When the active layer SVC sequence parameter set RBSP is a sequence parameter set RBSP, any sequence parameter set RBSP with the value of seq_parameter_set_id for the active layer SVC sequence parameter set RBSP shall have the same content as that of the active layer SVC sequence parameter set RBSP unless it follows the last access unit of a coded video sequence and precedes the first VCL NAL unit of another coded video sequence.

– When the active layer SVC sequence parameter set RBSP is a subset sequence parameter set RBSP, any subset sequence parameter set RBSP with the value of seq_parameter_set_id for the active layer SVC sequence parameter set RBSP shall have the same content as that of the active layer SVC sequence parameter set RBSP unless it follows the last access unit of a coded video sequence and precedes the first VCL NAL unit of another coded video sequence.

NOTE 5 – If picture parameter set RBSP or sequence parameter set RBSP are conveyed within the bitstream, these constraints impose an order constraint on the NAL units that contain the picture parameter set RBSP or sequence parameter set RBSP,

respectively. Otherwise (picture parameter set RBSP or sequence parameter set RBSP are conveyed by other means not specified in this Recommendation | International Standard), they must be available to the decoding process in a timely fashion such that these constraints are obeyed.

When present, a sequence parameter set extension RBSP includes parameters having a similar function to those of a sequence parameter set RBSP. For purposes of establishing constraints on the syntax elements of the sequence parameter set extension RBSP and for purposes of determining activation of a sequence parameter set extension RBSP, the sequence parameter set extension RBSP shall be considered part of the preceding sequence parameter set RBSP with the same value of seq_parameter_set_id. When a sequence parameter set RBSP is present that is not followed by a sequence parameter set extension RBSP with the same value of seq_parameter_set_id prior to the activation of the sequence parameter set RBSP, the sequence parameter set extension RBSP and its syntax elements shall be considered not present for the active sequence parameter set RBSP. The contents of sequence parameter set extension RBSPs only apply when the base layer, which conforms to one or more of the profiles specified in Annex A, of a coded video sequence conforming to one or more profiles specified in Annex G is decoded. Subset sequence parameter set RBSPs shall not be followed by a sequence parameter set extension RBSP.

NOTE 6 – Sequence parameter sets extension RBSPs are not considered to be part of a subset sequence parameter set RBSP and subset sequence parameter set RBSPs shall not be followed by a sequence parameter set extension RBSP.

For layer representations with DQId equal to DQIdMax, all constraints that are expressed on the relationship between the values of the syntax elements (and the values of variables derived from those syntax elements) in SVC sequence parameter sets and picture parameter sets and other syntax elements are expressions of constraints that apply only to the active SVC sequence parameter set and the active picture parameter set. For layer representations with a particular value of DQId less than DQIdMax, all constraints that are expressed on the relationship between the values of the syntax elements (and the values of variables derived from those syntax elements) in SVC sequence parameter sets and picture parameter sets and other syntax elements are expressions of constraints that apply only to the active layer SVC sequence parameter set and the active layer picture parameter set for the particular value of DQId. If any SVC sequence parameter set RBSP having profile_idc equal to one of the profile_idc values specified in Annex A or Annex G is present that is never activated in the bitstream (i.e., it never becomes the active SVC sequence parameter set or an active layer SVC sequence parameter set), its syntax elements shall have values that would conform to the specified constraints if it were activated by reference in an otherwise-conforming bitstream. If any picture parameter set RBSP is present that is never ever activated in the bitstream (i.e., it never becomes the active picture parameter set or an active layer picture parameter set), its syntax elements shall have values that would conform to the specified constraints if it were activated by reference in an otherwise-conforming bitstream.

During operation of the decoding process (see clause G.8), for layer representations with DQId equal to DQIdMax, the values of parameters of the active picture parameter set and the active SVC sequence parameter set shall be considered in effect. For layer representations with a particular value of DQId less than DQIdMax, the values of the parameters of the active layer picture parameter set and the active layer SVC sequence parameter set for the particular value of DQId shall be considered in effect. For interpretation of SEI messages that apply to access unit or dependency representations with dependency_id equal to DependencyIdMax or layer representation with DQId equal to DQIdMax, the values of the parameters of the picture parameter set and SVC sequence parameter set that are the active picture parameter set and the active SVC sequence parameter set, respectively, for the operation of the decoding process for the VCL NAL units of the primary coded picture in the same access unit shall be considered in effect unless otherwise specified in the SEI message semantics. For interpretation of SEI messages that apply to dependency representations with a particular value of dependency_id less than DependencyIdMax, the values of the parameters of the picture parameter set and SVC sequence parameter set that are the active layer picture parameter set and the active layer SVC sequence parameter set, respectively, for the operation of the decoding process for the VCL NAL units of the layer representation with DQId equal to (dependency_id << 4) in the same access unit shall be considered in effect unless otherwise specified in the SEI message semantics. For interpretation of SEI messages that apply to layer representations with a particular value of DQId less than DQIdMax, the values of the parameters of the picture parameter set and SVC sequence parameter set that are the active layer picture parameter set and the active layer SVC sequence parameter set, respectively, for the operation of the decoding process for the VCL NAL units of the layer representation with the particular value of DQId in the same access unit shall be considered in effect unless otherwise specified in the SEI message semantics.

G.7.4.1.2.2 Order of access units and association to coded video sequences

The specification of subclause 7.4.1.2.2 applies with the following modifications.

The first access unit of the bitstream shall only contain coded slice NAL units with nal_unit_type equal to 5 or idr_flag equal to 1.

The order of NAL units and coded pictures and their association to access units is described in subclause G.7.4.1.2.3.

G.7.4.1.2.3 Order of NAL units and coded pictures and association to access units

The specification of subclause 7.4.1.2.3 applies with the following modifications.

The association of VCL NAL units to primary or redundant coded pictures is specified in subclause G.7.4.1.2.5.

The constraints for the detection of the first VCL NAL unit of a primary coded picture are specified in subclause G.7.4.1.2.4.

The constraint expressed in subclause 7.4.1.2.3 on the order of a buffering period SEI message is replaced by the following constraints.

– When an SEI NAL unit containing a buffering period SEI message is present, the following applies.

  – If the buffering period SEI message is the only buffering period SEI message in the access unit and it is not included in a scalable nesting SEI message, the buffering period SEI message shall be the first SEI message payload of the first SEI NAL unit in the access unit.

  – Otherwise (the buffering period SEI message is not the only buffering period SEI message in the access unit or it is included in a scalable nesting SEI message), the following applies.

    – When a buffering period SEI message that is not included in a scalable nesting SEI message is present, this buffering period SEI message shall be the only SEI message payload of the first SEI NAL unit in the access unit.

    – A scalable nesting SEI message that includes a buffering period SEI message shall not include any other SEI messages and the scalable nesting SEI message that includes a buffering period SEI message shall be the only SEI message inside an SEI NAL unit.

    – All SEI NAL units that precede an SEI NAL unit that contains a scalable nesting SEI message with a buffering period SEI message as payload in an access unit shall only contain buffering period SEI messages or scalable nesting SEI messages with a buffering period SEI message as payload.

    – When present, a scalable nesting SEI message with all_layer_representations_in_au_flag equal to 1 and a buffering period SEI message as payload shall be the first scalable nesting SEI message in an access unit.

    – Any scalable nesting SEI messages that precedes a particular scalable nesting SEI message with particular values of sei_dependency_id[i] and sei_quality_id[i] and a buffering period SEI message as payload shall have values (sei_dependency_id[i] << 4) + sei_quality_id[i] for all present i that are less than any of the particular values (sei_dependency_id[i] << 4) + sei_quality_id[i] for the particular scalable nesting SEI message with a buffering period SEI message as payload.

The following additional constraints shall be obeyed.

– Each NAL unit with nal_unit_type equal to 1, 5 or 12 shall be immediately preceded by a prefix NAL unit.

– Each prefix NAL unit shall be immediately followed by a NAL unit with nal_unit_type equal to 1, 5, or 12.

G.7.4.1.2.4 Detection of the first VCL NAL unit of a primary coded picture

This subclause specifies constraints on VCL NAL unit syntax that are sufficient to enable the detection of the first VCL NAL unit of each primary coded picture.

The first VCL NAL unit of the primary coded picture of the current access unit, in decoding order, shall be different from the last VCL NAL unit of the primary coded picture of the previous access unit, in decoding order, in one or more of the following ways.

– dependency_id of the first VCL NAL unit of the primary coded picture of the current access unit is smaller than dependency_id of the last VCL NAL unit of the primary coded picture of the previous access unit

– dependency_id of the first VCL NAL unit of the primary coded picture of the current access unit is equal to dependency_id of the last VCL NAL unit of the primary coded picture of the previous access unit and any of the following conditions is true

  – quality_id of the first VCL NAL unit of the primary coded picture of the current access unit is smaller than quality_id of the last VCL NAL unit of the primary coded picture of the previous access unit

  – quality_id of the first VCL NAL unit of the primary coded picture of the current access unit and the last VCL NAL unit of the primary coded picture of the previous access unit is equal to 0, and any of the conditions specified in subclause 7.4.1.2.4 is fulfilled

G.7.4.1.2.5 Order of VCL NAL units and association to coded pictures

Each VCL NAL unit is part of a coded picture.

Let dId be the value of dependency_id and let qId be the value of quality_id of any particular VCL NAL unit. The order of the VCL NAL units within a coded picture is constrained as follows.

– For all VCL NAL units following this particular VCL NAL unit, the value of dependency_id shall be greater than or equal to dId.

– For all VCL NAL units with a value of dependency_id equal to dId following this particular VCL NAL unit, the value of quality_id shall be greater than or equal to qId.

For each set of VCL NAL units within a layer representation, the following applies.

– If arbitrary slice order, as specified in Annex A or subclause G.10, is allowed, coded slice NAL units of a layer representation may have any order relative to each other.

– Otherwise (arbitrary slice order is not allowed), coded slice NAL units of a slice group shall not be interleaved with coded slice NAL units of another slice group and the order of coded slice NAL units within a slice group shall be in the order of increasing macroblock address for the first macroblock of each coded slice NAL unit of the same slice group.

NAL units having nal_unit_type equal to 12 may be present in the access unit but shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

NAL units having nal_unit_type equal to 0 or in the range of 24 to 31, inclusive, which are unspecified, may be present in the access unit but shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

NAL units having nal_unit_type in the range of 21 to 23, inclusive, which are reserved, shall not precede the first VCL NAL unit of the primary coded picture within the access unit (when specified in the future by ITU-T | ISO/IEC).

G.7.4.2 Raw byte sequence payloads and RBSP trailing bits semantics

G.7.4.2.1 Sequence parameter set RBSP semantics

The semantics specified in subclause 7.4.2.1 apply.

G.7.4.2.1.1 Sequence parameter set data semantics

The semantics specified in subclause 7.4.2.1.1 apply with substituting SVC sequence parameter set for sequence parameter set. All constraints specified in subclause 7.4.2.1.1 apply only to the layer representations for which the SVC sequence parameter set is the active SVC sequence parameter set or the active layer SVC sequence parameter set as specified in subclause G.7.4.1.2.1. Additionally, the following applies.

constraint_set0_flag specifies the following.

– If the sequence parameter set data syntax structure is included in a sequence parameter set RBSP, the semantics specified in subclause 7.4.2.1.1 apply.

– Otherwise (the sequence parameter set data syntax structure is included in a subset sequence parameter set RBSP), contraint_set0_flag specifies that the coded video sequence obeys all constraints specified in subclause G.10.1.1. constraint_set0_flag equal to 0 specifies that the coded video sequence may or may not obey all constraints specified in subclause G.10.1.1.

constraint_set1_flag specifies the following.

– If the sequence parameter set data syntax structure is included in a sequence parameter set RBSP, the semantics specified in subclause 7.4.2.1.1 apply.

– Otherwise (the sequence parameter set data syntax structure is included in a subset sequence parameter set RBSP), contraint_set1_flag specifies that the coded video sequence obeys all constraints specified in subclause G.10.1.2. constraint_set1_flag equal to 0 specifies that the coded video sequence may or may not obey all constraints specified in subclause G.10.1.2.

constraint_set2_flag specifies the following.

– If the sequence parameter set data syntax structure is included in a sequence parameter set RBSP, the semantics specified in subclause 7.4.2.1.1 apply.

– Otherwise (the sequence parameter set data syntax structure is included in a subset sequence parameter set RBSP), the value of 1 for constraint_set2_flag is reserved for future use by ITU-T | ISO/IEC. constraint_set2_flag shall be equal to 0 for coded video sequences with profile_idc equal to 83 and 86 in bitstreams conforming to this

Recommendation | International Standard. Decoders conforming to this Recommendation | International Standard shall ignore the value of constraint_set2_flag when profile_idc is equal to 83 or 86.

constraint_set3_flag specifies the following.

– If the sequence parameter set data syntax structure is included in a sequence parameter set RBSP, the semantics specified in subclause 7.4.2.1.1 apply.

– Otherwise (the sequence parameter set data syntax structure is included in a subset sequence parameter set RBSP), the following applies.

  – If profile_idc is equal to 86, constraint_set3_flag equal to 1 specifies that the coded video sequence obeys all constraints specified in subclause G.10.1.3, and constraint_set3_flag equal to 0 specifies that the coded video sequence may or may not obey these corresponding constraints.

  – Otherwise (profile_idc is not equal to 86), the value of 1 for constraint_set3_flag is reserved for future use by ITU-T | ISO/IEC. constraint_set3_flag shall be equal to 0 for coded video sequences with profile_idc not equal to 86 in bitstreams conforming to this Recommendation | International Standard. Decoders conforming to this Recommendation | International Standard shall ignore the value of constraint_set3_flag when profile_idc is not equal to 86.

The value of separate_colour_plane_flag shall be equal to 0 and the value of qpprime_y_zero_transform_bypass_flag shall be equal to 0.

When the value of profile_idc does not indicate conformance to any of the profiles specified in Annex A and vui_parameters_present_flag is equal to 1, timing_info_present_flag shall be equal to 0, nal_hrd_parameters_present_flag shall be equal to 0, vcl_hrd_parameters_present_flag shall be equal to 0, and pic_struct_present_flag shall be equal to 0.

When the value of profile_idc does indicate conformance to one or more of the profiles specified in Annex A and vui_parameters_present_flag is equal to 1, the values of timing_info_present_flag, num_units_in_tick, time_scale, fixed_frame_rate_flag, nal_hrd_parameters_present_flag, vcl_hrd_parameters_present_flag, low_delay_hrd_flag, pic_struct_present_flag and the values of syntax elements included in the hrd_parameters( ) syntax structures, when present, shall be such that the bitstream activating the sequence parameter set is conforming to one or more of the profiles specified in Annex A.

G.7.4.2.1.1.1 Scaling list semantics

The semantics specified in subclause 7.4.2.1.1.1 apply.

G.7.4.2.1.2 Sequence parameter set extension RBSP semantics

The semantics specified in subclause 7.4.2.1.2 apply. Additionally, the following applies.

Sequence parameter set extension RBSPs can only follow sequence parameter set RBSPs in decoding order. Subset sequence parameter set RBSPs shall not be followed by a sequence parameter set extension RBSP. The contents of sequence parameter set extension RBSPs only apply when the base layer, which conforms to one or more of the profiles specified in Annex A, of a coded video sequence conforming to one or more profiles specified in Annex G is decoded.

G.7.4.2.1.3 Subset sequence parameter set RBSP semantics

svc_vui_parameters_present_flag equal to 0 indicates that the syntax structure svc_vui_parameters_extensions( ) is not present. svc_vui_parameters_present_flag equal to 1 indicates that the syntax structure svc_vui_parameters_extensions( ) is present.

additional_extension2_flag shall be equal to 0. The value of 1 for additional_extension2_flag is reserved for future use by ITU-T | ISO/IEC.

additional_extension2_data_flag may have any value. It shall not affect the conformance to profiles specified in Annex A or Annex G.

G.7.4.2.1.4 Sequence parameter set SVC extension semantics

inter_layer_deblocking_filter_control_present_flag equal to 1 specifies that a set of syntax elements controlling the characteristics of the deblocking filter for inter-layer prediction is present in the slice header. inter_layer_deblocking_filter_control_present_flag equal to 0 specifies that the set of syntax elements controlling the characteristics of the deblocking filter for inter-layer prediction is not present in the slice headers and their inferred values are in effect.

extended_spatial_scalability specifies the presence of syntax elements related to geometrical parameters for the resampling processes. The value of extended_spatial_scalability shall be in the range of 0 to 2, inclusive. When

extended_spatial_scalability is equal to 0, no geometrical parameters are present in the subset sequence parameter set and the slice headers referring to this subset sequence parameter set. When extended_spatial_scalability is equal to 1, geometrical parameters are present in the subset sequence parameter set, but not in the slice headers referring to this subset sequence parameter set. When extended_spatial_scalability is equal to 2, geometrical parameters are not present in the subset sequence parameter set, but they are present in the slice headers referring to this subset sequence parameter set.

chroma_phase_x_plus1_flag specifies the horizontal phase shift of the chroma components in units of half luma samples of a frame or layer frame. When chroma_phase_x_plus1_flag is not present, it shall be inferred to be equal to 1.

When chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are present, the following applies.

– If chroma_phase_x_plus1_flag is equal to 0, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should be equal to 0, 2, or 4.

– Otherwise (chroma_phase_x_plus1_flag is equal to 1), chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should be equal to 1, 3, or 5.

chroma_phase_y_plus1 specifies the vertical phase shift of the chroma components in units of half luma samples of a frame or layer frame. When chroma_phase_y_plus1 is not present, it shall be inferred to be equal to 1. The value of chroma_phase_y_plus1 shall be in the range of 0 to 2, inclusive.

When chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are present, the following applies.

– If chroma_phase_y_plus1 is equal to 0, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should be equal to 2 or 3.

– Otherwise, if chroma_phase_y_plus1 is equal to 1, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should be equal to 0 or 1.

– Otherwise (chroma_phase_y_plus1 is equal to 2), chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should be equal to 4 or 5.

seq_ref_layer_chroma_phase_x_plus1_flag specifies the horizontal phase shift of the chroma components in units of half luma samples of a layer frame for the layer pictures that may be used for inter-layer prediction. When seq_ref_layer_chroma_phase_x_plus1_flag is not present, it shall be inferred to be equal to chroma_phase_x_plus1_flag.

seq_ref_layer_chroma_phase_y_plus1 specifies the vertical phase shift of the chroma components in units of half luma samples of a layer frame for the layer pictures that may be used for inter-layer prediction. When seq_ref_layer_chroma_phase_y_plus1 is not present, it shall be inferred to be equal to chroma_phase_y_plus1. The value of seq_ref_layer_chroma_phase_y_plus1 shall be in the range of 0 to 2, inclusive.

seq_scaled_ref_layer_left_offset specifies the horizontal offset between the upper-left luma sample of a resampled layer picture used for inter-layer prediction and the upper-left luma sample of the current picture or current layer picture in units of two luma samples. When seq_scaled_ref_layer_left_offset is not present, it shall be inferred to be equal to 0.

seq_scaled_ref_layer_top_offset specifies the vertical offset between the upper-left luma sample of an resampled layer picture used for inter-layer prediction and the upper-left luma sample of the current picture or current layer picture. The vertical offset is specified in units of two luma samples when frame_mbs_only_flag is equal to 1, and it is specified in units of four luma samples when frame_mbs_only_flag is equal to 0. When seq_scaled_ref_layer_top_offset is not present, it shall be inferred to be equal to 0.

seq_scaled_ref_layer_right_offset specifies the horizontal offset between the bottom-right luma sample of an resampled layer picture used for inter-layer prediction and the bottom-right luma sample of the current picture or current layer picture in units of two luma samples. When seq_scaled_ref_layer_right_offset is not present, it shall be inferred to be equal to 0.

seq_scaled_ref_layer_bottom_offset specifies the vertical offset between the bottom-right luma sample of an resampled layer picture used for inter-layer prediction and the bottom-right luma sample of the current picture or current layer picture. The vertical offset is specified in units of two luma samples when frame_mbs_only_flag is equal to 1, and it is specified in units of four luma samples when frame_mbs_only_flag is equal to 0. When seq_scaled_ref_layer_bottom_offset is not present, it shall be inferred to be equal to 0.

seq_tcoeff_level_prediction_flag specifies the presence of the syntax element adaptive_tcoeff_level_prediction_flag in the subset sequence parameter set.

adaptive_tcoeff_level_prediction_flag specifies the presence of tcoeff_level_prediction_flag in the slice headers that refer to the subset sequence parameter set. When adaptive_tcoeff_level_prediction_flag is not present, it shall be inferred to be equal to 0.

slice_header_restriction_flag specifies the presence of the syntax elements in the slice headers that refer to the subset sequence parameter set.

G.7.4.2.2 Picture parameter set RBSP semantics

The semantics specified in subclause 7.4.2.2 apply with substituting SVC sequence parameter set for sequence parameter set. All constraints specified in subclause 7.4.2.2 apply only to the layer representations for which the picture parameter set is the active picture parameter set or the active layer picture parameter set as specified in subclause G.7.4.1.2.1.

G.7.4.2.3 Supplemental enhancement information RBSP semantics

The semantics specified in subclause 7.4.2.3 apply.

G.7.4.2.3.1 Supplemental enhancement information message semantics

The semantics specified in subclause 7.4.2.3.1 apply.

G.7.4.2.4 Access unit delimiter RBSP semantics

The semantics specified in subclause 7.4.2.4 apply.

G.7.4.2.5 End of sequence RBSP semantics

The semantics specified in subclause 7.4.2.5 apply.

G.7.4.2.6 End of stream RBSP semantics

The semantics specified in subclause 7.4.2.6 apply.

G.7.4.2.7 Filler data RBSP semantics

The semantics specified in subclause 7.4.2.7 apply.

G.7.4.2.8 Slice layer without partitioning RBSP semantics

The semantics specified in subclause 7.4.2.8 apply.

G.7.4.2.9 Slice data partition RBSP semantics

Slice data partition syntax is not present in bitstreams conforming to one or more of the profiles specified in Annex G.

G.7.4.2.10 RBSP slice trailing bits semantics

The semantics specified in subclause 7.4.2.10 apply.

G.7.4.2.11 RBSP trailing bits semantics

The semantics specified in subclause 7.4.2.11 apply.

G.7.4.2.12 Prefix NAL unit RBSP semantics

store_ref_base_pic_flag equal to 1 specifies that, when the value of dependency_id as specified in the NAL unit header is equal to the maximum value of dependency_id for the VCL NAL units of the current access unit, an additional representation of the coded picture that may or may not be identical to the decoded picture is marked as "used for reference". This additional representation is also referred to as reference base picture and may be used for inter prediction of following pictures in decoding order, but it is not output. When store_ref_base_pic_flag is not present, it shall be inferred to be equal to 0.

The syntax element store_ref_base_pic_flag shall have an identical value for all VCL NAL units of a dependency representation. When nal_ref_idc is equal to 0, the value of store_ref_base_pic_flag shall be equal to 0.

store_ref_base_pic_flag is considered to apply to the associated NAL unit.

prefix_nal_unit_additional_extension_flag shall be equal to 0. The value of 1 for prefix_nal_unit_additional_extension_flag is reserved for future use by ITU-T | ISO/IEC.

prefix_nal_unit_extension_flag may have any value.

NOTE – The syntax elements prefix_nal_unit_additional_extension_flag and prefix_nal_unit_extension_flag are not required by the decoding process specified in this Recommendation | International Standard.

G.7.4.2.13 Slice layer in scalable extension RBSP semantics

The slice layer in scalable extension RBSP consists of a slice header in scalable extension and slice data in scalable extension.

G.7.4.3 Slice header semantics

The semantics specified in subclause 7.4.3 apply with the following modifications.

All constraints specified in subclause 7.4.3 apply only to the layer representations with DQId equal to 0.

frame_num has the same semantics as specified in subclause G.7.4.3.4.

The slice_header( ) syntax structure shall be considered to contain the following syntax elements with the following inferred values.

– ref_layer_dq_id is inferred to be equal to –1.

– scan_idx_start is inferred to be equal to 0.

– scan_idx_end is inferred to be equal to 15.

The value of direct_spatial_mv_pred_flag shall be equal to 1.

The variable SpatialResolutionChangeFlag is set equal to 0.

G.7.4.3.1 Reference picture list reordering semantics

The semantics specified in subclause 7.4.3.1 apply.

G.7.4.3.2 Prediction weight table semantics

The semantics specified in subclause 7.4.3.2 apply.

G.7.4.3.3 Decoded reference picture marking semantics

The semantics specified in subclause 7.4.3.3 apply with substituting SVC sequence parameter set for sequence parameter set. The constraints specified in subclause 7.4.3.3 apply only to the dependency representation with dependency_id equal to the current value of dependency_id and the modifications a) and b) specified in subclause G.8.2 apply with currDependencyId being equal to the current value of dependency_id.

G.7.4.3.4 Slice header in scalable extension semantics

The value of the following SVC sequence parameter set syntax elements shall be the same across all coded slice NAL units of an access unit: bit_depth_luma_minus8, bit_depth_chroma_minus8, and chroma_format_idc.

When present, the value of the following slice header syntax elements shall be the same across all coded slice NAL units of an access unit: field_pic_flag and bottom_field_flag.

When present, the value of the following slice header syntax elements shall be the same across all slices of a dependency representation including slice headers of NAL units with nal_unit_type equal to 1, 2, or 5: frame_num, idr_pic_id, pic_order_cnt_lsb, delta_pic_order_cnt_bottom, delta_pic_order_cnt[0], and delta_pic_order_cnt[1].

When present, the value of the following slice header syntax elements shall be the same across all slices of a layer representation: pic_parameter_set_id, ref_layer_dq_id, disable_inter_layer_deblocking_filter_idc, inter_layer_slice_alpha_c0_offset_div2, inter_layer_slice_beta_offset_div2, constrained_intra_resampling_flag, ref_layer_chroma_phase_x_plus1_flag, ref_layer_chroma_phase_y_plus1, scaled_ref_layer_left_offset, scaled_ref_layer_top_offset, scaled_ref_layer_right_offset, scaled_ref_layer_bottom_offset, slice_group_change_cycle, store_ref_base_pic_flag, tcoeff_level_prediction_flag, and all syntax elements of the syntax structures dec_ref_pic_marking( ) and dec_ref_base_pic_marking( ).

Let setOfRefLayerSlices be the set of slices with dependency_id equal to the current value of dependency_id and quality_id equal to 0 that are covered or partly covered by the macroblocks of the current slice.

When quality_id is greater than 0, the value of (slice_type % 5) for all slices in the set setOfRefLayerSlices shall be the same as the value of (slice_type % 5) for the current slice.

When quality_id is greater than 0 and setOfRefLayerSlices contains more than one slice, the following constraints shall be obeyed.

a) When slice_type specifies an EP or EB slice, the value of the syntax element num_ref_idx_l0_active_minus1 (either the value transmitted in the slice header when num_ref_idx_active_override_flag is equal to 1 or the value of the referenced picture parameter set when num_ref_idx_active_override_flag is equal to 0) shall be the same across all slices of the set setOfRefLayerSlices.

b) When slice_type specifies an EB slice, the value of the syntax element num_ref_idx_l1_active_minus1 (either the value transmitted in the slice header when num_ref_idx_active_override_flag is equal to 1 or the value of the referenced picture parameter set when num_ref_idx_active_override_flag is equal to 0) shall be the same across all slices of the set setOfRefLayerSlices.

c) All elements of the syntax structure ref_pic_list_reordering( ) shall be the same across all slices of the set setOfRefLayerSlices.

d) When slice_type specifies an EP slice, the syntax element weighted_pred_flag shall be the same across all slices of the set setOfRefLayerSlices and the following applies.

   i. When weighted_pred_flag is equal to 1 and no_inter_layer_pred_flag is equal to 0 for any of the slices of the set setRefLayerSlices, base_pred_weight_table_flag shall be the same across all slices of the set setOfRefLayerSlices.

   ii. When weighted_pred_flag is equal to 1 for any of the slices of the set setRefLayerSlices and pred_weight_table( ) is present in any of the slices of the set setOfRefLayerSlices, pred_weight_table( ) shall be present in all slices of the set setOfRefLayerSlices and all syntax elements inside the syntax structure pred_weight_table( ) shall be the same across all slices of the set setOfRefLayerSlices.

e) When slice_type specifies an EB slice, the syntax element weighted_bipred_idc shall be the same across all slices of the set setOfRefLayerSlices and the following applies.

   i. When weighted_bipred_idc is equal to 1 and no_inter_layer_pred_flag is equal to 0 for any of the slices of the set setRefLayerSlices, base_pred_weight_table_flag shall the same across all slices of the set setOfRefLayerSlices.

   ii. When weighted_bipred_idc is equal to 1 for any of the slices of the set setRefLayerSlices and pred_weight_table( ) is present in any of the slices of the set setOfRefLayerSlices, pred_weight_table( ) shall be present in all slices of the set setOfRefLayerSlices and all syntax elements inside the syntax structure pred_weight_table( ) shall be the same across all slices of the set setOfRefLayerSlices.

When quality_id is greater than 0, the following syntax elements (that are not present) shall be inferred to be equal to the corresponding syntax elements of the slice headers of the slice with dependency_id equal to the current value of dependency_id and quality_id equal to 0 that covers the macroblock with the macroblock address first_mb_in_slice when present in this slice: direct_spatial_mv_pred_flag, num_ref_idx_l0_active_minus1, num_ref_idx_l1_active_minus1, all syntax elements of the syntax structure ref_pic_list_reordering( ), base_pred_weight_table_flag, all syntax elements of the syntax structure pred_weight_table( ), all syntax elements of the syntax structure dec_ref_pic_marking( ), all syntax elements of the syntax structure dec_ref_base_pic_marking( ), slice_group_change_cycle, and store_ref_base_pic_flag.

first_mb_in_slice has the same semantics as specified in subclause 7.4.3.

slice_type specifies the coding type of the slice according to Table G-1.

Table G-1 – Name association to slice_type for NAL units with nal_unit_type equal to 20.

slice_type	Name of slice_type
0, 5	EP (P slice in scalable extension)
1, 6	EB (B slice in scalable extension)
2, 7	EI (I slice in scalable extension)

slice_type values in the range of 5 to 7, inclusive, specify, in addition to the coding type of the current slice, that all other slices of the current layer representation shall have a value of slice_type equal to the current value of slice_type or equal to the current value of slice_type minus 5.

When idr_flag is equal to 1 or num_ref_frames is equal to 0, slice_type shall be equal to 2 or 7.

pic_parameter_set_id has the same semantics as specified in subclause 7.4.3. The syntax element profile_idc of the SVC sequence parameter set that is referred to by the picture_parameter_set (by using seq_parameter_set_id) with pic_parameter_set_id shall be equal to 83 or 86.

frame_num is used as an identifier for dependency representations and shall be represented by log2_max_frame_num_minus4 + 4 bits in the bitstream.

frame_num is constrained as specified in subclause 7.4.3 where this constraint applies to dependency representations with dependency_id equal to the current value of dependency_id and the modifications a) and b) specified in subclause G.8.2 apply with currDependencyId being equal to the current value of dependency_id.

field_pic_flag and **bottom_field_flag** have the same semantics as specified in subclause 7.4.3.

idr_pic_id identifies an IDR picture when dependency_id is equal to the maximum present value of dependency_id in the VCL NAL units of the current access unit. The value of idr_pic_id shall be in the range of 0 to 65535, inclusive.

When dependency_id is equal to the maximum value of dependency_id in all VCL NAL units of the current access unit and two consecutive access units in decoding order are both IDR access units, the value of idr_pic_id in the slices of the dependency representation with dependency_id equal to the current value of dependency_id in the first such IDR access unit shall differ from the idr_pic_id in the slices of the dependency representation with dependency_id equal to the current value of dependency_id in the second such IDR access unit.

NOTE 1 – The classification of an access unit as IDR access unit depends on the maximum present value of dependency_id. When NAL units are removed from a bitstream, e.g. in order to adjust the bitstream to the capabilities of a receiving device, the classification of access units as IDR access units may change. Since all bitstreams for different conformance points supported in a scalable bitstream (especially for different maximum values of dependency_id) shall conform to this specification, the constraints on idr_pic_id shall be obeyed for all conformance points that are contained in a scalable bitstream.

pic_order_cnt_lsb, **delta_pic_order_cnt_bottom**, **delta_pic_order_cnt**[0], and **delta_pic_order_cnt**[1] have the same semantics as specified in subclause 7.4.3.

redundant_pic_cnt has the same semantics as specified in subclause 7.4.3.

direct_spatial_mv_pred_flag has the same semantics as specified in subclause 7.4.3. Additionally, the value of direct_spatial_mv_pred_flag shall be equal to 1.

num_ref_idx_active_override_flag, **num_ref_idx_l0_active_minus1**, and **num_ref_idx_l1_active_minus1** have the same semantics as specified in subclause 7.4.3.

base_pred_weight_table_flag equal to 1 specifies that the variables for weighted prediction are inferred. When base_pred_weight_table_flag is not present, it shall be inferred as follows.

– If no_inter_layer_pred_flag is equal to 1 or quality_id is greater than 0, base_pred_weight_table_flag is inferred to be equal to 0.

– Otherwise (no_inter_layer_pred_flag is equal to 0 and quality_id is equal to 0), base_pred_weight_table_flag is inferred to be equal to 1.

Let setOfRefLayerSlices be the set of slices that is represented by the VCL NAL units with dependency_id equal to (ref_layer_dq_id >> 4) and quality_id equal to 0 inside the current access unit.

When base_pred_weight_table_flag equal to 1 the following constraints shall be obeyed.

a) For all slices in setOfRefLayerSlices, the value of (slice_type % 5) shall be equal to (slice_type % 5) of the current slice.

b) When base_pred_weight_table_flag equal to 1 and the syntax structure pred_weight_table( ) is present in any slice in setOfRefLayerSlices, it shall be present for all slices in setOfRefLayerSlices, and all syntax elements inside the syntax structure pred_weight_table( ) shall be identical for all slices in setOfRefLayerSlices.

c) When base_pred_weight_table_flag is present in any slice in setOfRefLayerSlices, it shall have an identical value in all slices in setOfRefLayerSlices.

d) When the current slice is an EP slice, the following applies.

   i. The value of num_ref_idx_l0_active_minus1 of all slices in setOfRefLayerSlices shall be identical to the value of num_ref_idx_l0_active_minus1 of the current slice.

   ii. For each slice in setOfRefLayerSlices all syntax elements inside the syntax structure ref_pic_list_reordering( ) shall be identical, and the syntax structure ref_pic_list_reordering( ) for the slices in setOfRefLayerSlices shall contain syntax elements so that for useRefBasePicFlag equal to 0 and 1, an invocation of subclause G.8.2.3 with currDependencyId set equal to (ref_layer_dq_id >> 4),

useRefLayerRepFlag, and any slice of setOfRefLayerSlices as the inputs derives a reference picture list refPicList0RefLayer that is identical to the reference picture list refPicList0, which is derived by invoking subclause G.8.2.3 with currDependencyId set equal to dependency_id, useRefLayerRepFlag, and the current slice as the inputs.

iii. The syntax element weighted_pred_flag shall be equal to 1 for all slices in setOfRefLayerSlices.

e) When the current slice is an EB slice, the following applies.

i. The value of num_ref_idx_l0_active_minus1 and num_ref_idx_l1_active_minus1 of all slices in setOfRefLayerSlices shall be identical to the value of num_ref_idx_l0_active_minus1 and num_ref_idx_l1_active_minus1, respectively, of the current slice.

ii. For each slice in setOfRefLayerSlices all syntax elements inside the syntax structure ref_pic_list_reordering( ) shall be identical, and the syntax structure ref_pic_list_reordering( ) for the slices in setOfRefLayerSlices shall contain syntax elements so that for useRefBasePicFlag equal to 0 and 1, an invoking of subclause G.8.2.3 with currDependencyId set equal to (ref_layer_dq_id >> 4), useRefLayerRepFlag, and any slice of setOfRefLayerSlices as the inputs derives reference picture lists refPicList0RefLayer and refPicList1RefLayer that are identical to the reference picture lists refPicList0 and refPicList1, respectively, which are derived by invoking subclause G.8.2.3 with currDependencyId set equal to dependency_id, useRefLayerRepFlag, and the current slice as the inputs.

iii. The syntax element weighted_bipred_idc shall be equal to 1 for all slices in setOfRefLayerSlices.

When quality_id is greater than 0, all elements of pred_weight_table are inferred as specified in the beginning of this subclause.

store_ref_base_pic_flag has the same semantics as specified in subclause G.7.4.2.12.

cabac_init_idc and **slice_qp_delta** have the same semantics as specified in subclause 7.4.3.

disable_deblocking_filter_idc specifies whether the operation of the deblocking filter shall be disabled across some block edges of the slice and specifies for which edges the filtering is disabled. When disable_deblocking_filter_idc is not present in the slice header, the value of disable_deblocking_filter_idc shall be inferred to be equal to 0.

The value of disable_deblocking_filter_idc shall be in the range of 0 to 6, inclusive. disable_deblocking_filter_idc equal to 0 specifies that all luma and chroma block edges of the current picture are filtered. disable_deblocking_filter_idc equal to 1 specifies that deblocking is disabled for all block edges of the current picture. disable_deblocking_filter_idc equal to 2 specifies that all luma and chroma block edges are filtered with exception of the block edges that coincide with slice boundaries. disable_deblocking_filter_idc equal to 3 specifies a two stage deblocking filter process: After filtering all block luma and chroma block edges that do not coincide with slice boundaries (as if disable_deblocking_filter_idc were equal to 2), the luma and chroma block edges that coincide with slice boundaries are filtered. disable_deblocking_filter_idc equal to 4 specifies that all luma block edges of the current picture are filtered, but the deblocking of the chroma block edges is disabled. disable_deblocking_filter_idc equal to 5 specifies that all luma block edges are filtered with exception of the block edges that coincide with slice boundaries (as if disable_deblocking_filter_idc were equal to 2), and that deblocking for chroma block edges is disabled. disable_deblocking_filter_idc equal to 6 specifies that the deblocking for chroma block edges is disabled and that the two stage deblocking filter process is used for luma block edges: After filtering all block luma block edges that do not coincide with slice boundaries (as if disable_deblocking_filter_idc were equal to 2), the luma block edges that coincide with slice boundaries are filtered.

slice_alpha_c0_offset_div2, and **slice_beta_offset_div2** have the same semantics as specified in subclause 7.4.3.

slice_group_change_cycle has the same semantics as specified in subclause 7.4.3.

ref_layer_dq_id specifies the layer representation inside the current access unit that is used for inter-layer prediction of the current layer representation. When ref_layer_dq_id is not present, it shall be inferred as follows.

– If quality_id is greater than 0, ref_layer_dq_id is inferred to be equal to (DQId – 1).

– Otherwise (quality_id is equal to 0), ref_layer_dq_id is inferred to be equal to –1.

When quality_id is equal to 0, the NAL units with DQId equal to ref_layer_dq_id shall have discardable_flag equal to 0.

When present, the value of ref_layer_dq_id shall be the same for all coded slice NAL units of a layer representation.

When ref_layer_dq_id is not equal to –1, the following variables are derived as follows.

– RefLayerPicSizeInMbs is set equal to the value of the variable PicSizeInMbs for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerPicWidthInMbs is set equal to the value of the variable PicWidthInMbs for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerPicHeightInMbs is set equal to the value of the variable PicHeightInMbs for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerChromaFormatIdc is set equal to the value of the syntax element chroma_format_idc for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerChromaArrayType is set equal to the value of ChromaArrayType for the layer representation with DQId equal to the value of ref_layer_dq_id.

– $RefLayerPicWidthInSamples_L$ is set equal to the value of the variable $PicWidthInSamples_L$ for the layer representation with DQId equal to the value of ref_layer_dq_id.

– $RefLayerPicHeightInSamples_L$ is set equal to the value of the variable $PicHeightInSamples_L$ for the layer representation with DQId equal to the value of ref_layer_dq_id.

– $RefLayerPicWidthInSamples_C$ is set equal to the value of the variable $PicWidthInSamples_C$ for the layer representation with DQId equal to the value of ref_layer_dq_id.

– $RefLayerPicHeightInSamples_C$ is set equal to the value of the variable $PicHeightInSamples_C$ for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerMbWidthC is set equal to the value of the variable MbWidthC for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerMbHeightC is set equal to the value of the variable MbHeightC for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerFrameMbsOnlyFlag is set equal to the value of the syntax element frame_mbs_only_flag for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerFieldPicFlag is set equal to the value of the syntax element field_pic_flag for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerBottomFieldFlag is set equal to the value of the syntax element bottom_field_flag for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerMbaffFrameFlag is set equal to the value of the variable MbaffFrameFlag for the layer representation with DQId equal to the value of ref_layer_dq_id.

disable_inter_layer_deblocking_filter_idc specifies whether the operation of the deblocking filter for inter-layer intra prediction is disabled across some block edges of the slice and specifies for which edges the filtering is disabled. When disable_inter_layer_deblocking_filter_idc is not present in the slice header, the value of disable_inter_layer_deblocking_filter_idc shall be inferred to be equal to 0. The value of disable_inter_layer_deblocking_filter_idc shall be in the range of 0 to 6, inclusive. The values 0 to 6 of disable_inter_layer_deblocking_filter_idc specify the same deblocking filter operations as the corresponding values of disable_deblocking_filter_idc, but for the deblocking of the intra macroblocks of the dependency representation specified by ref_layer_dq_id before resampling.

When quality_id is equal to 0 and SpatialResolutionChangeFlag as specified in the following paragraphs is equal to 0, disable_inter_layer_deblocking_filter_idc shall be equal to 1.

inter_layer_slice_alpha_c0_offset_div2 specifies the offset used in accessing the α and t_{C0} deblocking filter tables for filtering operations controlled by the macroblocks within the slice for inter-layer prediction. From this value, the offset that is applied when addressing these tables shall be computed as:

$$InterlayerFilterOffsetA = inter\_layer\_slice\_alpha\_c0\_offset\_div2 << 1 \quad \text{(G-67)}$$

The value of inter_layer_slice_alpha_c0_offset_div2 shall be in the range of –6 to +6, inclusive. When inter_layer_slice_alpha_c0_offset_div2 is not present in the slice header, the value of inter_layer_slice_alpha_c0_offset_div2 shall be inferred to be equal to 0.

inter_layer_slice_beta_offset_div2 specifies the offset used in accessing the β deblocking filter table for filtering operations controlled by the macroblocks within the slice for inter-layer prediction. From this value, the offset that is applied when addressing the β table of the deblocking filter is computed as:

$$InterlayerFilterOffsetB = inter\_layer\_slice\_beta\_offset\_div2 << 1 \quad \text{(G-68)}$$

The value of inter_layer_slice_beta_offset_div2 shall be in the range of –6 to +6, inclusive. When inter_layer_slice_beta_offset_div2 is not present in the slice header the value of inter_layer_slice_beta_offset_div2 shall be inferred to be equal to 0.

constrained_intra_resampling_flag specifies whether slice boundaries of the dependency representation that is specified for inter-layer prediction by ref_layer_dq_id are treated similar to layer picture boundaries for the intra resampling process. When constrained_intra_resampling_flag is equal to 1, disable_inter_layer_deblocking_filter_idc shall be equal to 1, 2, or 4.

When constrained_intra_resampling_flag is equal to 1, a macroblock cannot be coded using the Intra_Base macroblock prediction mode when it covers more than one slice in the reference layer as specified in subclause G.8.6.2.

When constrained_intra_resampling_flag is not present, it shall be inferred to be equal to 0.

ref_layer_chroma_phase_x_plus1_flag specifies the horizontal phase shift of the chroma components in units of half luma samples of a layer frame for the layer pictures that may be used for inter-layer prediction. When ref_layer_chroma_phase_x_plus1_flag is not present, it shall be inferred to be equal to seq_ref_layer_chroma_phase_x_plus1_flag.

When no_inter_layer_pred_flag is equal to 0, the following applies.

– When ref_layer_dq_id is greater than 0, ref_layer_chroma_phase_x_plus1_flag should be equal to chroma_phase_x_plus1_flag of the subset sequence parameter set RBSP that is referred to by the reference layer representation (with DQId equal to ref_layer_dq_id).

– When chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are present in the SVC sequence parameter set that is referred to by the reference layer representation (with DQId equal to ref_layer_dq_id), the following applies.

  – If ref_layer_chroma_phase_x_plus1_flag is equal to 0, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field of the SVC sequence parameter set that is referred to by the reference layer representation should be equal to 0, 2, or 4.

  – Otherwise (ref_layer_chroma_phase_x_plus1_flag is equal to 1), chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field of the SVC sequence parameter set that is referred to by the reference layer representation should be equal to 1, 3, or 5.

ref_layer_chroma_phase_y_plus1 specifies the vertical phase shift of the chroma components in units of half luma samples of a layer frame for the layer pictures that may be used for inter-layer prediction. When ref_layer_chroma_phase_y_plus1 is not present, it shall be inferred to be equal to seq_ref_layer_chroma_phase_y_plus1. The value of ref_layer_chroma_phase_y_plus1 shall be in the range of 0 to 2, inclusive.

When no_inter_layer_pred_flag is equal to 0, the following applies.

– When ref_layer_dq_id is greater than 0, ref_layer_chroma_phase_y_plus1 should be equal to chroma_phase_y_plus1 of the subset sequence parameter set RBSP that is referred to by the reference layer representation (with DQId equal to ref_layer_dq_id).

– When chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are present in the SVC sequence parameter set that is referred to by the reference layer representation (with DQId equal to ref_layer_dq_id), the following applies.

  – If ref_layer_chroma_phase_y_plus1 is equal to 0, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field of the SVC sequence parameter set that is referred to by the reference layer representation should be equal to 2 or 3.

  – Otherwise, if ref_layer_chroma_phase_y_plus1 is equal to 1, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field of the SVC sequence parameter set that is referred to by the reference layer representation should be equal to 0 or 1.

  – Otherwise (chroma_phase_y_plus1 is equal to 2), chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field of the SVC sequence parameter set that is referred to by the reference layer representation should be equal to 4 or 5.

scaled_ref_layer_left_offset specifies the horizontal offset between the upper-left luma sample of a resampled layer picture used for inter-layer prediction and the upper-left luma sample of the current picture or current layer picture in units of two luma samples.

When scaled_ref_layer_left_offset is not present, it shall be inferred as follows.

– If quality_id is greater than 0, scaled_ref_layer_left_offset is inferred to be equal to 0.

– Otherwise (quality_id is equal to 0), scaled_ref_layer_left_offset is inferred to be equal to seq_scaled_ref_layer_left_offset.

scaled_ref_layer_top_offset specifies the vertical offset between the upper-left luma sample of an resampled layer picture used for inter-layer prediction and the upper-left luma sample of the current picture or current layer picture. The vertical offset is specified in units of two luma samples when frame_mbs_only_flag is equal to 1, and it is specified in units of four luma samples when frame_mbs_only_flag is equal to 0.

When scaled_ref_layer_top_offset is not present, it shall be inferred as follows.

– If quality_id is greater than 0, scaled_ref_layer_top_offset is inferred to be equal to 0.

– Otherwise (quality_id is equal to 0), scaled_ref_layer_top_offset is inferred to be equal to seq_scaled_ref_layer_top_offset.

scaled_ref_layer_right_offset specifies the horizontal offset between the bottom-right luma sample of an resampled layer picture used for inter-layer prediction and the bottom-right luma sample of the current picture or current layer picture in units of two luma samples.

When scaled_ref_layer_right_offset is not present, it shall be inferred as follows.

– If quality_id is greater than 0, scaled_ref_layer_right_offset is inferred to be equal to 0.

– Otherwise (quality_id is equal to 0), scaled_ref_layer_right_offset is inferred to be equal to seq_scaled_ref_layer_right_offset.

scaled_ref_layer_bottom_offset specifies the vertical offset between the bottom-right luma sample of an resampled layer picture used for inter-layer prediction and the bottom-right luma sample of the current picture or current layer picture. The vertical offset is specified in units of two luma samples when frame_mbs_only_flag is equal to 1, and it is specified in units of four luma samples when frame_mbs_only_flag is equal to 0.

When scaled_ref_layer_bottom_offset is not present, it shall be inferred as follows.

– If quality_id is greater than 0, scaled_ref_layer_bottom_offset is inferred to be equal to 0.

– Otherwise (quality_id is equal to 0), scaled_ref_layer_bottom_offset is inferred to be equal to seq_scaled_ref_layer_bottom_offset.

The variables ScaledRefLayerLeftOffset, ScaledRefLayerRightOffset, ScaledRefLayerTopOffset, ScaledRefLayerBottomOffset, $ScaledRefLayerPicWidthInSamples_L$, and $ScaledRefLayerPicHeightInSamples_L$ are derived by

$$ScaledRefLayerLeftOffset = 2 * scaled\_ref\_layer\_left\_offset \quad (G\text{-}69)$$

$$ScaledRefLayerRightOffset = 2 * scaled\_ref\_layer\_right\_offset \quad (G\text{-}70)$$

$$ScaledRefLayerTopOffset = 2 * scaled\_ref\_layer\_top\_offset * (2 - frame\_mbs\_only\_flag) \quad (G\text{-}71)$$

$$ScaledRefLayerBottomOffset = 2 * scaled\_ref\_layer\_bottom\_offset * (2 - frame\_mbs\_only\_flag) \quad (G\text{-}72)$$

$$ScaledRefLayerPicWidthInSamples_L = PicWidthInMbs * 16 - ScaledRefLayerLeftOffset - ScaledRefLayerRightOffset \quad (G\text{-}73)$$

$$ScaledRefLayerPicHeightInSamples_L = PicHeightInMbs * 16 - (ScaledRefLayerTopOffset + ScaledRefLayerBottomOffset) / (1 + field\_pic\_flag) \quad (G\text{-}74)$$

When no_inter_layer_pred_flag is equal to 0, the following applies.

– The bitstream shall not contain data that result in $ScaledRefLayerPicWidthInSamples_L$ less than $RefLayerPicWidthInSamples_L$.

– When RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 1, the bitstream shall not contain data that result in ($ScaledRefLayerPicHeightInSamples_L$ * (1 + field_pic_flag)) less than ($RefLayerPicHeightInSamples_L$ * (1 + RefLayerFieldPicFlag)).

– When RefLayerFrameMbsOnlyFlag is equal to 1 and frame_mbs_only_flag is equal to 0, the bitstream shall not contain data that result in ($ScaledRefLayerPicHeightInSamples_L$ * (1 + field_pic_flag)) less than (2 * $RefLayerPicHeightInSamples_L$).

When ChromaArrayType is not equal to 0, the variables $ScaledRefLayerPicWidthInSamples_C$, and $ScaledRefLayerPicHeightInSamples_C$ are derived by

$$ScaledRefLayerPicWidthInSamples_C = ScaledRefLayerPicWidthInSamples_L / SubWidthC \quad (G\text{-}75)$$
$$ScaledRefLayerPicHeightInSamples_C = ScaledRefLayerPicHeightInSamples_L / SubHeightC \quad (G\text{-}76)$$

The variable CroppingChangeFlag is derived as follows.

– If quality_id is equal to 0 and extended_spatial_scalability is equal to 2, CroppingChangeFlag is set equal to 1.

– Otherwise (quality_id is greater than 0 or extended_spatial_scalability is less than 2), CroppingChangeFlag is set equal to 0.

The variable SpatialResolutionChangeFlag is derived as follows.

– If no_inter_layer_pred_flag is equal to 1, quality_id is greater than 0, or all of the following conditions are true, SpatialResolutionChangeFlag is set equal to 0.
  – CroppingChangeFlag is equal to 0
  – $ScaledRefLayerPicWidthInSamples_L$ is equal to $RefLayerPicWidthInSamples_L$
  – $ScaledRefLayerPicHeightInSamples_L$ is equal to $RefLayerPicHeightInSamples_L$
  – (ScaledRefLayerLeftOffset % 16) is equal to 0
  – (ScaledRefLayerTopOffset % (16 * (1 + frame_mbs_only_flag))) is equal to 0
  – field_pic_flag is equal to RefLayerFieldPicFlag
  – MbaffFrameFlag is equal to RefLayerMbaffFrameFlag
  – chroma_format_idc is equal to RefLayerChromaFormatIdc
  – chroma_phase_x_plus1_flag is equal to ref_layer_chroma_phase_x_plus1_flag
  – chroma_phase_y_plus1 is equal to ref_layer_chroma_phase_y_plus1
– Otherwise, SpatialResolutionChangeFlag is set equal to 1.

The variable RestrictedSpatialResolutionChangeFlag is derived as follows.

– If no_inter_layer_pred_flag is equal to 1, quality_id is greater than 0, or all of the following conditions are true, RestrictedSpatialResolutionChangeFlag is set equal to 1.
  – $ScaledRefLayerPicWidthInSamples_L$ is equal to $RefLayerPicWidthInSamples_L$ or (2 * $RefLayerPicWidthInSamples_L$)
  – $ScaledRefLayerPicHeightInSamples_L$ is equal to $RefLayerPicHeightInSamples_L$ or (2 * $RefLayerPicHeightInSamples_L$)
  – (ScaledRefLayerLeftOffset % 16) is equal to 0
  – (ScaledRefLayerTopOffset % (16 * (1 + frame_mbs_only_flag))) is equal to 0
  – MbaffFrameFlag is equal to RefLayerMbaffFrameFlag
  – field_pic_flag is equal to RefLayerFieldPicFlag
– Otherwise, RestrictedSpatialResolutionChangeFlag is set equal to 0.

slice_skip_flag equal to 0 specifies the presence of slice data in the slice. slice_skip_flag equal to 1 specifies that the syntax elements for the macroblock layer of the slice are derived by the following process.

1. CurrMbAddr is derived by

$$CurrMbAddr = first\_mb\_in\_slice * (1 + MbaffFrameFlag) \quad (G\text{-}77)$$

2. The variable mbIdx proceeds over the values 0..num_mbs_in_slice_minus1, and for each value of mbIdx, the following ordered steps are specified.
   a. The bitstream shall not contain data that result in in_crop_window(CurrMbAddr) equal to 0.

b. For the macroblock with address CurrMbAddr, the syntax elements mb_skip_flag (when applicable), mb_skip_run (when applicable), mb_field_decoding_flag, base_mode_flag, residual_prediction_flag and coded_block_pattern shall be inferred as follows.

– mb_skip_flag (when applicable) and mb_skip_run (when applicable) are inferred to be equal to 0

– mb_field_decoding_flag is inferred to be equal to 0
NOTE 2 – The frame/field mode used for decoding is inferred in subclause G.8.1.5.1.

– base_mode_flag is inferred to be equal to 1

– residual_prediction_flag is inferred to be equal to 1

– coded_block_pattern is inferred to be equal to 0

– QP_Y is inferred to be equal to $SliceQP_Y$

– QP'_Y is inferred to be equal to $(QP_Y + QpBdOffset_Y)$

c. CurrMbAddr is set to NextMbAddress(CurrMbAddr)

num_mbs_in_slice_minus1 plus 1specifies the number of macroblocks for a slice with slice_skip_flag equal to 1.

adaptive_base_mode_flag specifies the presence of syntax elements in the slice header and in the macroblock layer in scalable extension. When adaptive_base_mode_flag is not present, it shall be inferred to be equal to 0.

default_base_mode_flag specifies how base_mode_flag is inferred when it is not present in macroblock layer in scalable extension. When default_base_mode_flag is not present, it shall be inferred to be equal to 0.

adaptive_motion_prediction_flag specifies the presence of syntax elements in the macroblock layer in scalable extension. When adaptive_motion_prediction_flag is not present, it shall be inferred to be equal to 0.

default_motion_prediction_flag specifies how motion_prediction_flag_l0[ ] and motion_prediction_flag_l1[ ] are inferred when they are not present in macroblock layer in scalable extension. When default_motion_prediction_flag is not present, it shall be inferred to be equal to 0.

adaptive_residual_prediction_flag specifies the presence of syntax elements in the macroblock layer in scalable extension. When adaptive_residual_prediction_flag is not present, it shall be inferred to be equal to 0.

default_residual_prediction_flag specifies how residual_prediction_flag is inferred when it is not present in the macroblock layer in scalable extension. When default_residual_prediction_flag is not present, it shall be inferred to be equal to 0.

tcoeff_level_prediction_flag equal to 1 specifies that an alternative inter-layer prediction process is applied as specified in subclause G.8. When tcoeff_level_prediction_flag is not present it shall be inferred as follows.

– If no_inter_layer_pred_flag is equal to 1, tcoeff_level_prediction_flag is inferred to be equal to 0.

– Otherwise (no_inter_layer_pred_flag is equal to 0), tcoeff_level_prediction_flag is inferred to be equal to the value of seq_tcoeff_level_prediction_flag.

When SpatialResolutionChangeFlag is equal to 1, tcoeff_level_prediction_flag shall be equal to 0.

When tcoeff_level_prediction_flag is equal to 1, the following constraints shall be obeyed.

a) The layer representation with DQId equal to ref_layer_dq_id shall have no_inter_layer_pred_flag equal to 1 or tcoeff_level_prediction_flag equal to 1.

b) All elements of ScalingList4x4 shall be the same for the slices of the current layer representation and all slices of the layer representation with DQId equal to the value of ref_layer_dq_id.

c) All elements of ScalingList8x8 shall be the same for the slices of the current layer representation and all slices of the layer representation with DQId equal to the value of ref_layer_dq_id.

d) The value of the syntax element use_ref_base_pic_flag shall be equal to 0 for the slices of the current layer representation and all slices of the layer representation with DQId equal to the value of ref_layer_dq_id.

scan_idx_start specifies the first scanning position for the transform coefficient levels in the current slice. When scan_idx_start is not present, it shall be inferred to be equal to 0.

scan_idx_end specifies the last scanning position for the transform coefficient levels in the current slice. When scan_idx_end is not present, it shall be inferred to be equal to 15.

G.7.4.3.5 Decoded reference base picture marking semantics

The syntax elements adaptive_ref_base_pic_marking_mode_flag, memory_management_control_operation, difference_of_pic_nums_minus1 and long_term_pic_num specify marking of reference base pictures as "unused for reference".

adaptive_ref_base_pic_marking_mode_flag has the same semantics as the syntax element adaptive_ref_pic_marking_mode_flag in the dec_ref_pic_marking() syntax structure. When adaptive_ref_base_pic_marking_mode_flag is not present, it shall be inferred to be equal to 0.

memory_management_control_operation specifies a control operation to be applied to affect the reference picture marking. The memory_management_control_operation syntax element is followed by data necessary for the operation specified by the value of memory_management_control_operation. The values and control operations associated with memory_management_control_operation are specified in Table G-2. The memory_management_control_operation syntax elements are processed by the decoding process in the order in which they appear, and the semantics constraints expressed for each memory_management_control_operation apply at the specific position in that order at which that individual memory_management_control_operation is processed.

memory_management_control_operation shall not be equal to 1 unless the specified reference picture is marked as "used for short-term reference" and as "reference base picture" when the memory_management_control_operation is processed by the decoding process.

memory_management_control_operation shall not be equal to 2 unless the specified long-term picture number refers to a reference picture that is marked as "used for long-term reference" and as "reference base picture" when the memory_management_control_operation is processed by the decoding process.

Table G-2 – Memory management control operation (memory_management_control_operation) values

memory_management_control_operation	Memory Management Control Operation
0	End memory_management_control_operation syntax element loop
1	Mark a short-term reference base picture as "unused for reference"
2	Mark a long-term reference base picture as "unused for reference"

difference_of_pic_nums_minus1 is used (with memory_management_control_operation equal to 1) to mark a short-term reference picture as "unused for reference". When the associated memory_management_control_operation is processed by the decoding process, the resulting picture number derived from difference_of_pic_nums_minus1 shall be a picture number assigned to one of the reference pictures marked as "used for reference" and as "reference base picture".

The resulting picture number is constrained as follows.

– If field_pic_flag is equal to 0, the resulting picture number shall be one of the set of picture numbers assigned to reference frames or complementary reference field pairs, or there is no reference frame or complementary reference field pair that has been assigned the resulting picture number.

– Otherwise (field_pic_flag is equal to 1), the resulting picture number shall be one of the set of picture numbers assigned to reference fields, or there is no reference pair that has been assigned the resulting picture number.

long_term_pic_num is used (with memory_management_control_operation equal to 2) to mark a long-term reference picture as "unused for reference". When the associated memory_management_control_operation is processed by the decoding process, long_term_pic_num shall be equal to a long-term picture number assigned to one of the reference pictures marked as "used for long-term reference" and as "reference base picture".

The resulting long-term picture number is constrained as follows.

– If field_pic_flag is equal to 0, the resulting long-term picture number shall be one of the set of long-term picture numbers assigned to reference frames or complementary reference field pairs, or there is no reference frame or complementary reference field pair that has been assigned the resulting long-term picture number..

– Otherwise (field_pic_flag is equal to 1), the resulting long-term picture number shall be one of the set of long-term picture numbers assigned to reference fields, or there is no reference pair that has been assigned the resulting long-term picture number.

When present in a prefix NAL unit, the syntax elements of the dec_ref_base_pic_marking( ) syntax structure are considered to apply to the associated NAL unit.

G.7.4.4 Slice data semantics

The semantics specified in subclause 7.4.4 apply.

G.7.4.4.1 Slice data in scalable extension semantics

The semantic specified in subclauses 7.4.4 apply with the following modifications.

mb_skip_run specifies the number of consecutive skipped macroblocks for which, when decoding an EP slice, mb_type shall be inferred to be P_Skip and the macroblock type is collectively referred to as a P macroblock type, or for which, when decoding an EB slice, mb_type shall be inferred to be B_Skip and the macroblock type is collectively referred to as a B macroblock type. The value of mb_skip_run shall be in the range of 0 to PicSizeInMbs – CurrMbAddr, inclusive.

mb_skip_flag equal to 1 specifies that for the current macroblock, when decoding an EP slice, mb_type shall be inferred to be P_Skip and the macroblock type is collectively referred to as P macroblock type, or for which, when decoding an EB slice, mb_type shall be inferred to be B_Skip and the macroblock type is collectively referred to as B macroblock type. mb_skip_flag equal to 0 specifies that the current macroblock is not skipped.

G.7.4.5 Macroblock layer semantics

The semantics specified in subclause 7.4.5 apply. Additionally, the following applies.

The macroblock_layer( ) syntax structure shall be considered to contain the following syntax elements with the following inferred values.

– base_mode_flag is inferred to be equal to 0.

– residual_prediction_flag is inferred to be equal to 0.

G.7.4.5.1 Macroblock prediction semantics

The semantics specified in subclause 7.4.5.1 apply. Additionally, the following applies.

The mb_pred( ) syntax structure shall be considered to contain the following syntax elements with the following inferred values.

– motion_prediction_flag_l0[mbPartIdx] is inferred to be equal to 0 for each value of mbPartIdx in the range from 0 to NumMbPart(mb_type) − 1, inclusive.

– motion_prediction_flag_l1[mbPartIdx] is inferred to be equal to 0 for each value of mbPartIdx in the range from 0 to NumMbPart(mb_type) − 1, inclusive.

G.7.4.5.2 Sub-macroblock prediction semantics

The semantics specified in subclause 7.4.5.2 apply. Additionally, the following applies.

The sub_mb_pred( ) syntax structure shall be considered to contain the following syntax elements with the following inferred values.

– motion_prediction_flag_l0[mbPartIdx] is inferred to be equal to 0 for each value of mbPartIdx in the range from 0 to 3, inclusive.

– motion_prediction_flag_l1[mbPartIdx] is inferred to be equal to 0 for each value of mbPartIdx in the range from 0 to 3, inclusive.

G.7.4.5.3 Residual data semantics

The semantics specified in subclause 7.4.5.3 apply.

G.7.4.5.3.1 Residual luma semantics

The semantics specified in subclause 7.4.5.3.1 apply.

G.7.4.5.3.2 Residual block CAVLC semantics

The semantics specified in subclause 7.4.5.3.2 apply.

G.7.4.5.3.3 Residual block CABAC semantics

The semantics specified in subclause 7.4.5.3.3 apply.

G.7.4.6 Macroblock layer in scalable extension semantics

The semantic specified in subclauses 7.4.5 apply. Additionally, the following modifications and extensions are specified.

base_mode_flag equal to 1 specifies that the macroblock prediction mode as well as the corresponding motion data (when applicable) are inferred as specified in subclause G.8. base_mode_flag equal to 0 specifies that mb_type is not inferred.

When base_mode_flag is not present, base_mode_flag shall be inferred as follows.

– If in_crop_window(CurrMbAddr) is equal to 0, the value of base_mode_flag is inferred to be equal to 0.

– Otherwise (in_crop_window(CurrMbAddr) is equal to 1), the value of base_mode_flag is inferred to be equal to default_base_mode_flag.

When store_ref_base_pic_flag is equal to 1 and quality_id is greater than 0, base_mode_flag shall be equal to 1.

mb_type specifies the macroblock type. The semantics of mb_type depend on the slice type.

Tables and semantics are specified for the various macroblock types for EI, EP, and EB slices. Each table presents the value of mb_type, the name of mb_type, the number of macroblock partitions used (given by NumMbPart(mb_type) function), the prediction mode of the macroblock (when it is not partitioned) or the first partition (given by the MbPartPredMode(mb_type, 0) function) and the prediction mode of the second partition (given by the MbPartPredMode(mb_type, 1) function). When a value is not applicable it is designated by "na". In the text, the value of mb_type may be referred to as the macroblock type and a value X of MbPartPredMode( ) may be referred to in the text by "X macroblock (partition) prediction mode" or as "X prediction macroblocks".

Table G-3 shows the allowed collective macroblock types for each slice_type.

Table G-3 – Allowed collective macroblock types for slice_type.

slice_type	allowed collective macroblock types
EI (slice)	I (see Table 7-11 and Table G-4) (macroblock types)
EP (slice)	P (see Table 7-13) and I (see Table 7-11 and Table G-4) (macroblock types)
EB (slice)	B (see Table 7-14) and I (see Table 7-11 and Table G-4) (macroblock types)

Macroblock types that may be collectively referred to as I macroblock types are specified in Table G-4 and Table 7-11. mb_type value 0 is specified in Table G-4, whereas the other mb_type are specified in Table 7-11. Table G-4 additionally specifies the inferred macroblock type I_BL.

The macroblock types for EI slices are all I macroblock types.

Table G-4 – Macroblock types for EI slices.

mb_type	Name of mb_type	transform_size_8x8_flag	MbPartPredMode (mb_type, 0)	Intra16x16PredMode	CodedBlockPatternChroma	CodedBlockPatternLuma
0	I_NxN	0	Intra_4x4	na	Equation 7-34	Equation 7-34
0	I_NxN	1	Intra_8x8	na	Equation 7-34	Equation 7-34
inferred	I_BL	na	Intra_Base	na	Equation 7-34	Equation 7-34

Macroblock types that may be collectively referred to as P macroblock types are specified in Table 7-13.

The macroblock types for EP slices are specified in Table 7-13, Table 7-11 and Table G-4. mb_type values 0 to 4 are specified in Table 7-13, mb_type value 5 is specified in Table G-4 indexed by subtracting 5 from the value of mb_type and mb_type values 6 to 30 are specified in Table 7-11, indexed by subtracting 5 from the value of mb_type. Table G-4 additionally specifies the inferred macroblock type I_BL.

Macroblock types that may be collectively referred to as B macroblock types are specified in Table 7-14.

The macroblock types for EB slices are specified in Table 7-14, Table 7-11 and Table G-4. mb_type values 0 to 22 are specified in Table 7-14, mb_type values 23 is specified in Table G-4 indexed by subtracting 23 from the value of mb_type and mb_type 24 to 48 are specified in Table 7-14, indexed by subtracting 23 from the value of mb_type. Table G-4 additionally specifies the inferred macroblock type I_BL.

coded_block_pattern specifies which of the four 8x8 luma blocks and associated chroma blocks of a macroblock may contain non-zero transform coefficient values. For macroblocks with prediction mode not equal to Intra_16x16, coded_block_pattern is present in the bitstream and the variables CodedBlockPatternLuma and CodedBlockPatternChroma are derived as specified by Equation 7-34.

The meaning of CodedBlockPatternLuma and CodedBlockPatternChroma is specified in subclause 7.4.5.

residual_prediction_flag equal to 1 specifies that the residual signal of the current macroblock is predicted as specified in subclause G.8 using the layer representation specified by ref_layer_dq_id. residual_prediction_flag equal to 0 specifies that the residual signal of the current macroblock is not predicted.

When the syntax element residual_prediction_flag is not present, residual_prediction_flag shall be inferred as follows.

– If all of the following conditions are true, residual_prediction_flag is inferred to be equal to default_residual_prediction_flag.
  – slice_type is not equal to EI
  – in_crop_window(CurrMbAddr) is equal to 1
  – base_mode_flag is equal to 1 or mb_type does not specify an I macroblock type
– Otherwise, residual_prediction_flag is inferred to be equal to 0.

All elements of the arrays LumaLevel, LumaLevel8x8, Intra16x16DCLevel, Intra16x16ACLevel, CbLevel, CbLevel8x8, CbIntra16x16DCLevel, CbIntra16x16ACLevel, CrLevel, CrLevel8x8, CrIntra16x16DCLevel, CrIntra16x16ACLevel, ChromaDCLevel, and ChromaACLevel are set equal to 0 before parsing the residual( ) syntax structure.

G.7.4.6.1 Macroblock prediction in scalable extension semantics

The semantics specified in subclauses 7.3.5.1 apply. Additionally, the following semantics are specified.

motion_prediction_flag_l0[mbPartIdx **]** equal to 1 specifies that an alternative motion vectors prediction process as specified in subclause G.8 is used for deriving the list 0 motion vector of the macroblock partition mbPartIdx and that the list 0 reference index of the macroblock partition mbPartIdx is inferred as specified in subclause G.8.

When motion_prediction_flag_l0[mbPartIdx] is not present, motion_prediction_flag_l0[mbPartIdx] shall be inferred as follows.

– If in_crop_window(CurrMbAddr) is equal to 0, motion_prediction_flag_l0[mbPartIdx] is inferred to be equal to 0.
– Otherwise (in_crop_window(CurrMbAddr) is equal to 1), motion_prediction_flag_l0[mbPartIdx] is inferred to be equal to default_motion_prediction_flag.

motion_prediction_flag_l1[mbPartIdx **]** has the same semantics as motion_prediction_flag_l0[mbPartIdx], with l0 and list 0 replaced by l1 and list 1, respectively.

G.7.4.6.2 Sub-macroblock prediction in scalable extension semantics

The semantic specified in subclauses 7.4.5.2 apply. Additionally, the following semantics are specified.

motion_prediction_flag_l0[mbPartIdx **]** and **motion_prediction_flag_l1[** mbPartIdx **]** have the same semantics as specified in subclause G.7.3.6.1.

G.8 SVC decoding process

This subclause describes the decoding process for an access unit, given syntax elements and upper-case variables from subclause G.7 (with reference made to clause 7 in subclause G.7) that are derived from the bitstream.

NOTE 1 – All syntax elements and upper-case variables from subclause G.7 are available for the entire current access unit. When syntax elements or upper-case variables appear with identical names in subclause G.7 they are referred herein through unique identifiers.

Output of this process are decoded samples of the current primary coded picture.

The decoding process is specified such that all decoders shall produce numerically identical results. Any decoding process that produces identical results to the process described here conforms to the decoding process requirements of this Recommendation | International Standard.

All sub-bitstreams that can be derived using the sub-bitstream extraction process as specified in subclause G.8.8.1 with any combination of values for priority_id, temporal_id, dependency_id, or quality_id as the input shall result in a set of coded video sequences, with each coded video sequence conforming to one or more of the profiles specified in Annex A and Annex G.

This subclause specifies the decoding process for an access unit of a coded video sequence conforming to one or more of the profiles specified in subclause G.10.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the decoding process specified in this subclause and all child processes invoked from the process specified in this subclause are the syntax elements and derived upper-case variables for the current access unit.

At the start of the decoding process for an access unit, the following applies.

1. Variables and functions relating to picture order count are derived by invoking the SVC decoding process for picture order count as specified in subclause G.8.2.1.
2. The SVC decoding process for gaps in frame_num as specified in subclause G.8.2.5 is invoked.
3. For each value of dependency_id present in the NAL units that are input to this process as specified above, the following applies.
   - The decoding process for macroblock to slice group map as specified in subclause 8.2.2 is invoked with the syntax elements of the NAL units with dependency_id as input.
   - The function NextMbAddress( ) as specified in subclause 8.2.2 is used for parsing the slice data syntax structures of all NAL units with the corresponding value of dependency_id.

The derivation process for the set of layer representations required for decoding as specified in subclause G.8.1.1 is invoked and the output is a list dqIdList of integer values specifying layer representation identifiers. The variables DQIdMin and DQIdMax are set equal to the minimum and maximum values, respectively, of the entries of the list dqIdList, and the variable DependencyIdMax is set equal to (DQIdMax >> 4). DependencyIdMax shall be the same for all access units of the coded video sequence.

The collective terms currentVars and refLayerVars are initially marked as not available.

The variable currDQId proceeds over the values DQIdMin..DQIdMax, and when a value of currDQId is present in the list dqIdList, the following ordered steps apply.

1. The variable spatResChangeFlag is set equal to the variable SpatialResolutionChangeFlag of the layer representation with DQId equal to currDQId.
2. Depending on spatResChangeFlag, the following applies.
   - If spatResChangeFlag is equal to 0, the base decoding process for layer representations without resolution change as specified in subclause G.8.1.3.1 is invoked with currDQId and currentVars as the inputs and the output is a modified version of currentVars.
   - Otherwise (spatResChangeFlag is equal to 1), the base decoding process for layer representations with resolution change as specified in subclause G.8.1.3.2 is invoked with currDQId and currentVars as the inputs and the outputs are variables assigned to the collective term refLayerVars and a modified version of currentVars.
3. When currDQId is equal to (DependencyIdMax << 4) and store_ref_base_pic_flag for the dependency representation with dependency_id equal to DependencyIdMax is equal to 1, the target layer representation decoding process as specified in subclause G.8.1.3.3 is invoked with currDQId, refLayerVars, and currentVars

as the inputs and the outputs are assigned to the sample array B_L and, when ChromaArrayType is not equal to 0, the sample arrays B_{Cb} and B_{Cr}.

NOTE 2 – The sample arrays B_L, B_{Cb}, and B_{Cr} represent the reference base picture for an access unit with store_ref_base_pic_flag equal to 1 for the dependency representation with dependency_id equal to DependencyIdMax.

The target layer representation decoding process as specified in subclause G.8.1.3.3 is invoked with currDQId, refLayerVars, and currentVars as the inputs and the outputs are assigned to the sample array S_L and, when ChromaArrayType is not equal to 0, the sample arrays S_{Cb} and S_{Cr}.

NOTE 3 – The sample arrays S_L, S_{Cb}, and S_{Cr} represent the decoded picture for the access unit.

The SVC decoded reference picture marking process as specified in subclause G.8.2.4 is invoked.

G.8.1 SVC initialisation and decoding processes

Subclause G.8.1.1 specifies the derivation process for the set of layer representations required for decoding.

Subclause G.8.1.2 specifies the array assignment, initialisation, and restructuring processes.

Subclause G.8.1.3 specifies the layer representation decoding processes.

Subclause G.8.1.4 specifies the slice decoding processes.

Subclause G.8.1.5 specifies the macroblock initialisation and decoding processes.

G.8.1.1 Derivation process for the set of layer representations required for decoding

Inputs to this process are the coded slice NAL units of an access unit.

Output of this process is a list dqIdList of integer values specifying layer representation identifiers.

With currDQId being set equal to the maximum value of DQId for all coded slice NAL units of the access unit and with refLayerDQId(dqId) specifying the maximum value of ref_layer_dq_id for all coded slice NAL units of the layer representation of the access unit with DQId equal to dqId, the list dqIdList is derived as specified by the following pseudo-code.

```
numEntries = 0
dqIdList[ numEntries++ ] = currDQId
while( refLayerDQId( currDQId ) >= 0 )  {
    dqIdList[ numEntries++ ] = refLayerDQId( currDQId )                    (G-78)
    currDQId = dqIdList[ numEntries – 1 ]
}
```

G.8.1.2 Array assignment, initialisation, and restructuring processes

Subclause G.8.1.2.1 specifies the array assignment and initialisation process.

Subclause G.8.1.2.2 specifies the array restructuring process.

G.8.1.2.1 Array assignment and initialisation process

Output of this process is a set of arrays that are assigned to the collective term currentVars.

The following arrays are collectively referred to as currentVars.

– A one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as sliceIdc[mbAddr]. All elements of the array sliceIdc are initially marked as unspecified.

– A one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of a layer representation are field macroblocks and which macroblocks are frame macroblocks. An element of this array for a macroblock with address mbAddr is referred to as fieldMbFlag[mbAddr]. All elements of the array fieldMbFlag are initially marked as unspecified.

– A one-dimensional array cTrafo with PicSizeInMbs elements specifying the luma and, when ChromArrayType is equal to 3, chroma transform types for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as cTrafo[mbAddr]. Unless marked as unspecified, each element of cTrafo is equal to T_4x4, T_8x8, T_16x16, or T_PCM. All elements of the array cTrafo are initially marked as unspecified.

– A one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as mbType[mbAddr]. Unless marked as unspecified, each element of mbType is equal to I_4x4, I_8x8, I_16x16, I_PCM, I_BL, or one of the Inter macroblock types specified in Table 7-13 and Table 7-14. All elements of the array mbType are initially marked as unspecified.

– A (PicSizeInMbs)x4 array subMbType specifying sub-macroblock types for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr and a macroblock partition index mbPartIdx is referred to as subMbType[mbAddr][mbPartIdx]. A one-dimensional array specifying sub-macroblock types for the macroblock partitions of a macroblock with address mbAddr is referred to as subMbType[mbAddr]. Unless marked as unspecified, each element of subMbType is equal to one of the sub-macroblock types specified in Table 7-17 and Table 7-18. All elements of the array subMbType are initially marked as unspecified.

– A one-dimensional array mvCnt with PicSizeInMbs elements specifying the number of motion vectors for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as mvCnt[mbAddr]. All elements of the array mvCnt are initially set equal to 0.

– A one-dimensional array tQP_Y with PicSizeInMbs elements specifying luma quantisation parameters for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as tQP_Y[mbAddr]. All elements of the array tQP_Y are initially set equal to 0.

– When ChromaArrayType is not equal to 0, two one-dimensional arrays tQP_{Cb} and tQP_{Cr} with PicSizeInMbs elements specifying Cb and Cr quantisation parameters, respectively, for the macroblocks of a layer representation. An element of these arrays for a macroblock with address mbAddr is referred to as tQP_{CX}[mbAddr] with CX being replaced by Cb or Cr. All elements of the arrays tQP_{Cb} and tQP_{Cr} are initially set equal to 0.

– A (PicSizeInMbs)x16 array ipred4x4 specifying Intra_4x4 prediction modes for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr and a 4x4 block with index c4x4BlkIdx is referred to as ipred4x4[mbAddr][c4x4BlkIdx]. A one-dimensional array specifying Intra_4x4 prediction modes for the 4x4 blocks of a macroblock with address mbAddr is referred to as ipred4x4[mbAddr]. All elements of the array ipred4x4 are initially marked as unspecified.

– A (PicSizeInMbs)x4 array ipred8x8 specifying Intra_8x8 prediction modes for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr and a 8x8 block with index c8x8BlkIdx is referred to as ipred8x8[mbAddr][c8x8BlkIdx]. A one-dimensional array specifying Intra_8x8 prediction modes for the 8x8 blocks of a macroblock with address mbAddr is referred to as ipred8x8[mbAddr]. All elements of the array ipred8x8 are initially marked as unspecified.

– A one-dimensional array ipred16x16 with PicSizeInMbs elements specifying Intra_16x16 prediction modes for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as ipred16x16[mbAddr]. All elements of the array ipred16x16 are initially marked as unspecified.

– When ChromaArrayType is equal to 1 or 2, a one-dimensional array ipredChroma with PicSizeInMbs elements specifying intra chroma prediction modes for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as ipredChroma[mbAddr]. All elements of the array ipredChroma are initially marked as unspecified.

– Two (PicSizeInMbs)x4 arrays predFlagL0 and predFlagL1 specifying prediction utilization flags for the macroblocks of a layer representation. An element of these arrays for a macroblock with address mbAddr and a macroblock partition index mbPartIdx is referred to as predFlagLX[mbAddr][mbPartIdx] with X being replaced by 0 or 1. A one-dimensional array specifying prediction utilization flags for the macroblock partitions of a macroblock with address mbAddr is referred to as predFlagLX[mbAddr] with X being replaced by 0 or 1. All elements of the arrays predFlagL0 and predFlagL1 are initially set equal to 0.

– Two (PicSizeInMbs)x4 arrays refIdxL0 and refIdxL1 specifying reference indices for the macroblocks of a layer representation. An element of these arrays for a macroblock with address mbAddr and a macroblock partition index mbPartIdx is referred to as refIdxLX[mbAddr][mbPartIdx] with X being replaced by 0 or 1. A one-dimensional array specifying reference indices for the macroblock partitions of a macroblock with address mbAddr is referred to as refIdxLX[mbAddr] with X being replaced by 0 or 1. All elements of the arrays refIdxL0 and refIdxL1 are initially set equal to –1.

– Two (PicSizeInMbs)x4x4x2 arrays mvL0 and mvL1 specifying motion vector components for the macroblocks of a layer representation. An element of these arrays for a macroblock with address mbAddr, a macroblock partition index mbPartIdx, a sub-macroblock partition index subMbPartIdx, and a motion vector component index c is referred to as mvLX[mbAddr][mbPartIdx][subMbPartIdx][c] with X being replaced by 0 or 1. A one-dimensional array with 2 elements representing the motion vector for a sub-macroblock partition

subMbPartIdx of a macroblock partition mbPartIdx inside a macroblock mbAddr is referred to as mvLX[mbAddr][mbPartIdx][subMbPartIdx] with X being replaced by 0 or 1. A 4x2 array representing the motion vectors for a macroblock partition mbPartIdx inside a macroblock mbAddr is referred to as mvLX[mbAddr][mbPartIdx] with X being replaced by 0 or 1. A 4x4x2 array representing the motion vectors for a macroblock mbAddr is referred to as mvLX[mbAddr] with X being replaced by 0 or 1. A motion vector component with component index c for a macroblock partition mbPartIdx of a macroblock mbAddr that is not split into sub-macroblock partitions can also be referred to as mvLX[mbAddr][mbPartIdx][c] with X being replaced by 0 or 1, which is identical to mvLX[mbAddr][mbPartIdx][0][c]. A motion vector for a macroblock partition mbPartIdx of a macroblock mbAddr that is not split into sub-macroblock partitions can also be referred to as mvLX[mbAddr][mbPartIdx] with X being replaced by 0 or 1, which is identical to mvLX[mbAddr][mbPartIdx][0]. All elements of the arrays mvL0 and mvL1 are initially set equal to 0.

– A (PicSizeInMbs)x(256 + 2 * MbWidthC * MbHeightC) array tCoeffLevel specifying transform coefficient level values for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr and a transform coefficient index tCoeffIdx is referred to as tCoeffLevel[mbAddr][tCoeffIdx]. A one-dimensional array specifying the transform coefficient level values for a macroblock with address mbAddr is referred to as tCoeffLevel[mbAddr]. All elements of the array tCoeffLevel are initially set equal to 0.

– A (PicSizeInMbs)x(256 + 2 * MbWidthC * MbHeightC) array sTCoeff specifying scaled transform coefficient values for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr and a transform coefficient index tCoeffIdx is referred to as sTCoeff[mbAddr][tCoeffIdx]. A one-dimensional array specifying the scaled transform coefficient values for a macroblock with address mbAddr is referred to as sTCoeff[mbAddr]. All elements of the array sTCoeff are initially set equal to 0.

– A ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array rS_L specifying residual luma sample values for a layer picture. An element of this array for a luma location (x, y) relative to the upper-left luma sample of the macroblock with address 0 is referred to as rS_L[x, y]. All elements of the array rS_L are initially set equal to 0.

– When ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays rS_{Cb} and rS_{Cr} specifying residual chroma sample values for a layer picture. An element of these arrays for a chroma location (x, y) relative to the upper-left chroma sample of the macroblock with address 0 is referred to as rS_{CX}[x, y] with CX being replaced by Cb or Cr. All elements of the arrays rS_{Cb} and rS_{Cr} are initially set equal to 0.

– A ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array cS_L specifying constructed luma sample values for a layer picture. An element of this array for a luma location (x, y) relative to the upper-left luma sample of the macroblock with address 0 is referred to as cS_L[x, y]. All elements of the array cS_L are initially set equal to 0.

– When ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays cS_{Cb} and cS_{Cr} specifying constructed chroma sample values for a layer picture. An element of these arrays for a chroma location (x, y) relative to the upper-left chroma sample of the macroblock with address 0 is referred to as cS_{CX}[x, y] with CX being replaced by Cb or Cr. All elements of the arrays cS_{Cb} and cS_{Cr} are initially set equal to 0.

G.8.1.2.2 Array restructuring process

This process is only invoked when no_inter_layer_pred_flag is equal to 0, SpatialResolutionChangeFlag is equal to 0, and any of the variables ScaledRefLayerLeftOffset, ScaledRefLayerRightOffset, ScaledRefLayerTopOffset, or ScaledRefLayerBottomOffset is not equal to 0.

Input to this process is a set of arrays collectively referred to as currentVars.

Output of this process is the set of arrays collectively referred to as currentVars with modifications related to the array sizes as well as the ordering of array elements.

The variables that are assigned to the collective term currentVars are assigned to the collective term refLayerVars.

The array assignment and initialisation process as specified in subclause G.8.1.2.1 is invoked and the output is the set of arrays collectively referred to as currentVars.

The variables xOffset, yOffset, xOffsetC, and yOffsetC are derived by

xOffset = ScaledRefLayerLeftOffset (G-79)
yOffset = ScaledRefLayerTopOffset / (1 + field_pic_flag) (G-80)
xOffsetC = (xOffset >> 4) * MbWidthC (G-81)
yOffsetC = (yOffset >> 4) * MbHeightC (G-82)

For the macroblock address mbAddr proceeding over the values 0..(PicSizeInMbs – 1), the following ordered steps are specified.

1. With eS set equal to (1 + MbaffFrameFlag), the variables refMbX and refMbY are derived by

$$refMbX = ((mbAddr / eS) \% PicWidthInMbs) - (xOffset / 16) \quad \text{(G-83)}$$
$$refMbY = ((mbAddr / eS) / PicWidthInMbs) * eS + (mbAddr \% eS) - (yOffset / 16) \quad \text{(G-84)}$$

2. The reference layer macroblock address refMbAddr is derived as follows.
   - If any of the following conditions is true, refMbAddr is marked as not available.
     - refMbX is less than 0 or refMbX is greater than or equal to RefLayerPicWidthInMbs
     - refMbY is less than 0 or refMbY is greater than or equal to RefLayerPicHeightInMbs
   - Otherwise, with bS set equal to (1 + RefLayerMbaffFrameFlag), refMbAddr is derived by

$$refMbAddr = (refMbY / bS) * bS * RefLayerPicWidthInMbs + (refMbY \% bS) + refMbX \quad \text{(G-85)}$$

3. When refMbAddr is available, for X being replaced by sliceIdc, fieldMbFlag, cTrafo, mbType, subMbType, mvCnt, tQP_Y, tQP_{Cb} (when ChromaArrayType is not equal to 0), tQP_{Cb} (when ChromaArrayType is not equal to 0), ipred4x4, ipred8x8, ipred16x16, ipredChroma (when ChromaArrayType is equal to 1 or 2), predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, tCoeffLevel, and sTCoeff and with currArray representing the array X of the collective term currentVars and refLayerArray representing the array X of the collective term refLayerVars, the array element currArray[mbAddr], which can be a scalar or an array, is set equal to the array element refLayerArray[refMbAddr].

For X being replaced by rS_Y and cS_Y and with currArray representing the array X of the collective term currentVars and refLayerArray representing the array X of the collective term refLayerVars, the array currArray is modified by

$$currArray[x, y] = refLayerArray[x - xOffset, y - yOffset] \quad \text{(G-86)}$$

with $x = Max(0, xOffset)..Min(PicWidthInSamples_L, RefLayerPicWidthInSamples_L - xOffset)$
and $y = Max(0, yOffset)..Min(PicHeightInSamples_L, RefLayerPicHeightInSamples_L - yOffset)$

When ChromaArrayType is not equal to 0, for X being replaced by rS_{Cb}, rS_{Cr}, cS_{Cb}, and cS_{Cr} and with currArray representing the array X of the collective term currentVars and refLayerArray representing the array X of the collective term refLayerVars, the array currArray is modified by

$$currArray[x, y] = refLayerArray[x - xOffsetC, y - yOffsetC] \quad \text{(G-87)}$$

with $x = Max(0, xOffsetC)..Min(PicWidthInSamples_C, RefLayerPicWidthInSamples_C - xOffsetC)$
and $y = Max(0, yOffsetC)..Min(PicHeightInSamples_C, RefLayerPicHeightInSamples_C - yOffsetC)$

G.8.1.3 Layer representation decoding processes

Subclause G.8.1.3.1 specifies the base decoding process for layer representations without resolution change.

Subclause G.8.1.3.2 specifies the base decoding process for layer representations with resolution change.

Subclause G.8.1.3.3 specifies the target layer representation decoding process

G.8.1.3.1 Base decoding process for layer representations without resolution change

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a set of arrays collectively referred to as currentVars.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current layer representation with DQId equal to currDQId.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current layer representation with DQId equal to currDQId.

The base decoding process for layer representations without resolution change proceeds in the following ordered steps.

1. The variable noInterLayerPredFlag is set equal to the minimum value of no_inter_layer_pred_flag of the slices of the layer representation with DQId equal to currDQId.

2. Depending on noInterLayerPredFlag, the following applies.

   – If noInterLayerPredFlag is equal to 1, the array assignment and initialisation process as specified in subclause G.8.1.2.1 is invoked and the output is a modified set of arrays collectively referred to as currentVars.

   – Otherwise (noInterLayerPredFlag is equal to 0), the following ordered steps are specified.

      a. When tcoeff_level_prediction_flag is equal to 0, the macroblock address mbAddr proceeds over the values 0..(RefLayerPicSizeInMbs – 1), and for each macroblock address mbAddr, the macroblock decoding process prior to decoding a layer representation without resolution change and tcoeff_level_prediction_flag equal to 0 as specified in subclause G.8.1.5.4 is invoked with ref_layer_dq_id, mbAddr, and currentVars as the inputs and the output is a modified version of currentVars.

      b. When any of the variables ScaledRefLayerLeftOffset, ScaledRefLayerRightOffset, ScaledRefLayerTopOffset, or ScaledRefLayerBottomOffset is not equal to 0, the array restructuring process as specified in subclause G.8.1.2.2 is invoked with currentVars as the input and the output is a modified version of currentVars.

3. Let setOfSlices be the set of all slices of the current layer representation with DQId equal to currDQId. For each slice of the set setOfSlices, the base decoding process for slices without resolution change as specified in subclause G.8.1.4.1 is invoked with currSlice representing the currently processed slice, currDQId, and currentVars as the inputs and the output is a modified version of currentVars.

4. When currDQId is less than or equal to (DependencyIdMax << 4), with sliceIdc being the array sliceIdc of the collective term currentVars, the bitstream shall not contain data that results in any value of (sliceIdc[mbAddr] & 127) with mbAddr = 0..(PicSizeInMbs – 1) not equal to currDQId.

   NOTE – This constraint and a similar constraint in subclause G.8.1.3.2 specify that all layer representations with quality_id equal to 0 and all layer representations that are employed for inter-layer prediction shall be completely covered by the slices of the access unit. An additional constraint for layer representations with dependency_id equal to DependencyIdMax and quality_id greater than 0 is specified in subclause G.8.1.5.1.

G.8.1.3.2 Base decoding process for layer representations with resolution change

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a set of arrays collectively referred to as currentVars.

Outputs of this process are

– a set of arrays collectively referred to as refLayerVars,

– the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current layer representation with DQId equal to currDQId.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current layer representation with DQId equal to currDQId.

The base decoding process for layer representations with resolution change proceeds in the following ordered steps.

1. The macroblock address mbAddr proceeds over the values 0..(RefLayerPicSizeInMbs – 1), and for each macroblock address mbAddr, the macroblock decoding process prior to resolution change as specified in subclause G.8.1.5.5 is invoked with ref_layer_dq_id, mbAddr, and currentVars as the inputs and the output is a modified version of currentVars.

2. The deblocking filter process for Intra_Base prediction as specified in subclause G.8.7.1 is invoked with dependencyIdRefLayer set equal to (ref_layer_dq_id >> 4) and currentVars as the inputs and the output is a modified version of currentVars.

3. The variables that are assigned to the collective term currentVars are assigned to the collective term refLayerVars.

4. The array assignment and initialisation process as specified in subclause G.8.1.2.1 is invoked and the output is assigned to the collective term currentVars.

5. Let setOfSlices be the set of all slices of the current layer representation with DQId equal to currDQId. For each slice of the set setOfSlices, the base decoding process for slices with resolution change as specified in subclause G.8.1.4.2 is invoked with currSlice representing the currently processed slice, currDQId, refLayerVars, and currentVars as the inputs and the output is a modified version of currentVars.

6. With sliceIdc being the array sliceIdc of the collective term currentVars, the bitstream shall not contain data that results in any value of (sliceIdc[mbAddr] & 127) with mbAddr = 0..(PicSizeInMbs – 1) not equal to currDQId.

   NOTE – This constraint and a similar constraint in subclause G.8.1.3.1 specify that all layer representations with quality_id equal to 0 and all layer representation that are employed for inter-layer prediction shall be completely covered by the slices of the access unit. An additional constraint for layer representations with dependency_id equal to DependencyIdMax and quality_id greater than 0 is specified in subclause G.8.1.5.1.

G.8.1.3.3 Target layer representation decoding process

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a set of arrays collectively referred to as refLayerVars,

– a set of arrays collectively referred to as currentVars.

Outputs of this process are

– a (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$) array s_L containing constructed luma sample values,

– when ChromaArrayType is not equal to 0, two (PicWidthInSamples$_C$)x(PicHeightInSamples$_C$) arrays s_{Cb} and s_{Cr} containing constructed chroma sample values.

In this process the constructed samples of the array s_L and, when ChromaArrayType is not equal to 0, the arrays s_{Cb} and s_{Cr} are derived using the variables that are assigned to currentVars.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current layer representation with DQId equal to currDQId.

The target layer representation decoding process proceeds in the following ordered steps.

1. The variables that are assigned to the collective term currentVars are assigned to the collective term tempVars, and in the following of this subclause, the arrays that are collectively referred to as tempVars are referred to by their names as specified in subclause G.8.1.2.1.

   NOTE 1 – Any following modification of the variables assigned to the collective term tempVars does not influence the variables assigned to the collective term currentVars.

2. The reference picture lists refPicList0 and refPicList1 are initially marked as not available.

3. The macroblock address mbAddr proceeds over the values 0..(PicSizeInMbs – 1), and for each macroblock address mbAddr, the following ordered steps are specified.

   a. Let currSlice specify the slice with DQId equal to (((sliceIdc[mbAddr] & 127) >> 4) << 4) and first_mb_in_slice equal to (sliceIdc[mbAddr] >> 7).

   b. Let firstMbInSlice and sliceType be the syntax elements first_mb_in_slice and slice_type of the slice currSlice.

   c. When mbAddr is equal to firstMbInSlice, the reference picture lists refPicList0 and refPicList1 are marked as not available.

   d. When mbAddr is equal to firstMbInSlice and (sliceType % 5) is less than 2, the SVC decoding process for reference picture lists construction as specified in subclause G.8.2.3 is invoked with dependency_id, use_ref_base_pic_flag, and the current slice as the inputs and the outputs are the modified reference picture list refPicList0 and, when (sliceType % 5) is equal to 1, the modified reference picture list refPicList1.

      NOTE 2 – The reference picture lists refPicList0 and refPicList1 are only constructed for the slices of the layer representation with dependency_id equal to DependencyIdMax and quality_id equal to 0. For slices with dependency_id equal to DependencyIdMax and quality_id greater than 0, the reference picture lists are inferred.

e. The target macroblock decoding process as specified in subclause G.8.1.5.6 is invoked with currDQId, mbAddr, refLayerVars, tempVars, refPicList0 (when available), and refPicList1 (when available) as the inputs and the output is a modified version of tempVars.

NOTE 3 – Although the target layer representation decoding process is invoked twice for pictures with store_ref_base_pic_flag equal to 1, only a single motion compensation operation is needed for each macroblock.

4. The deblocking filter process for target representations as specified in subclause G.8.7.2 is invoked with tempVars as the input and the output is a modified version of tempVars.

5. All sample values of the array S_L are copied to the array s_L, which is output of this subclause.

6. When ChromaArrayType is not equal to 0, all sample values of the arrays S_{Cb} and S_{Cr} are copied to the arrays s_{Cb} and s_{Cr}, respectively, which are output of this subclause.

G.8.1.4 Slice decoding processes

Subclause G.8.1.4.1 specifies the base decoding process for slices without resolution change.

Subclause G.8.1.4.2 specifies the base decoding process for slices with resolution change.

G.8.1.4.1 Base decoding process for slices without resolution change

Inputs to this process are

– the current slice currSlice,

– a variable currDQId specifying the current layer representation,

– a set of arrays collectively referred to as currentVars.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current slice currSlice.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the slice header of the current slice currSlice, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice currSlice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

When currDQId is equal to 0 and (slice_type % 5) is equal to 1, the SVC decoding process for reference picture lists construction as specified in subclause G.8.2.3 is invoked with currDependencyId equal to 0, useRefBasePicFlag equal to use_ref_base_pic_flag, and the current slice as input and the output is the reference picture list refPicList1.

The macroblocks of the current slice currSlice are processed in increasing order of their macroblock addresses. For each macroblock with macroblock address mbAddr, the base decoding process for macroblocks in slices without resolution change as specified in subclause G.8.1.5.2 is invoked with currDQId, mbAddr, currentVars, and, when currDQId is equal to 0 and (slice_type % 5) is equal to 1, the reference picture list refPicList1 as the inputs and the output is a modified version of currentVars.

G.8.1.4.2 Base decoding process for slices with resolution change

Inputs to this process are

– the current slice currSlice,

– a variable currDQId specifying the current layer representation,

– a set of arrays collectively referred to as refLayerVars,

– a set of arrays collectively referred to as currentVars.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current slice currSlice.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the slice header of the current slice currSlice, the current picture parameter, which is identified

by the syntax element pic_parameter_set_id inside the slice header of the current slice currSlice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

When CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2, the SVC decoding process for reference picture lists construction as specified in subclause G.8.2.3 is invoked with dependency_id, use_ref_base_pic_flag, and the current slice as the inputs and the outputs are the reference picture list refPicList0 and, when (sliceType % 5) is equal to 1, the reference picture list refPicList1.

The macroblocks of the current slice currSlice are processed in increasing order of their macroblock addresses. For each macroblock with macroblock address mbAddr, the base decoding process for macroblocks in slices with resolution change as specified in subclause G.8.1.5.3 is invoked with currDQId, mbAddr, refLayerVars, currentVars, refPicList0 (when CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2), and refPicList1 (when CroppingChangeFlag is equal to 1 and (slice_type % 5) is equal to 1) as the inputs and the output is a modified version of currentVars.

G.8.1.5 Macroblock initialisation and decoding processes

Subclause G.8.1.5.1 specifies the macroblock initialisation process.

Subclause G.8.1.5.2 specifies the base decoding process for macroblocks in slices without resolution change.

Subclause G.8.1.5.3 specifies the base decoding process for macroblocks in slices with resolution change.

Subclause G.8.1.5.4 specifies the macroblock decoding process prior to decoding a layer representation without resolution change and tcoeff_level_prediction_flag equal to 0.

Subclause G.8.1.5.5 specifies the macroblock decoding process prior to resolution change.

Subclause G.8.1.5.6 specifies the target macroblock decoding process.

G.8.1.5.1 Macroblock initialisation process

Inputs to this process are

– a set of arrays collectively referred to as refLayerVars,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2, the reference picture list refPicList0,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Outputs of this process are

– a variable sliceIdc specifying the slice identification for the current macroblock,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable cTrafo specifying the transform type for the current macroblock,

– a variable mbType specifying the macroblock type of the current macroblock,

– a list subMbType with 4 elements specifying the sub-macroblock types of the current macroblock,

– a variable mvCnt specifying an initialisation value for the motion vector count of the current macroblock,

– a variable tQP_Y specifying the luma quantisation parameter for the current macroblock,

– when ChromaArrayType is not equal to 0, two variables tQP_{Cb} and tQP_{Cr} specifying the chroma quantisation parameters for the current macroblock.

– two 2x2 arrays refIdxILPredL0 and refIdxILPredL1 specifying inter-layer predictors for the reference indices of the current macroblock,

– two 4x4x2 arrays mvILPredL0 and mvILPredL1 specifying inter-layer predictors for the motion vector components of the current macroblock.

Inside this subclause, the arrays sliceIdc, fieldMbFlag, cTrafo, mbType, subMbType, tQP_Y, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, and sTCoeff that are collectively referred to as refLayerVars are referred to as refLayerSliceIdc, refLayerFieldMbFlag, refLayerCTrafo, refLayerMbType, refLayerSubMbType, $refLayerQP_Y$, refLayerPredFlagL0, refLayerPredFlagL1, refLayerRefIdxL0, refLayerRefIdxL1, refLayerMvL0, refLayerMvL1, and refLayerSTCoeff, respectively.

The variable sliceIdc is set equal to ((first_mb_in_slice << 7) + DQId).

The variable fieldMbFlag is derived as follows.

– If field_pic_flag is equal to 1, fieldMbFlag is set equal to 1.

– Otherwise, if SpatialResolutionChangeFlag is equal to 0 and slice_skip_flag is equal to 1, fieldMbFlag is set equal to refLayerFieldMbFlag[CurrMbAddr].

– Otherwise, fieldMbFlag is set equal to mb_field_decoding_flag.

The derivation process for macroblock type, sub-macroblock type, and inter-layer predictors for reference indices and motion vectors as specified in subclause G.8.1.5.1.1 is invoked with fieldMbFlag, refLayerFieldMbFlag, refLayerMbType, refLayerSubMbType, refLayerPredFlagL0, refLayerPredFlagL1, refLayerRefIdxL0, refLayerRefIdxL1, refLayerMvL0, refLayerMvL1, refPicList0 (when available), and refPicList1 (when available) as the inputs and the outputs are the variable mbType, the list subMbType, the 2x2 arrays refIdxILPredL0 and refIdxILPredL1, and the 4x4x2 arrays mvILPredL0 and mvILPredL1.

The derivation process for quantisation parameters and transform type as specified in subclause G.8.1.5.1.2 is invoked with mbType, subMbType, refLayerMbType, refLayerCTrafo, refLayerQP_Y, and refLayerSTCoeff as the inputs and the outputs are cTrafo, tQP_Y, and, when ChromaArrayType is not equal to 0, tQP_{Cb} and tQP_{Cr}.

The variable mvCnt is set equal to 0.

When quality_id is greater than 0, the bitstream shall not contain data that result in (sliceIdcRefLayer[CurrMbAddr] & 127) not equal to (DQId – 1).

When no_inter_layer_pred_flag is equal to 0, SpatialResolutionChangeFlag is equal to 0, and fieldMbFlag is not equal to refLayerFieldMbRef[CurrMbAddr], the following constraints shall be obeyed.

a) The bitstream shall not contain data that result in base_mode_flag equal to 1, or any motion_prediction_flag_lX[mbPartIdx] with X being replaced by 0 and 1 and mbPartIdx = 0..3 equal to 1.

b) When residual_prediction_flag is equal to 1, the bitstream shall not contain data that result in any element refLayerSTCoeff[CurrMbAddr][i] not equal to 0 for i = 0..(255 + 2 * MbWidthC * MbHeightC).

G.8.1.5.1.1 Derivation process for macroblock type, sub-macroblock type, and inter-layer predictors for reference indices and motion vectors

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying the macroblock types for the macroblocks of the reference layer representation,

– a (RefLayerPicSizeInMbs)x4 array refLayerSubMbType specifying the sub-macroblock types for the macroblocks of the reference layer representation,

– two (RefLayerPicSizeInMbs)x4 arrays refLayerPredFlagL0 and refLayerPredFlagL1 specifying prediction utilization flags for the macroblocks of the reference layer representation,

– two (RefLayerPicSizeInMbs)x4 arrays refLayerRefIdxL0 and refLayerRefIdxL1 specifying reference indices for the macroblocks of the reference layer representation,

– two (RefLayerPicSizeInMbs)x4x4x2 arrays refLayerMvL0 and refLayerMvL1 specifying motion vector components for the macroblocks of the reference layer representation,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2, the reference picture list refPicList0,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Outputs of this process are

– a variable mbType specifying the macroblock type of the current macroblock,

– a list subMbType with 4 elements specifying the sub-macroblock types of the current macroblock,

– two 2x2 arrays refIdxILPredL0 and refIdxILPredL1 specifying inter-layer predictors for the reference indices of the current macroblock,

– two 4x4x2 arrays mvILPredL0 and mvILPredL1 specifying inter-layer predictors for the motion vector components of the current macroblock.

The variable mbTypeILPred, the list subMbTypeILPred, the 2x2 arrays refIdxILPredL0 and refIdxILPredL1, and the 4x4x2 arrays mvILPredL0 and mvILPredL1 are derived as follows.

– If base_mode_flag is equal to 1 or any syntax element motion_prediction_flag_lX[mbPartIdx] with X being replaced by 0 and 1 and mbPartIdx = 0..3 is equal to 1, the derivation process for inter-layer predictors for macroblock type, sub-macroblock type, reference indices, and motion vectors as specified in subclause G.8.6.1 is invoked with fieldMbFlag, refLayerFieldMbFlag, refLayerMbType, refLayerSubMbType, refLayerPredFlagL0, refLayerPredFlagL1, refLayerRefIdxL0, refLayerRefIdxL1, refLayerMvL0, refLayerMvL1, refPicList0 (when available), and refPicList1 (when available) as the inputs and the outputs are the variable mbTypeILPred, the list subMbTypeILPred, the 2x2 arrays refIdxILPredL0 and refIdxILPredL1, and the 4x4x2 arrays mvILPredL0 and mvILPredL1.

– Otherwise (base_mode_flag is equal to 0 and all syntax elements motion_prediction_flag_lX[mbPartIdx] with X being replaced by 0 and 1 and mbPartIdx = 0..3 are equal to 0), mbTypeILPred is marked as not available, all elements subMbTypeILPred[mbPartIdx] with mbPartIdx = 0..3 of the list subMbTypeILPred are marked as not available, all elements of the 2x2 arrays refIdxILPredL0 and refIdxILPredL1 are set equal to –1, and all elements of the 4x4x2 arrays mvILPredL0 and mvILPredL1 are set equal to 0.

Depending on base_mode_flag, mb_type, and transform_size_8x8_flag, the variable mbType is derived as follows.

– If base_mode_flag is equal to 1, mbType is set equal to mbTypeILPred.

– Otherwise, if MbPartPredMode(mb_type, 0) is equal to Intra_4x4, mbType is set equal to I_4x4.

– Otherwise, if MbPartPredMode(mb_type, 0) is equal to Intra_8x8, mbType is set equal to I_8x8.

– Otherwise, if MbPartPredMode(mb_type, 0) is equal to Intra_16x16, mbType is set equal to I_16x16.

– Otherwise, if mb_type is equal to I_PCM, mbType is set equal to I_PCM.

– Otherwise (base_mode_flag is equal to 0 and mb_type specifies a P or B macroblock type), mbType is set equal to mb_type.

Depending on mbType and base_mode_flag, the list subMbType is derived as follows.

– If mbType is not equal to P_8x8 or B_8x8, all elements subMbType[mbPartIdx] with mbPartIdx = 0..3 are marked as unspecified.

– Otherwise, if base_mode_flag is equal to 1, each element subMbType[mbPartIdx] with mbPartIdx = 0..3 is set equal to subMbTypeILPred[mbPartIdx].

– Otherwise (mbType is equal to P_8x8 or B_8x8 and base_mode_flag is equal to 0), each element subMbType[mbPartIdx] with mbPartIdx = 0..3 is set equal to sub_mb_type[mbPartIdx].

When slice_type is equal to EP and base_mode_flag is equal to 1, the bitstream shall not contain data that result in any element refIdxILPredL0[mbPartIdx] with mbPartIdx = 0..3 that is less than 0.

When residual_prediction_flag equal to 1 is present in the bitstream, the bitstream shall not contain data that result in mbType being equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL.

G.8.1.5.1.2 Derivation process for quantisation parameters and transform type

Inputs to this process are

– a variable mbType specifying the macroblock type for the current macroblock,

– a list subMbType with 4 elements specifying the sub-macroblock types for the current macroblock,

– a one-dimensional array refLayerMbType specifying macroblock types for the macroblocks of the reference layer representation,

– a one-dimensional array refLayerCTrafo specifying transform types for the macroblocks of the reference layer representation,

– a one-dimensional array refLayerQP_Y specifying luma quantisation parameters for the macroblocks of the reference layer representation,

– an (RefLayerPicSizeInMbs)x(256 + 2 * MbWidthC * MbHeightC) array refLayerSTCoeff specifying scaled transform coefficient values for the macroblocks of the reference layer representation.

Outputs of this process are

– a variable cTrafo specifying the transform type for the current macroblock,

– a variable tQP_Y specifying the luma quantisation parameter for the current macroblock,

– when ChromaArrayType is not equal to 0, two variables tQP_{Cb} and tQP_{Cr} specifying the chroma quantisation parameters for the current macroblock.

The variable tQP_Y is derived as follows.

– If SpatialResolutionChangeFlag is equal to 0, CodedBlockPatternLuma is equal to 0, CodedBlockPatternChroma is equal to 0, and any of the following conditions is true, tQP_Y is set equal to $refLayerQP_Y$[CurrMbAddr].

  – mbType is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL and base_mode_flag is equal to 1

  – mbType is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL and residual_prediction_flag is equal to 1

– Otherwise, tQP_Y is set equal to QP_Y.

When ChromaArrayType is not equal to 0, for CX being replaced by Cb and Cr, the variable tQP_{CX} is set equal to the value of QP_{CX} that corresponds to a value of tQP_Y for QP_Y as specified in subclause 8.5.8.

The variable predCoeffFlag is derived as follows.

– If SpatialResolutionChangeFlag is equal to 0 and any of the following conditions is true, predCoeffFlag is set equal to 1.

  – base_mode_flag is equal to 1, tcoeff_level_prediction_flag is equal to 0, and refLayerMbType[CurrMbAddr] is equal to I_BL,

  – base_mode_flag is equal to 1, tcoeff_level_prediction_flag is equal to 1, and mbType is equal to I_PCM, I_16x16, I_8x8, or I_4x4,

  – residual_prediction_flag is equal to 1 and mbType is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL

– Otherwise, predCoeffFlag is set equal to 0.

The variable cTrafo is derived as follows.

– If mbType is equal to I_PCM, cTrafo is set equal to T_PCM.

– Otherwise, if mbType is equal to I_16x16, cTrafo is set equal to T_16x16.

– Otherwise, if mbType is equal to I_8x8 or transform_size_8x8_flag is equal to 1, cTrafo is set equal to T_8x8.

– Otherwise, if predCoeffFlag is equal to 1, cTrafo is set equal to cTrafoRefLayer.

– Otherwise (predCoeffFlag is equal to 0, transform_size_8x8_flag is equal to 0, and mbType is not equal to I_PCM, I_16x16, or I_8x8), cTrafo is set equal to T_4x4.

When base_mode_flag is equal to 1, the following constraints shall be obeyed.

a) When mbType is equal to P_8x8 or B8x8 and NumSubMbPart(subMbType[mbPartIdx]) is not equal to 1 for any mbPartIdx = 0..3, the bitstream shall not contain transform_size_8x8_flag equal to 1.

b) When mbType is equal to I_PCM, the bitstream shall not contain data that result in CodedBlockPatternLuma not equal to 0 or CodedBlockPatternChroma not equal to 0.

c) When mbType is equal to I_16x16 or I_4x4, the bitstream shall not contain transform_8x8_size_flag equal to 1.

d) When mbType is equal to I_8x8 and transform_size_8x8_flag is equal to 0, the bitstream shall not contain data that result in CodedBlockPatternLuma not equal to 0.

When predCoeffFlag is equal to 1, the following constraints shall be obeyed.

a) When refLayerCTrafo[CurrMbAddr] is equal to T_8x8 and transform_size_8x8_flag is equal 0, the bitstream shall not contain data that result in CodedBlockPatternLuma not equal to 0.

b) When refLayerCTrafo[CurrMbAddr] is equal to T_4x4 and transform_size_8x8_flag equal to 1, the bitstream shall not contain data that result in any element refLayerSTCoeff[CurrMbAddr][i] not equal to 0 for i = 0..(ChromaArrayType != 3 ? 255 : 767).

G.8.1.5.2 Base decoding process for macroblocks in slices without resolution change

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a variable mbAddr specifying the current macroblock inside the current layer representation,

– a set of arrays collectively referred to as currentVars,

– when currDQId is equal to 0 and (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current macroblock, which is specified by its address mbAddr and the layer representation identifier currDQId.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current macroblock, which is the macroblock with address mbAddr inside the layer representation with DQId equal to currDQId, the slice header of the current slice, which is the slice that contains the current macroblock, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

The base decoding process for macroblocks in slices without resolution change is specified by the following ordered steps.

1. The variable CurrMbAddr is set equal to mbAddr.
2. When tcoeff_level_prediction_flag is equal to 1, the variable $refQP_Y$ is set equal to tQP_Y[mbAddr] and, when ChromaArrayType is not equal to 0, the variables $refQP_{Cb}$ and $refQP_{Cr}$ are set equal to tQP_{Cb}[mbAddr] and tQP_{Cr}[mbAddr], respectively.
3. When no_inter_layer_pred_flag is equal to 0, the variable refLayerIntraBLFlag is derived as follows.
   – If mbType[mbAddr] is equal to I_BL, refLayerIntraBLFlag is set equal to 1.
   – Otherwise (mbType[mbAddr] is not equal to I_BL), refLayerIntraBLFlag is set equal to 0.
4. The macroblock initialisation process as specified in subclause G.8.1.5.1 is invoked with refLayerVars set equal to currentVars as the input and the outputs are assigned to sliceIdc[mbAddr], fieldMbFlag[mbAddr], cTrafo[mbAddr], mbType[mbAddr], subMbType[mbAddr], mvCnt[mbAddr], tQP_Y[mbAddr], tQP_{Cb}[mbAddr] (when ChromaArrayType is not equal to 0), tQP_{Cr}[mbAddr] (when ChromaArrayType is not equal to 0), the 2x2 arrays refIdxILPredL0 and refIdxILPredL1, and the 4x4x2 arrays mvILPredL0 and mvILPredL1.
5. The SVC derivation process for motion vector components and reference indices as specified in subclause G.8.4.1 is invoked with sliceIdc, fieldMbFlag, mbType, subMbType, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, mvCnt, refIdxILPredL0, refIdxILPredL1, mvILPredL0, mvILPredL1, and refPicList1 (when available) as the inputs and the outputs are modified versions of the arrays predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, and mvCnt.
6. Depending on mbType[mbAddr], the following applies.
   – If mbType[mbAddr] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, the following ordered steps are specified.
     a. When base_mode_flag is equal to 0, the SVC derivation process for intra prediction modes as specified in subclause G.8.3.1 is invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4, ipred8x8, ipred16x16, and, when ChromaArrayType is equal to 1 or 2, ipredChroma as the inputs and the outputs are modified versions of ipred4x4, ipred8x8, ipred16x16, and, when ChromaArrayType is equal to 1 or 2, ipredChroma.
     b. When base_mode_flag is equal to 1, the transform coefficient level scaling process prior to transform coefficient refinement as specified in subclause G.8.5.2 is invoked with cTrafo[mbAddr], tCoeffLevel[mbAddr], tQP_Y[mbAddr], $refQP_Y$, and, when ChromaArrayType is not equal to 0,

tQP_{Cb}[mbAddr], tQP_{Cr}[mbAddr], $refQP_{Cb}$, and $refQP_{Cr}$ as the inputs and the output is a modified version of tCoeffLevel[mbAddr].

c. The transform coefficient scaling and refinement process as specified in subclause G.8.5.1 is invoked with refinementFlag set equal to base_mode_flag, fieldMbFlag[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], and tCoeffLevel[mbAddr] as the inputs and the outputs are modified versions of sTCoeff[mbAddr] and tCoeffLevel[mbAddr].

d. The sample array re-initialisation process as specified in subclause G.8.5.5 is invoked with fieldMbFlag[mbAddr], rS_L, and, when ChromaArrayType is not equal to 0, rS_{Cb} and rS_{Cr} as the inputs and the outputs are a modified version of rS_L and, when ChromaArrayType is not equal to 0, modified versions of rS_{Cb} and rS_{Cr}.

e. The sample array re-initialisation process as specified in subclause G.8.5.5 is invoked with fieldMbFlag[mbAddr], cS_L, and, when ChromaArrayType is not equal to 0, cS_{Cb} and cS_{Cr} as the inputs and the outputs are a modified version of cS_L and, when ChromaArrayType is not equal to 0, modified versions of cS_{Cb} and cS_{Cr}.

– Otherwise, if mbType[mbAddr] is equal to I_BL, the transform coefficient scaling and refinement process as specified in subclause G.8.5.1 is invoked with refinementFlag set equal to refLayerIntraBLFlag, fieldMbFlag[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], and tCoeffLevel[mbAddr] as the inputs and the outputs are modified versions of sTCoeff[mbAddr] and tCoeffLevel[mbAddr].

– Otherwise (mbType[mbAddr] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL), the following ordered steps are specified.

a. When residual_prediction_flag is equal to 1, the transform coefficient level scaling process prior to transform coefficient refinement as specified in subclause G.8.5.2 is invoked with cTrafo[mbAddr], tCoeffLevel[mbAddr], tQP_Y[mbAddr], $refQP_Y$, and, when ChromaArrayType is not equal to 0, tQP_{Cb}[mbAddr], tQP_{Cr}[mbAddr], $refQP_{Cb}$, and $refQP_{Cr}$ as the inputs and the output is a modified version of tCoeffLevel[mbAddr].

b. The transform coefficient scaling and refinement process as specified in subclause G.8.5.1 is invoked with refinementFlag set equal to residual_prediction_flag, fieldMbFlag[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], and tCoeffLevel[mbAddr] as the inputs and the outputs are modified versions of sTCoeff[mbAddr] and tCoeffLevel[mbAddr].

c. When residual_prediction_flag is equal to 0, the sample array re-initialisation process as specified in subclause G.8.5.5 is invoked with fieldMbFlag[mbAddr], rS_L, and, when ChromaArrayType is not equal to 0, rS_{Cb} and rS_{Cr} as the inputs and the outputs are a modified versions of rS_L and, when ChromaArrayType is not equal to 0, modified versions of rS_{Cb} and rS_{Cr}.

d. When residual_prediction_flag is equal to 0, the sample array re-initialisation process as specified in subclause G.8.5.5 is invoked with fieldMbFlag[mbAddr], cS_L, and, when ChromaArrayType is not equal to 0, cS_{Cb} and cS_{Cr} as the inputs and the outputs are a modified versions of cS_L and, when ChromaArrayType is not equal to 0, modified versions of cS_{Cb} and cS_{Cr}.

G.8.1.5.3 Base decoding process for macroblocks in slices with resolution change

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a variable mbAddr specifying the current macroblock inside the current layer representation,

– a set of arrays collectively referred to as refLayerVars,

– a set of arrays collectively referred to as currentVars,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2, the reference picture list refPicList0,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current macroblock, which is specified by its address mbAddr and the layer representation identifier currDQId, as well as variables assigned to refLayerVars.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current macroblock, which is the macroblock with address mbAddr inside the layer representation with DQId equal to currDQId, the slice header of the current slice, which is the slice that contains the current macroblock, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

Inside this subclause, the arrays sliceIdc, fieldMbFlag, cTrafo, mbType, cS_L, cS_{Cb}, cS_{Cr}, rS_L, rS_{Cb}, and rS_{Cr} of the collective term refLayerVars are referred to as refLayerSliceIdc, refLayerFieldMbFlag, refLayerCTrafo, refLayerMbType, $refS_L$, $refS_{Cb}$, $refS_{Cr}$, $refR_L$, $refR_{Cb}$, and $refR_{Cr}$, respectively.

The base decoding process for macroblocks in slices with resolution change is specified by the following ordered steps.

1. The variable CurrMbAddr is set equal to mbAddr.
2. The macroblock initialisation process as specified in subclause G.8.1.5.1 is invoked with refLayerVars, refPicList0 (when available), and refPicList1 (when available) as the inputs and the outputs are assigned to sliceIdc[mbAddr], fieldMbFlag[mbAddr], cTrafo[mbAddr], mbType[mbAddr], subMbType[mbAddr], mvCnt[mbAddr], tQP_Y[mbAddr], tQP_{Cb}[mbAddr] (when ChromaArrayType is not equal to 0), tQP_{Cr}[mbAddr] (when ChromaArrayType is not equal to 0), the 2x2 arrays refIdxILPredL0 and refIdxILPredL1, and the 4x4x2 arrays mvILPredL0 and mvILPredL1.
3. The SVC derivation process for motion vector components and reference indices as specified in subclause G.8.4.1 is invoked with sliceIdc, fieldMbFlag, mbType, subMbType, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, mvCnt, refIdxILPredL0, refIdxILPredL1, mvILPredL0, and mvILPredL1 as the inputs and the outputs are modified versions of the arrays predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, and mvCnt.
4. The variable intraResamplingFlag is derived as follows.
   - If any of the following conditions is true, intraResamplingFlag is set equal to 1.
     - RestrictedSpatialResolutionChangeFlag is equal to 1 and mbType[mbAddr] is equal to I_BL
     - RestrictedSpatialResolutionChangeFlag is equal to 0, MbaffFrameFlag is equal to 0, RefLayerMbaffFrameFlag is equal to 0, and mbType[mbAddr] is not equal to I_PCM, I_16x16, I_8x8, or I_4x4
   - Otherwise, intraResamplingFlag is set equal to 0.
5. When intraResamplingFlag is equal to 1, the resampling process for intra samples as specified in subclause G.8.6.2 is invoked with fieldMbFlag[mbAddr], refLayerSliceIdc, refLayerFieldMbFlag, refLayerMbType, $refS_L$, cS_L, and, when ChromaArrayType is not equal to 0, $refS_{Cb}$, $refS_{Cr}$, cS_{Cb}, and cS_{Cr} as the inputs and the outputs are a modified version of the array cS_L and, when ChromaArrayType is not equal to 0, modified versions of the array cS_{Cb}, and cS_{Cr}.
6. Depending on mbType[mbAddr], the following applies.
   - If mbType[mbAddr] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, the SVC derivation process for intra prediction modes as specified in subclause G.8.3.1 is invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4, ipred8x8, ipred16x16, and, when ChromaArrayType is equal to 1 or 2, ipredChroma as the inputs and the outputs are modified versions of ipred4x4, ipred8x8, ipred16x16, and, when ChromaArrayType is equal to 1 or 2, ipredChroma.
   - Otherwise, if mbType[mbAddr] is not equal to I_BL and residual_prediction_flag is equal to 1, the resampling process for residual samples as specified in subclause G.8.6.3 is invoked with fieldMbFlag[mbAddr], refLayerFieldMbFlag, refLayerCTrafo, $refR_L$, rS_L, and, when ChromaArrayType is not equal to 0, $refR_{Cb}$, $refR_{Cr}$, rS_{Cb}, and rS_{Cr} as the inputs and the outputs are a modified version of the array rS_L and, when ChromaArrayType is not equal to 0, modified versions of the array rS_{Cb}, and rS_{Cr}.
   - Otherwise, the arrays of the collective term currentVars are not modified.
7. The transform coefficient scaling and refinement process as specified in subclause G.8.5.1 is invoked with refinementFlag set equal to 0, fieldMbFlag[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], and tCoeffLevel[mbAddr] as the inputs and the outputs are modified versions of sTCoeff[mbAddr] and tCoeffLevel[mbAddr].

G.8.1.5.4 Macroblock decoding process prior to decoding a layer representation without resolution change and tcoeff_level_prediction_flag equal to 0

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a variable mbAddr specifying the current macroblock inside the current layer representation,

– a set of arrays collectively referred to as currentVars.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current macroblock, which is specified by its address mbAddr and the layer representation identifier currDQId.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current macroblock, which is the macroblock with address mbAddr inside the layer representation with DQId equal to currDQId, the slice header of the current slice, which is the slice that contains the current macroblock, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

The target macroblock decoding process is specified by the following ordered steps.

1. The variable CurrMbAddr is set equal to mbAddr.
2. When mbType[mbAddr] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, the SVC intra sample prediction and construction process as specified in subclause G.8.3.2 is invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4[mbAddr], ipred8x8[mbAddr], ipred16x16[mbAddr], ipredChroma[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], cS_L, and, when ChromaArrayType is not equal to 0, cS_{Cb} and cS_{Cr} as the inputs and the outputs are a modified version of the array cS_L and, when ChromaArrayType is not equal to 0, modified versions of the arrays cS_{Cb} and cS_{Cr}.

G.8.1.5.5 Macroblock decoding process prior to resolution change

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a variable mbAddr specifying the current macroblock inside the current layer representation,

– a set of arrays collectively referred to as currentVars.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current macroblock, which is specified by its address mbAddr and the layer representation identifier currDQId.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current macroblock, which is the macroblock with address mbAddr inside the layer representation with DQId equal to currDQId, the slice header of the current slice, which is the slice that contains the current macroblock, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

The target macroblock decoding process is specified by the following ordered steps.

1. The variable CurrMbAddr is set equal to mbAddr.
2. Depending on mbType[mbAddr], the following applies.
   – If mbType[mbAddr] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, the SVC intra sample prediction and construction process as specified in subclause G.8.3.2 in invoked with sliceIdc, fieldMbFlag, mbType,

ipred4x4[mbAddr], ipred8x8[mbAddr], ipred16x16[mbAddr], ipredChroma[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], cS_L, and, when ChromaArrayType is not equal to 0, cS_{Cb} and cS_{Cr} as the inputs and the outputs are a modified version of the array cS_L and, when ChromaArrayType is not equal to 0, modified versions of the arrays cS_{Cb} and cS_{Cr}.

– Otherwise, if mbType[mbAddr] is equal to I_BL, the following ordered steps are specified.

  a. The residual construction and accumulation process as specified in subclause G.8.5.3 is invoked with accumulationFlag set equal to 0, fieldMbFlag[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], rS_L, and, when ChromaArrayType is not equal to 0, rS_{Cb} and rS_{Cr} as the inputs and the outputs are a modified version of rS_L and, when ChromaArrayType is not equal to 0, modified versions of rS_{Cb} and rS_{Cr}.

  b. The sample array accumulation process as specified in subclause G.8.5.4 is invoked with fieldMbFlag[mbAddr], rS_L, cS_L, and, when ChromaArrayType is not equal to 0, rS_{Cb}, rS_{Cr} cS_{Cb}, and cS_{Cr} as the inputs and the outputs are a modified version of cS_L and, when ChromaArrayType is not equal to 0, modified versions of cS_{Cb} and cS_{Cr}.

– Otherwise (mbType[mbAddr] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL), the following ordered steps are specified.

  a. The residual construction and accumulation process as specified in subclause G.8.5.3 is invoked with accumulationFlag set equal to 1, fieldMbFlag[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], rS_L, and, when ChromaArrayType is not equal to 0, rS_{Cb} and rS_{Cr} as the inputs and the outputs are a modified version of rS_L and, when ChromaArrayType is not equal to 0, modified versions of rS_{Cb} and rS_{Cr}.

  b. The sample array re-initialisation process as specified in subclause G.8.5.5 is invoked with fieldMbFlag[mbAddr], cS_L, and, when ChromaArrayType is not equal to 0, cS_{Cb} and cS_{Cr} as the inputs and the outputs are a modified versions of cS_L and, when ChromaArrayType is not equal to 0, modified versions of cS_{Cb} and cS_{Cr}.

G.8.1.5.6 Target macroblock decoding process

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a variable mbAddr specifying the current macroblock inside the current layer representation,

– a set of arrays collectively referred to as refLayerVars,

– a set of arrays collectively referred to as currentVars,

– when (slice_type % 5) is less than 2, the reference picture list refPicList0,

– when (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current macroblock, which is specified by its address mbAddr and the layer representation identifier currDQId.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current macroblock, which is the macroblock with address mbAddr inside the layer representation with DQId equal to currDQId, the slice header of the current slice, which is the slice that contains the current macroblock, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

Inside this subclause, the arrays fieldMbFlag and mbType of the collective term refLayerVars are referred to as refLayerFieldMbFlag and refLayerMbType, respectively.

The target macroblock decoding process is specified by the following ordered steps.

1. The variable CurrMbAddr is set equal to mbAddr.

2. When tcoeff_level_prediction is equal to 1, (sliceIdc[mbAddr] &127) is not equal to currDQId, and ChromaArrayType is not equal to 0, the following ordered steps are specified.

   NOTE – By the following ordered steps, only the transform coefficient levels for chroma are scaled (and the scaled transform coefficients are derived accordingly) when the chroma quantisation parameter offsets of the current layer representation with DQId equal to currDQId and the layer representation with DQId equal to (sliceIdc[mbAddr] &127) are different.

   a. The variable cQP_Y is set equal to tQP_Y[mbAddr], and for CX being replaced by Cb and Cr, the variable cQP_{CX} is set equal to the value of QP_{CX} that corresponds to a value of cQP_Y for QP_Y as specified in subclause 8.5.8.

   b. The transform coefficient level scaling process prior to transform coefficient refinement as specified in subclause G.8.5.2 is invoked with cTrafo[mbAddr], tCoeffLevel[mbAddr], tQP_Y set equal to cQP_Y, $refQP_Y$ set equal to tQP_Y[mbAddr], and, when ChromaArrayType is not equal to 0, tQP_{Cb} set equal to cQP_{Cb}, tQP_{Cr} set equal to cQP_{Cr}, $refQP_{Cb}$ set equal to tQP_{Cb}[mbAddr], $refQP_{Cr}$ set equal to tQP_{Cr}[mbAddr] as the inputs and the output is a modified version of tCoeffLevel[mbAddr].

   c. The transform coefficient scaling and refinement process as specified in subclause G.8.5.1 is invoked with refinementFlag equal to 1, fieldMbFlag[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], and tCoeffLevel[mbAddr] as the inputs and the outputs are modified versions of sTCoeff[mbAddr] and tCoeffLevel[mbAddr]. For this invocation of the process in subclause G.8.5.1, all elements of the arrays LumaLevel, LumaLevel8x8, Intra16x16DCLevel, Intra16x16ACLevel, CbLevel, CbLevel8x8, CbIntra16x16DCLevel, CbIntra16x16ACLevel, CrLevel, CrLevel8x8, CrIntra16x16DCLevel, CrIntra16x16ACLevel, ChromaDCLevel, and ChromaACLevel are inferred to be equal to 0, and the quantisation parameter QP'_Y is set equal to (tQP_Y[mbAddr] + $QpBdOffset_Y$).

3. Depending on mbType[mbAddr], the following applies.

   – If mbType[mbAddr] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, the SVC intra sample prediction and construction process as specified in subclause G.8.3.2 in invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4[mbAddr], ipred8x8[mbAddr], ipred16x16[mbAddr], ipredChroma[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], cS_L, and, when ChromaArrayType is not equal to 0, cS_{Cb} and cS_{Cr} as the inputs and the outputs are a modified version of the array cS_L and, when ChromaArrayType is not equal to 0, modified versions of the arrays cS_{Cb} and cS_{Cr}.

   – Otherwise, if mbType[mbAddr] is equal to I_BL, the following ordered steps are specified.

      a. The residual construction and accumulation process as specified in subclause G.8.5.3 is invoked with accumulationFlag set equal to 0, fieldMbFlag[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], rS_L, and, when ChromaArrayType is not equal to 0, rS_{Cb} and rS_{Cr} as the inputs and the outputs are a modified version of rS_L and, when ChromaArrayType is not equal to 0, modified versions of rS_{Cb} and rS_{Cr}.

      b. The sample array accumulation process as specified in subclause G.8.5.4 is invoked with fieldMbFlag[mbAddr], rS_L, cS_L, and, when ChromaArrayType is not equal to 0, rS_{Cb}, rS_{Cr} cS_{Cb}, and cS_{Cr} as the inputs and the outputs are a modified version of cS_L and, when ChromaArrayType is not equal to 0, modified versions of cS_{Cb} and cS_{Cr}.

   – Otherwise (mbType[mbAddr] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL), the following ordered steps are specified.

      a. The residual construction and accumulation process as specified in subclause G.8.5.3 is invoked with accumulationFlag set equal to 1, fieldMbFlag[mbAddr], cTrafo[mbAddr], sTCoeff[mbAddr], rS_L, and, when ChromaArrayType is not equal to 0, rS_{Cb} and rS_{Cr} as the inputs and the outputs are a modified version of rS_L and, when ChromaArrayType is not equal to 0, modified versions of rS_{Cb} and rS_{Cr}.

      b. The SVC decoding process for Inter prediction samples as specified in subclause G.8.4.2 is invoked with fieldMbFlag[mbAddr], mbType[mbAddr], subMbType[mbAddr], predFlagL0[mbAddr], predFlagL1[mbAddr], refIdxL0[mbAddr], refIdxL1[mbAddr], mvL0[mbAddr], mvL1[mbAddr], refLayerFieldMbFlag, refLayerMbType, refPicList0, refPicList1 (when available), cS_L, and, when ChromaArrayType is not equal to 0, cS_{Cb} and cS_{Cr} as the inputs and the outputs are a modified version of cS_L and, when ChromaArrayType is not equal to 0, modified versions of cS_{Cb} and cS_{Cr}.

      c. The sample array accumulation process as specified in subclause G.8.5.4 is invoked with fieldMbFlag[mbAddr], rS_L, cS_L, and, when ChromaArrayType is not equal to 0, rS_{Cb}, rS_{Cr} cS_{Cb}, and

cS_{Cr} as the inputs and the outputs are a modified version of cS_L and, when ChromaArrayType is not equal to 0, modified versions of cS_{Cb} and cS_{Cr}.

4. The variable MvCnt for the macroblock mbAddr is set equal to mvCnt[mbAddr].

G.8.2 SVC reference picture lists construction and decoded reference picture marking process

The SVC decoding process for picture order count is specified in subclause G.8.2.1.

The SVC decoding process for picture numbers is specified in subclause G.8.2.2.

The SVC decoding process for reference picture lists construction is specified in subclause G.8.2.3.

The SVC decoded reference picture marking process is specified in subclause G.8.2.4.

The SVC decoding process for gaps in frame_num is specified in subclause G.8.2.5.

The decoding process for picture order counts is independently applied for different values of dependency_id. Syntax elements that are related to picture order count for a particular value of dependency_id do not influence the derivation of picture order counts for other values of dependency_id.

The reference picture marking is independently applied for different values of dependency_id. Syntax elements that are related to reference picture marking for a particular value of dependency_id do not influence the reference picture marking for other values of dependency_id.

The decoding process for gaps is frame_num is independently applied for different values of dependency_id.

Reference picture lists for different dependency representations are constructed independently. Syntax elements that are related to reference picture list construction for a particular value of dependency_id do not influence the reference picture list construction for other values of dependency_id. Reference picture list for a particular value of dependency_id are constructed based on the reference picture marking for this particular value of dependency_id. The reference picture marking for a particular value of dependency_id does not influence the reference picture list construction for a different value of dependency_id.

Only the elements of the reference picture lists for dependency_id equal to DependencyIdMax represent decoded pictures that are associated with decoded samples. Only the reference picture lists for dependency_id equal to DependencyIdMax are used for the derivation of inter prediction samples as specified in subclause G.8.4.2. The elements of the reference picture lists for dependency representation with dependency_id less than DependencyIdMax represent layer pictures, which are not associated with decoded samples. The elements of the reference picture lists for dependency_id equal to 0 are associated with the arrays fieldMbFlag, mbType, subMbType, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, and mvL1 as specified in subclause G.8.1.2.1 that were derived when decoding the layer representation with dependency_id equal to 0 and quality_id equal to 0 for the corresponding access unit. These arrays are used for the derivation of motion vectors and reference indices for layer representation with dependency_id equal to 0 and quality_id equal to 0 as specified in subclause G.8.4.1.2. The elements of the reference picture lists for all dependency representations with dependency_id greater than 0 are associated with the variables ScaledRefLayerLeftOffset, ScaledRefLayerRightOffset, ScaledRefLayerTopOffset, and ScaledRefLayerBottomOffset. These variables are used for deriving inter-layer motion vector predictions as specified in subclause G.8.6.1.2.

NOTE – For each access unit, decoded samples only need to be stored for the dependency representation with dependency_id equal to DependencyIdMax, and motion data arrays only need to be stored for the dependency representation with dependency_id equal to 0.

The SVC decoding processes for picture order count, reference picture list construction, reference picture marking, and gaps in frame_num are specified using processes specified in subclause 8. The following modifications to the processes specified in this subclause and the processes of subclause 8 that are invoked from these processes apply with currDependencyId representing the value of dependency_id for the dependency representation for which the processes are invoked.

a) All syntax elements and derived upper-case variables that are referred to in this process or in a child process invoked from this process are syntax elements and upper-case variables for the dependency representation with dependency_id equal to currDependencyId.

b) When dependency_id is less than DependencyIdMax, the following applies.

   – A frame, field, top field, bottom field, picture, and decoded picture is interpreted as layer frame, layer field, layer top field, layer bottom field, layer picture, and decoded layer picture, respectively, that represent an intermediate decoding result for the dependency representation with dependency_id equal to currDependencyId.

   – An IDR picture is interpreted as layer picture with IdrPicFlag is equal to 1 for the dependency representation with dependency_id equal to currDependencyId.

- A reference frame, reference field, and reference picture is interpreted as layer frame, layer field, and layer picture with nal_ref_idc greater than 0 for the dependency representation with dependency_id equal to currDependencyId.
- A non-reference frame, non-reference field, and non-reference picture is interpreted as layer frame, layer field, and layer picture with nal_ref_idc equal to 0 for the dependency representation with dependency_id equal to currDependencyId.
- A complementary non-reference field pair is interpreted as complementary non-reference layer field pair for the dependency representation with dependency_id equal to currDependencyId. A complementary non-reference layer field pair for a particular value of dependency_id is a pair of two layer fields with nal_ref_idc equal to 0 for the particular value of dependency_id that are in consecutive access units containing a dependency representation with the particular value of dependency_id as two coded layer field and have opposite parity where the first layer field is not already a paired layer field.
- A complementary reference field pair is interpreted as complementary reference layer field pair for the dependency representation with dependency_id equal to currDependencyId. A complementary reference layer field pair for a particular value of dependency_id is a pair of two layer fields with nal_ref_idc greater than 0 for the particular value of dependency_id that are in consecutive access units containing a dependency representation with the particular value of dependency_id as two coded layer fields and share the same value of frame_num where the second layer field in decoding order has IdrPicFlag equal to 0 and does not include a memory_management_control_operation syntax element equal to 5.
- A complementary field pair is interpreted as complementary layer field pair for the dependency representation with dependency_id equal to currDependencyId. A complementary layer field pair is a collective term for a complementary reference layer field pair and a complementary non-reference layer field pair.
- A non-paired non-reference field is interpreted as layer field with nal_ref_idc equal to 0 for the dependency representation with dependency_id equal to currDependencyId that is not part of a complementary non-reference layer field pair.
- A non-paired reference field is interpreted as layer field with nal_ref_idc greater than 0 for the dependency representation with dependency_id equal to currDependencyId that is not part of a complementary reference layer field pair.
- A non-paired reference field is interpreted as layer field for the dependency representation with dependency_id equal to currDependencyId that is not part of a complementary layer field pair.

G.8.2.1 SVC decoding process for picture order count

Outputs of this process are the variables TopFieldOrderCnt (if applicable) and BottomFieldOrderCnt (if applicable) for all dependency representations of the current access unit.

For all dependency representations of the current access unit, the variables TopFieldOrderCnt (if applicable) and BottomFieldOrderCnt (if applicable) are derived by invoking the decoding process for picture order count as specified in subclause 8.2.1. For these invocations of the process specified in subclause 8.2.1, the modifications a) and b) specified in subclause G.8.2 apply with currDependencyId being equal to dependency_id of the corresponding dependency representation.

For all dependency representations of an access unit, either TopFieldOrderCnt or BottomFieldOrderCnt or both are derived. When both are derived in two or more dependency representations of an access unit, their difference shall be the same in these dependency representations of the access unit.

The values of TopFieldOrderCount and BottomFieldOrderCount are restricted as follows.

- For each access unit, the one-dimensional array picOrderCnt is derived as follows.
  - If TopFieldOrderCnt is derived in all dependency representations of an access unit, the variable picOrderCnt[dId] is set equal to TopFieldOrderCnt of the dependency representation with dependency_id being equal to dId.
  - Otherwise (TopFieldOrderCnt is not derived in all dependency representations of an access unit), the variable picOrderCnt[dId] is set equal to BottomFieldOrderCnt of the dependency representation with dependency_id being equal to dId.
- Let au0 and au1 be any pair of access units in the bitstream with au1 being later in decoding order than au0.
- Let the flag idrConditionFlag be derived for each dependency representation in an access unit as follows.

  - If the dependency representation in the access unit has IdrPicFlag equal to 1 or a memory_management_control_operation syntax element equal to 5, idrConditionFlag is set equal to 1.
  - Otherwise (the dependency representation in the access unit has IdrPicFlag equal to 0 and does not have a memory_management_control_operation syntax element equal to 5), idrConditionFlag is set equal to 0.
- Let the set dIdSet0 be the set of all dependency_id values in au0.
- Let the set dIdSet1 be the set of all dependency_id values in au1 for which idrConditionFlag is not equal to 1 in any access unit in decoding order between the access unit that follows au0 and the access unit au1, inclusive.
- For all values of dId that are present in both sets dIdSet0 and dIdSet1, the differences between the value picOrderCnt[dId] in au0 and the value picOrderCnt[dId] in au1 shall be the same.

G.8.2.2 SVC decoding process for picture numbers

This process is invoked when the SVC decoding process for reference picture lists construction specified in subclause G.8.2.3 is invoked or when the SVC reference picture marking process for a dependency representation as specified in subclause G.8.2.4.1 is invoked.

Inputs to this process are

- a variable currDependencyId specifying a dependency representation,
- a variable useRefBasePicFlag specifying whether this process refers to reference base pictures or decoded pictures.

Outputs of this process are variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum assigned to all pictures marked as "used for short-term reference" or "used for long-term reference".

From here to the end of this subclause, the modifications a) and b) specified in subclause G.8.2 apply.

The variable maxFrameNum is derived by

$$maxFrameNum = (1 << (log2\_max\_frame\_num\_minus4 + 4)) \quad \text{(G-88)}$$

To each short-term and long-term reference picture a variable useFlag is assigned as follows.

- If useRefBasePicFlag is equal to 0, the following applies.
  - If the reference picture is not marked as "reference base picture", useFlag is set equal to 1.
  - Otherwise (the reference picture is marked as "reference base picture"), useFlag is set equal to 0.
- Otherwise, if the reference picture is a short-term reference picture, the following applies.
  - If the short-term reference picture is marked as "reference base picture" or if there does not exist a short-term reference picture with an identical value frame_num coded in slice header(s) with dependency_id equal to currDependencyId that is marked as "reference base picture", useFlag is set equal to 1.
  - Otherwise (the short-term picture is not marked as "reference base picture" and there exists a short-term reference picture with an identical value frame_num coded in slice header(s) with dependency_id equal to currDependencyId that is marked as "reference base picture"), useFlag is set equal to 0.
- Otherwise (useRefBasePicFlag is equal to 1 and the reference picture is a long-term reference picture), the following applies.
  - If the long-term reference picture is marked as "reference base picture" or if there does not exist a long-term reference picture with an identical value of LongTermFrameIdx that is marked as "reference base picture", useFlag is set equal to 1.
  - Otherwise (the long-term picture is not marked as "reference base picture" and there exists a long-term reference picture with an identical value of LongTermFrameIdx that is marked as "reference base picture"), useFlag is set equal to 0.

To each short-term reference picture the variables FrameNum and FrameNumWrap are assigned as follows.

- If useFlag is equal to 0, FrameNum and FrameNumWrap for the short-term picture are marked as "unspecified".
- Otherwise, FrameNum is set equal to the syntax element frame_num that has been decoded in the slice header(s) with dependency_id equal to currDependencyId of the corresponding short-term reference picture. And the variable FrameNumWrap is derived by

```
if( FrameNum > frame_num )
        FrameNumWrap = FrameNum – maxFrameNum                    (G-89)
else
        FrameNumWrap = FrameNum
```

where the value of frame_num used in Equation G-89 is the frame_num in the slice header(s) with dependency_id equal to currDependencyId for the current access unit.

NOTE – The values of FrameNum and FrameNumWrap are dependent on the value of currDependencyId. For the calculation of FrameNum and FrameNumWrap only syntax elements of NAL units with dependency_id equal to currDependencyId are used.

Each long-term reference picture has an associated value of LongTermFrameIdx (that was assigned to it as specified in subclause 8.2.5). When useFlag is equal to 0 for a long-term picture, LongTermFrameIdx is temporarily marked as "unspecified". This marking is removed after the invocation of the SVC decoding process for reference picture lists construction as specified in subclause G.8.2.3 or the invocation of the SVC decoded reference picture marking process as specified in subclause G.8.2.4.

To each short-term reference picture a variable PicNum is assigned, and to each long-term reference picture a variable LongTermPicNum is assigned. The values of these variables depend on the value of field_pic_flag and bottom_field_flag for the current slice with dependency_id equal to currDependencyId and they are set as follows.

– If field_pic_flag is equal to 0, the following applies.
  – For each short-term reference frame or complementary reference field pair the following applies.
    – If FrameNumWrap is marked as "unspecified", PicNum is marked as "unspecified".
    – Otherwise (FrameNumWrap is not marked as "unspecified"), PicNum is derived by

      PicNum = FrameNumWrap (G-90)

  – For each long-term reference frame or long-term complementary reference field pair the following applies
    – If LongTermFrameIdx is marked as "unspecified", LongTermPicNum is marked as "unspecified".
    – Otherwise (LongTermFrameIdx is not marked as "unspecified"), LongTermPicNum is derived by

      LongTermPicNum = LongTermFrameIdx (G-91)

– Otherwise (field_pic_flag is equal to 1), the following applies.
  – Let current field refer to the slices of the current access unit with dependency_id equal to currDependencyId.
  – For each short-term reference field the following applies.
    – If FrameNumWrap is marked as "unspecified", PicNum is marked as unspecified.
    – Otherwise (FrameNumWrap is not marked as "unspecified"), the following applies.
      – If the reference field has the same parity as the current field

        PicNum = 2 * FrameNumWrap + 1 (G-92)

      – Otherwise (the reference field has the opposite parity of the current field),

        PicNum = 2 * FrameNumWrap (G-93)

  – For each long-term reference field the following applies.
    – If LongTermFrameIdx is marked as "unspecified", LongTermPicNum is marked as "unspecified".
    – Otherwise (LongTermFrameIdx is not marked as "unspecified"), the following applies.
      – If the reference field has the same parity as the current field

        LongTermPicNum = 2 * LongTermFrameIdx + 1 (G-94)

– Otherwise (the reference field has the opposite parity of the current field),

LongTermPicNum = 2 * LongTermFrameIdx (G-95)

G.8.2.3 SVC decoding process for reference picture lists construction

This process is invoked at the beginning of decoding each P, EP, B, or EB slice.

Inputs to this process are

– a variable currDependencyId

– a variable useRefLayerRepFlag

– the current slice currSlice

Outputs of this process are

– a reference picture list refPicList0

– for B and EB slices, a reference picture list refPicList1

After applying the process described in this subclause, the output reference picture lists refPicList0 and refPicList1 (when applicable) shall not contain any pictures for which the syntax element temporal_id is greater than the syntax element temporal_id of the current picture.

From here to the end of this subclause, the modifications a) and b) specified in subclause G.8.2 apply.

A variable biPred is derived as follows:

– If the current slice currSlice is a B or EB slice, biPred is set equal to 1.

– Otherwise, biPred is set equal to 0.

Decoded reference pictures are marked as "used for short-term reference" or "used for long-term reference" as specified by the bitstream and specified in subclause G.8.2.4. Short-term reference pictures are identified by the value of frame_num that is decoded in the slice header(s) with dependency_id equal to currDependencyId. Long-term reference pictures are identified by a long-term frame index as specified by the bitstream and specified in subclause G.8.2.4.

Subclause G.8.2.2 is invoked with currDependencyId and useRefBasePicFlag as inputs to specify

– the assignment of variables FrameNum, FrameNumWrap, and PicNum to each of the short-term reference pictures, and

– the assignment of variables LongTermPicNum to each of the long-term reference pictures.

NOTE – During the invocation of subclause G.8.2.2 the variables FrameNum, FrameNumWrap, PicNum, and LongTermPicNum can be marked as “unspecified”. Furthermore, the variables LongTermFrameIdx can be temporarily marked as “unspecified” for this subclause and all invocations inside this subclause.

Reference pictures are addressed through reference indices as specified in subclause 8.4.2.1. A reference index is an index into a reference picture list. When biPred is equal to 0, a single reference picture list refPicList0 is constructed. When decoding a B or EB slice (biPred is equal to 1), a second independent reference picture list refPicList1 is constructed in addition to refPicList0.

At the beginning of decoding of each slice, reference picture list refPicList0, and for biPred equal to 1 refPicList1, are derived as follows.

– Initial reference picture lists RefPicList0 and, for biPred equal to 1, RefPicList1 are derived by invoking the initialisation process for reference picture lists as specified in subclause 8.2.4.2. During the initialisation process in subclause 8.2.4.2 all short-term reference pictures for which FrameNum, FrameNumWrap, and PicNum have been marked as “unspecified” by the invocation of subclause G.8.2.2 and all long-term pictures for which LongTermFrameIdx and LongTermPicNum have been marked as “unspecified” by the invocation of subclause G.8.2.2 are considered as non-existing. The reference picture lists are constructed by using only short-term pictures with values of FrameNum, FrameNumWrap, and PicNum that are not marked as “unspecified” and long-term pictures with values of LongTermFrameIdx and LongTermPicNum that are not marked as “unspecified”.

– The initial reference picture list RefPicList0 and for biPred equal to 1 RefPicList1 are modified by invoking the reordering process for reference picture lists as specified in subclause 8.2.4.3. During the reordering process in subclause 8.2.4.2 all short-term reference pictures for which FrameNum, FrameNumWrap, and PicNum have been marked as “unspecified” by the invocation of subclause G.8.2.2 and all long-term pictures for which LongTermFrameIdx and LongTermPicNum have been marked as “unspecified” by the invocation of subclause

G.8.2.2 are considered as non-existing. Short-term pictures with values of FrameNum, FrameNumWrap, and PicNum that are marked as “unspecified” and long-term pictures with values of LongTermFrameIdx and LongTermPicNum that are marked as “unspecified” shall not be referred to by reference picture list reordering commands.

– RefPicList0 is assigned to refPicList0.

– When biPred is equal to 1, RefPicList1 is assigned to refPicList1.

NOTE – By the invocation of the process in subclause G.8.2.2 the parameters of some reference picture might have been marked as "unspecified". Since, these pictures are not considered in the construction process for reference picture lists, the reference picture lists refPicList0 and for biPred equal to 1 refPicList1 are dependent on the value of the input parameter currDependencyId.

The number of entries in the modified reference picture list refPicList0 is num_ref_idx_l0_active_minus1 + 1, and for biPred equal to 1 the number of entries in the modified reference picture list refPicList1 is num_ref_idx_l1_active_minus1 + 1. A reference picture may appear at more than one index in the modified reference picture lists refPicList0 or refPicList1.

For all long-term reference pictures for which LongTermFrameIdx has been marked as “unspecified” during the invocation of subclause G.8.2.2, this marking of LongTermFrameIdx is removed.

G.8.2.4 SVC decoded reference picture marking process

For all dependency representations of the current access unit, when nal_ref_idc is greater than 0 for the slice data NAL units of the dependency representation, the SVC reference picture marking process for a dependency representation as specified in subclause G.8.2.4.1 is invoked. For these invocations of the process specified in subclause G.8.2.4.1, the modifications a) and b) specified in subclause G.8.2 apply with currDependencyId being equal to dependency_id for the corresponding dependency representation.

G.8.2.4.1 SVC reference picture marking process for a dependency representation

Input to this process is a variable currDependencyId.

Output of this process is a modified reference picture marking for dependency representations with dependency_id equal to currDependencyId.

This process is invoked for a decoded picture when nal_ref_idc is not equal to 0 for the dependency representation with dependency_id being equal to currDependencyId.

All syntax elements of the dec_ref_pic_marking( ) syntax structure and the dec_ref_base_pic_marking( ) syntax structure that are referred to by the process specified in this subclause and all child processes invoked from this process are syntax elements of the slice headers with dependency_id equal to currDependencyId and quality_id equal to 0.

NOTE – Coded slice NAL units with quality_id greater than 0 do not contain the syntax structures dec_ref_pic_marking( ) and dec_ref_base_pic_marking( ). For these NAL units, the syntax elements specifying the decoded reference picture marking are inferred from coded slice NAL units with dependency_id equal to DependencyIdMax and quality_id equal to 0. Coded slice NAL units with dependency_id equal to 0 and quality_id equal to 0 do not contain the syntax structure dec_ref_base_pic_marking( ). For these NAL units, the syntax elements of the syntax structure dec_ref_base_pic_marking( ) are inferred from the associated prefix NAL units, which directly precedes the coded slice NAL unit in decoding order.

A decoded picture with nal_ref_idc not equal to 0, referred to as a reference picture, is marked as "used for short-term reference" or "used for long-term reference". When store_ref_base_pic_flag is equal to 1, a second representation of the decoded picture also referred to as reference base picture is marked as "used for short-term reference" or "used for long-term reference" and additionally marked as "reference base picture". Pictures that are marked as "reference base picture" are only used as references for inter prediction of following pictures with use_ref_base_pic_flag equal to 1. These pictures are not used for inter prediction of pictures with use_ref_base_pic_flag equal to 0, and these pictures do not represent an output of the decoding process.

For a decoded reference frame, both of its fields are marked the same as the frame. For a complementary reference field pair, the pair is marked the same as both of its fields. A picture that is marked as "used for short-term reference" is identified by its FrameNum and, when it is a field, by its parity, and, when it is a reference base picture, by the marking "reference base picture". A picture that is marked as "used for long-term reference" is identified by its LongTermFrameIdx and, when it is a field, by its parity, and, when it is a reference base picture, by the marking "reference base picture".

While decoded pictures are represented by the sample arrays S_L and, when ChromaArrayType is not equal to 0, S_{Cb} and S_{Cr}, reference base pictures are represented by the sample arrays B_L and, when ChromaArrayType is not equal to 0, B_{Cb} and B_{Cr}. When reference base pictures are referenced in the inter prediction process via subclause 8.4.2.1, the samples arrays B_L, B_{Cb}, and B_{Cr} are referred to as S_L, S_{Cb}, and S_{Cr}, respectively. Reference base pictures are associated with the same descriptive information such as the variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and

LongTermPicNum as the corresponding decoded picture that is marked by the same invocation of the decoded reference picture marking process.

Frames or complementary field pairs marked as "used for short-term reference" or as "used for long-term reference" can be used as a reference for inter prediction when decoding a frame until the frame, the complementary field pair, or one of its constituent fields is marked as "unused for reference". A field marked as "used for short-term reference" or as "used for long-term reference" can be used as a reference for inter prediction when decoding a field until marked as "unused for reference".

A picture can be marked as "unused for reference" by the sliding window reference picture marking process, a first-in, first-out mechanism specified in subclause 8.2.5.3, or by the adaptive memory control reference picture marking process, a customised adaptive marking operation specified in subclause 8.2.5.4.

A short-term reference picture is identified for use in the decoding process by its variables FrameNum and FrameNumWrap and its picture number PicNum, and, when it is a reference base picture, by the marking as "reference base picture". A long-term reference picture is identified for use in the decoding process by its variable LongTermFrameIdx, its long-term picture number LongTermPicNum, and, when it is a reference base picture, by the marking as "reference base picture". When the current picture is not an IDR picture, the assignment of the variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum for the reference pictures is specified as follows.

– The variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum are assigned to all reference pictures marked as "reference base pictures" by invoking subclause G.8.2.2 with currDependencyId set equal to DependencyIdMax and useRefBasePicFlag set equal to 1 as the inputs.

  NOTE – By this first invoking of subclause G.8.2.2 the variables may be also assigned to reference pictures not marked as "reference base picture". For these pictures, the variables are again assigned by the following invoking of subclause G.8.2.2 and the variables that are assigned in both invocations of subclause G.8.2.2 are identical.

– The variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum are assigned to all reference pictures not marked as "reference base picture" by invoking subclause G.8.2.2 with currDependencyId set equal to DependencyIdMax and useRefBasePicFlag set equal to 0 as the inputs.

Decoded reference picture marking proceeds in the following ordered steps.

– All slices of the current access unit are decoded.

– Depending on the current picture, the following applies.

  – If the current picture is an IDR picture, the following applies.

    – All reference pictures are marked as "unused for reference".

    – Depending on long_term_reference_flag, the following applies.

      – If long_term_reference_flag is equal to 0, the following applies.

        – The IDR picture is marked as "used for short-term reference" and MaxLongTermFrameIdx is set equal to "no long-term frame indices"

        – When store_ref_base_pic_flag is equal to 1, the reference base picture of the IDR picture is marked as "used for short-term reference" and as "reference base picture".

      – Otherwise (long_term_reference_flag is equal to 1), the following applies.

        – The IDR picture is marked as "used for long-term reference", the LongTermFrameIdx for the IDR picture is set equal to 0, and MaxLongTermFrameIdx is set equal to 0.

        – When store_ref_base_pic_flag is equal to 1, the reference base picture of the IDR picture is marked as "used for long-term reference" and as "reference base picture", and the LongTermFrameIdx for the IDR picture is set equal to 0.

  – Otherwise (the current picture is not an IDR picture), the following applies.

    – When store_ref_base_pic_flag is equal to 1, the following applies.

      – If adaptive_ref_base_pic_marking_mode_flag is equal to 1, the adaptive memory control decoded reference picture marking process as specified in subclause 8.2.5.4 is invoked with the syntax elements from the syntax structure dec_ref_base_pic_marking( ) and adaptive_ref_base_pic_marking_mode_flag replacing adaptive_ref_pic_marking_mode_flag. Only the reference pictures that are marked as "reference base picture" are considered in this invocation of the process.

– Otherwise (adaptive_ref_base_pic_marking_mode_flag is equal to 0), the sliding window decoded reference picture marking process as specified in subclause 8.2.5.3 is invoked with adaptive_ref_base_pic_marking_mode_flag replacing adaptive_ref_pic_marking_mode_flag. When during the invocation of this process there is a decoded picture not marked as "reference base picture" and a reference base picture marked as "reference base picture", and both of which have the smallest value of FrameNumWrap, then only the picture marked as "reference base picture" is marked as "unused for reference".

– The reference base picture of the current decoded picture is be marked as "used for short-term reference" and as "reference base picture".

– Depending on adaptive_ref_pic_marking_mode_flag, the following applies.

– If adaptive_ref_pic_marking_mode_flag is equal to 0, the following applies.

– The sliding window decoded reference picture marking process as specified in subclause 8.2.5.3 is invoked. When during the invocation of this process there is a decoded picture not marked as "reference base picture" and a reference base picture marked as "reference base picture", and both of which have the smallest value of FrameNumWrap, then only the reference base picture is marked as "unused for reference".

– The current decoded picture is marked as "used for short-term reference".

– Otherwise (adaptive_ref_pic_marking_mode_flag is equal to 1), the following applies.

– The adaptive memory control decoded reference picture marking process as specified in subclause 8.2.5.4 with the syntax elements from the dec_ref_pic_marking( ) syntax structure is invoked. Only the reference pictures that are not marked as "reference base picture" are considered in the invocation of the process. Additionally, the following applies.

– All pictures for which LongTermFrameIdx is greater than MaxLongTermFrameIdx and that are marked as "used for long-term reference" and "reference base picture" are marked as "unused for reference".

– When during the invocation of this process a LongTermFrameIdx is assigned to a picture and there exists a "reference base picture" with the same value of PicNum (before assigning the long-term frame index), the LongTermFrameIdx is also assigned to the reference base picture, and the marking is changed from "used for short-term reference" to "used for long-term reference".

– When the current picture was not marked as "used for long-term reference" by memory_management_control_operation equal to 6, it is marked as "used for short-term reference".

NOTE – When store_ref_base_pic_flag is equal to 1, num_ref_frames shall be greater than or equal to 2.

When the adaptive memory control decoded reference picture marking process as specified in subclause 8.2.5.4 is invoked to mark reference pictures as "unused for reference" after decoding of a reference picture with temporal_id equal to tL, no reference picture with temporal_id less than tL shall be marked as "unused for reference".

For all long-term reference pictures for which LongTermFrameIdx has been marked as "unspecified" during the invocation of subclause G.8.2.2, this marking of LongTermFrameIdx is removed.

G.8.2.5 SVC decoding process for gaps in frame_num

For all dependency representations of the current access unit, the following applies.

– The syntax elements gaps_in_frame_num_value_allowed_flag and frame_num and the derived variables PrevRefFrameNum and MaxFrameNum are the syntax elements and derived upper-case variables for the considered dependency representation.

– When gaps_in_frame_num_value_allowed_flag is equal to 0, the bitstream shall not contain data that result in frame_num not being equal to PrevRefFrameNum or (PrevRefFrameNum + 1) % MaxFrameNum.

NOTE – When gaps_in_frame_num_value_allowed_flag is equal to 0 and frame_num is not equal to PrevRefFrameNum and is not equal to (PrevRefFrameNum + 1) % MaxFrameNum, the decoding process should infer an unintentional loss of pictures.

– When frame_num is not equal to PrevRefFrameNum and is not equal to (PrevRefFrameNum + 1) % MaxFrameNum, the decoding process for gaps in frame_num as specified in subclause 8.2.5.2 is invoked. For this invocation of the process specified in subclause 8.2.5.2, the modifications a) and b) specified in subclause G.8.2 apply with currDependencyId being equal to dependency_id for the considered dependency representation.

G.8.3 SVC intra decoding processes

Subclause G.8.3.1 specifies the SVC derivation process for intra prediction modes.

Subclause G.8.3.2 specifies the SVC intra sample prediction and construction process.

G.8.3.1 SVC derivation process for intra prediction modes

This process is only invoked when base_mode_flag is equal to 0 and mbType[CurrMbAddr] specified as input to this process is equal to I_PCM, I_16x16, I_8x8, or I_4x4.

Inputs to this process are

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a list fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a list mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a (PicSizeInMbs)x16 array ipred4x4 specifying Intra_4x4 prediction modes for macroblocks of the current layer representation,

– a (PicSizeInMbs)x4 array ipred8x8 specifying Intra_8x8 prediction modes for macroblocks of the current layer representation,

– a list intra16x16 with PicSizeInMbs elements specifying Intra_16x16 prediction modes for macroblocks of the current layer representation,

– when ChromaArrayType is equal to 1 or 2, a list intraChroma with PicSizeInMbs elements specifying intra chroma prediction modes for macroblocks of the current layer representation.

Outputs of this process are

– a modified version of the array ipred4x4,

– a modified version of the array ipred8x8,

– a modified version of the array ipred16x16,

– when ChromaArrayType is equal to 1 or 2, a modified version of the array ipredChroma.

For all processes specified in clause 6 that are invoked from the process specified in this subclause or a child process of the process specified in this subclause, the following modifications apply.

a) In subclause 6.4.11.2, a macroblock with address mbAddr is treated as field macroblock when fieldMbFlag[mbAddr] is equal to 1, and it is treated as frame macroblock when fieldMbFlag[mbAddr] is equal to 0. In particular, the current macroblock is treated as field macroblock when fieldMbFlag[CurrMbAddr] is equal to 1, and it is treated as frame macroblock when fieldMbFlag[CurrMbAddr] is equal to 0.

b) In subclause 6.4.7, a macroblock with address mbAddr is treated to belong to a different slice than the current macroblock CurrMbAddr, when sliceIdc[mbAddr] is not equal to sliceIdc[CurrMbAddr].

c) In subclause 6.4.11.2, a macroblock mbAddr is treated as top macroblock when (mbAddr % 2) is equal to 0, and it is treated as bottom macroblock when (mbAddr % 2) is equal to 1.

When mbType[CurrMbAddr] is not equal to I_PCM, the following applies.

– If mbType[CurrMbAddr] is equal to I_4x4, the SVC derivation process for Intra_4x4 prediction modes as specified in subclause G.8.3.1.1 is invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4, and ipred8x8 as the inputs and the output is a modified version of the array ipred4x4.

– Otherwise, if mbType[CurrMbAddr] is equal to I_8x8, the SVC derivation process for Intra_8x8 prediction modes as specified in subclause G.8.3.1.2 is invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4, and ipred8x8 as the inputs and the output is a modified version of the array ipred8x8.

– Otherwise, if mbType[CurrMbAddr] is equal to I_16x16, ipred16x16[CurrMbAddr] is set equal to Intra16x16PredMode.

When ChromaArrayType is equal to 1 or 2 and mbType[CurrMbAddr] is not equal to I_PCM, ipredChroma[CurrMbAddr] is set equal to intra_chroma_pred_mode.

G.8.3.1.1 SVC derivation process for Intra_4x4 prediction modes

Inputs to this process are

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a list fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a list mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a (PicSizeInMbs)x16 array ipred4x4 specifying Intra_4x4 prediction modes for macroblocks of the current layer representation,

– a (PicSizeInMbs)x4 array ipred8x8 specifying Intra_8x8 prediction modes for macroblocks of the current layer representation.

Output of this process is a modified version of the array ipred4x4.

The 4x4 blocks indexed by c4x4BlkIdx = 0..15 are processed in increasing order of c4x4BlkIdx, and for each 4x4 block, the following ordered steps are specified.

1. The derivation process for neighbouring 4x4 luma blocks as specified in subclause 6.4.10.4 is invoked with c4x4BlkIdx as the input and the outputs are assigned to mbAddrA, c4x4BlkIdxA, mbAddrB, and c4x4BlkIdxB. For this invocation of the process in subclause 6.4.10.4, the modifications specified in items a) through c) in subclause G.8.3.1 apply.
2. For N being replaced by A and B, the variables availableFlagN are derived as follows.
   – If the macroblock mbAddrN is available and mbType[mbAddrN] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, availableFlagN is set equal to 1.
   – Otherwise (macroblock mbAddrN is not available or mbType[mbAddrN] is not equal to I_PCM, I_16x16, I_8x8, or I_4x4), availableFlagN is set equal to 0.
3. The variable dcPredModePredictedFlag is derived as follows.
   – If availableFlagA or availableFlagB is equal to 0, dcPredModePredictedFlag is set equal to 1.
   – Otherwise (availableFlagA is equal to 1 and availableFlagB is equal to 1), dcPredModePredictedFlag is set equal to 0.
4. For N being replaced by A and B, the variables intraMxMPredModeN are derived as follows.
   – If dcPredModePredictedFlag is equal to 0 and mbType[mbAddrN] is equal to I_4x4, intraMxMPredModeN is set equal to ipred4x4[mbAddrN][c4x4BlkIdxN].
   – Otherwise, if dcPredModePredictedFlag is equal to 0 and mbType[mbAddrN] is equal to I_8x8, intraMxMPredModeN is set equal to ipred8x8[mbAddrN][c4x4BlkIdxN >> 2].
   – Otherwise (dcPredModePredictedFlag is equal to 1 or (mbType[mbAddrN] is not equal to I_4x4 and mbType[mbAddrN] is not equal to I_8x8)), intraMxMPredModeN is set equal to 2.
5. The element ipred4x4[CurrMbAddr][c4x4BlkIdx] of the array ipred4x4 is derived by applying the procedure specified in the following pseudo-code.

```
predIntra4x4PredMode = Min( intraMxMPredModeA, intraMxMPredModeB )
if( prev_intra4x4_pred_mode_flag[ c4x4BlkIdx ] )
   ipred4x4[ CurrMbAddr ][ c4x4BlkIdx ] = predIntra4x4PredMode
else if( rem_intra4x4_pred_mode[ c4x4BlkIdx ] < predIntra4x4PredMode )                (G-96)
   ipred4x4[ CurrMbAddr ][ c4x4BlkIdx ] = rem_intra4x4_pred_mode[ c4x4BlkIdx ]
else
   ipred4x4[ CurrMbAddr ][ c4x4BlkIdx ] = rem_intra4x4_pred_mode[ c4x4BlkIdx ] + 1
```

G.8.3.1.2 SVC derivation process for Intra_8x8 prediction modes

Inputs to this process are

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a list fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a list mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a (PicSizeInMbs)x16 array ipred4x4 specifying Intra_4x4 prediction modes for macroblocks of the current layer representation,

– a (PicSizeInMbs)x4 array ipred8x8 specifying Intra_8x8 prediction modes for macroblocks of the current layer representation.

Output of this process is a modified version of the array ipred8x8.

The 8x8 blocks indexed by c8x8BlkIdx = 0..3 are processed in increasing order of c8x8BlkIdx, and for each 8x8 block, the following ordered steps are specified.

1. The derivation process for neighbouring 8x8 luma blocks as specified in subclause 6.4.10.2 is invoked with c8x8BlkIdx as the input and the outputs are assigned to mbAddrA, c8x8BlkIdxA, mbAddrB, and c8x8BlkIdxB. For this invocation of the process in subclause 6.4.10.2, the modifications specified in items a) through c) in subclause G.8.3.1 apply.
2. For N being replaced by A and B, the variables availableFlagN are derived as follows.
   – If the macroblock mbAddrN is available and mbType[mbAddrN] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, availableFlagN is set equal to 1.
   – Otherwise (macroblock mbAddrN is not available or mbType[mbAddrN] is not equal to I_PCM, I_16x16, I_8x8, or I_4x4), availableFlagN is set equal to 0.
3. The variable dcPredModePredictedFlag is derived as follows.
   – If availableFlagA or availableFlagB is equal to 0, dcPredModePredictedFlag is set equal to 1.
   – Otherwise (availableFlagA is equal to 1 and availableFlagB are equal to 1), dcPredModePredictedFlag is set equal to 0.
4. For N being replaced by A and B, the variables intraMxMPredModeN are derived as follows.
   – If dcPredModePredictedFlag is equal to 0 and mbType[mbAddrN] is equal to I_4x4, intraMxMPredModeN is set equal to ipred4x4[mbAddrN][c8x8BlkIdxN * 4 + c4x4Idx] with the variable c4x4Idx being derived as follows.
     – If N is equal to B, c4x4Idx is set equal to 2.
     – Otherwise, if fieldMbFlag[CurrMbAddr] is equal to 0, fieldMbFlag[mbAddrN] is equal to 1, and c8x8BlkIdx is equal to 2, c4x4Idx is set equal to 3.
     – Otherwise (N is equal to A and (fieldMbFlag[CurrMbAddr] is equal to 1 or fieldMbFlag[mbAddrN] is equal to 0 or c8x8BlkIdx is not equal to 2)), c4x4Idx is set equal to 1.
   – Otherwise, if dcPredModePredictedFlag is equal to 0 and mbType[mbAddrN] is equal to I_8x8, intraMxMPredModeN is set equal to ipred8x8[mbAddrN][c8x8BlkIdxN].
   – Otherwise (dcPredModePredictedFlag is equal to 1 or (mbType[mbAddrN] is not equal to I_4x4 and mbType[mbAddrN] is not equal to I_8x8)), intraMxMPredModeN is set equal to 2.
5. The element ipred8x8[CurrMbAddr][c8x8BlkIdx] of the array ipred8x8 is derived by applying the procedure specified in the following pseudo-code.

```
predIntra8x8PredMode = Min( intraMxMPredModeA, intraMxMPredModeB )
if( prev_intra8x8_pred_mode_flag[ c8x8BlkIdx ] )
   ipred8x8[ CurrMbAddr ][ c8x8BlkIdx ] = predIntra8x8PredMode
else if( rem_intra8x8_pred_mode[ c8x8BlkIdx ] < predIntra8x8PredMode )                (G-97)
   ipred8x8[ CurrMbAddr ][ c8x8BlkIdx ] = rem_intra8x8_pred_mode[ c8x8BlkIdx ]
else
   ipred8x8[ CurrMbAddr ][ c8x8BlkIdx ] = rem_intra8x8_pred_mode[ c8x8BlkIdx ] + 1
```

G.8.3.2 SVC intra sample prediction and construction process

This process is only invoked when mbType specified as input to this process is equal to I_PCM, I_16x16, I_8x8, or I_4x4.

Inputs to this process are

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a list ipred4x4 with 16 elements specifying Intra_4x4 prediction modes for the current macroblock,

– a list ipred8x8 with 4 elements specifying Intra_8x8 prediction modes for the current macroblock,

– a variable ipred16x16 specifying the Intra_16x16 prediction mode for the current macroblock,

– a variable ipredChroma specifying the intra chroma prediction mode for the current macroblock,

– a variable cTrafo specifying the transform type for the current macroblock,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements,

– a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array $picSamples_L$ containing constructed luma sample values for the current layer representation,

– when ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays $picSamples_{Cb}$ and $picSamples_{Cr}$ containing constructed chroma sample values for the current layer representation.

Outputs of this process are

– a modified version of the array $picSamples_L$,

– when ChromaArrayType is not equal to 0, modified versions of the arrays $picSamples_{Cb}$ and $picSamples_{Cr}$.

For all processes specified in clauses 6 or 8 that are invoked from the process specified in this subclause or a child process of the process specified in this subclause, the following modifications apply.

a) In subclause 6.4.11.2, a macroblock with address mbAddr is treated as field macroblock when fieldMbFlag[mbAddr] is equal to 1, and it is treated as frame macroblock when fieldMbFlag[mbAddr] is equal to 0. In particular, the current macroblock is treated as field macroblock when fieldMbFlag[CurrMbAddr] is equal to 1, and it is treated as frame macroblock when fieldMbFlag[CurrMbAddr] is equal to 0.

b) In subclause 6.4.7, a macroblock with address mbAddr is treated to belong to a different slice than the current macroblock CurrMbAddr, when sliceIdc[mbAddr] is not equal to sliceIdc[CurrMbAddr].

c) In subclause 6.4.11.2, a macroblock mbAddr is treated as top macroblock when (mbAddr % 2) is equal to 0, and it is treated as bottom macroblock when (mbAddr % 2) is equal to 1.

d) In subclauses 8.3.1.2, 8.3.2.2, 8.3.3, and 8.3.4, the variables Intra4x4PredMode, Intra8x8PredMode, Intra16x16PredMode, and intra_chroma_pred_mode are replaced by ipred4x4, ipred8x8, ipred16x16, and ipredChroma, respectively.

e) In subclauses 8.3.1.2, 8.3.2.2, 8.3.3, and 8.3.4, the syntax element mb_type of a macroblock with macroblock address mbAddr is replaced by mbType[mbAddr].

f) In subclauses 8.3.1.2, 8.3.2.2, 8.3.3, and 8.3.4, a macroblock with mbAddrN is treated as coded in Inter prediction mode when mbType[mbAddrN] is not equal to I_PCM, I_16x16, I_8x8, or I_4x4.

The SVC intra sample prediction and construction process proceeds in the following ordered steps.

1. The construction process for luma residuals or chroma residuals with ChromaArrayType equal to 3 as specified in subclause G.8.5.3.1 is invoked with cTrafo and sTCoeff as the inputs and the outputs are residual luma sample values as a 16x16 array $mbRes_L$ with elements $mbRes_L$[x, y].

2. When ChromaArrayType is not equal to 0, the construction process for chroma residuals as specified in subclause G.8.5.3.2 is invoked with cTrafo and sTCoeff as the inputs and the outputs are residual chroma

sample values as two (MbWidthC)x(MbHeightC) arrays $mbRes_{Cb}$ and $mbRes_{Cr}$ with elements $mbRes_{Cb}[x, y]$ and $mbRes_{Cr}[x, y]$, respectively.

3. The SVC intra prediction and construction process for luma samples or chroma samples with ChromaArrayType equal to 3 as specified in subclause G.8.3.2.1 is invoked with $BitDepth_Y$, sliceIdc, fieldMbFlag, mbType, ipred4x4, ipred8x8, ipred16x16, $mbRes_L$, and $picSamples_L$ as the inputs and the output is a modified version of the array $picSamples_L$.

4. When ChromaArrayType is not equal to 0, the SVC intra prediction and construction process for chroma samples as specified in subclause G.8.3.2.2 is invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4, ipred8x8, ipred16x16, ipredChroma, $mbRes_{Cb}$, $mbRes_{Cr}$, $picSamples_{Cb}$, and $picSamples_{Cr}$ as the inputs and the outputs are modified versions of the arrays $picSamples_{Cb}$ and $picSamples_{Cr}$.

G.8.3.2.1 SVC intra prediction and construction process for luma samples or chroma samples with ChromaArrayType equal to 3

Inputs to this process are

– a variable bitDepth specifying the bit depth,

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a list ipred4x4 with 16 elements specifying Intra_4x4 prediction modes for the current macroblock,

– a list ipred8x8 with 4 elements specifying Intra_8x8 prediction modes for the current macroblock,

– a variable ipred16x16 specifying the Intra_16x16 prediction mode for the current macroblock,

– a 16x16 array mbRes containing residual sample values for the current macroblock,

– a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array picSamples containing constructed sample values for the current layer representation.

Outputs of this process is a modified version of the array picSamples.

Depending on mbType[CurrMbAddr], the following applies.

– If mbType[CurrMbAddr] is equal to I_PCM, the SVC construction process for luma samples and chroma samples with ChromaArrayType equal to 3 of I_PCM macroblocks as specified in subclause G.8.3.2.1.1 is invoked with fieldMbFlag, mbRes, and picSamples as the inputs and the output is a modified version of the array picSamples.

– Otherwise, if mbType[CurrMbAddr] is equal to I_4x4, the SVC Intra_4x4 sample prediction and construction process as specified in subclause G.8.3.2.1.2 is invoked with bitDepth, sliceIdc, fieldMbFlag, mbType, ipred4x4, mbRes, and picSamples as the inputs and the output is a modified version of the array picSamples.

– Otherwise, if mbType[CurrMbAddr] is equal to I_8x8, the SVC Intra_8x8 sample prediction and construction process as specified in subclause G.8.3.2.1.3 is invoked with bitDepth, sliceIdc, fieldMbFlag, mbType, ipred8x8, mbRes, and picSamples as the inputs and the output is a modified version of the array picSamples.

– Otherwise (mbType[CurrMbAddr] is equal to I_16x16), the SVC Intra_16x16 sample prediction and construction process as specified in subclause G.8.3.2.1.4 is invoked with bitDepth, sliceIdc, fieldMbFlag, mbType, ipred16x16, mbRes, and picSamples as the inputs and the output is a modified version of the array picSamples.

G.8.3.2.1.1 SVC construction process for luma samples and chroma samples with ChromaArrayType equal to 3 of I_PCM macroblocks

Inputs to this process are

– a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a 16x16 array mbRes containing residual sample values for the current macroblock,

– a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array picSamples containing constructed sample values for the current layer representation.

Outputs of this process is a modified version of the array picSamples.

The picture sample array construction process for a signal component as specified in subclause G.8.5.4.3 is invoked with fieldMbFlag[CurrMbAddr], mbW set equal to 16, mbH set equal to 16, mbRes, and picSamples as the inputs and the output is a modified version of the array picSamples.

G.8.3.2.1.2 SVC Intra_4x4 sample prediction and construction process

Inputs to this process are

– a variable bitDepth specifying the bit depth,

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a list ipred4x4 with 16 elements specifying Intra_4x4 prediction modes for the current macroblock,

– a 16x16 array mbRes containing residual sample values for the current macroblock,

– a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array picSamples containing constructed sample values for the current layer representation.

Outputs of this process is a modified version of the array picSamples.

Let mbSamples be a 16x16 array containing constructed intra sample values for the current macroblock. All elements of mbSamples are initially set equal to 0.

The 4x4 blocks indexed by c4x4BlkIdx = 0..15 are processed in increasing order of c4x4BlkIdx, and for each 4x4 block, the following ordered steps are specified.

1. The Intra_4x4 sample prediction process as specified in subclause 8.3.1.2 is invoked with c4x4BlkIdx and picSamples as the inputs and the outputs are intra prediction sample values as a 4x4 array pred4x4 with elements pred4x4[x, y]. For this invocation of the process in subclause 8.3.1.2, the modifications specified in items a) through f) of subclause G.8.3.2 apply. Additionally in subclause 8.3.1.2.3, which may be invoked as part of the process specified in subclause 8.3.1.2, the variable $BitDepth_Y$ is replaced by bitDepth.

2. The inverse 4x4 luma block scanning process as specified in subclause 6.4.3 is invoked with c4x4BlkIdx as the input and the output is assigned to (xP, yP).

3. For x = xP..(xP + 3) and y = yP..(yP + 3) and with Clip(a) specifying Clip3(0, (1 << bitDepth) – 1, a), the elements mbSamples[x, y] of the 16x16 array mbSamples are derived by

$$mbSamples[x, y] = Clip(pred4x4[x – xP, y – yP] + mbRes[x, y]) \quad \text{(G-98)}$$

4. The picture sample array construction process for a signal component as specified in subclause G.8.5.4.3 is invoked with fieldMbFlag[CurrMbAddr], mbW set equal to 16, mbH set equal to 16, mbSamples, and picSamples as the inputs and the output is a modified version of the array picSamples.

   NOTE – When c4x4BlkIdx is less than 15, the array mbSamples does only contain constructed intra samples for 4x4 blocks with c4x4BlkIdx less than or equal to the current value of c4x4BlkIdx.

G.8.3.2.1.3 SVC Intra_8x8 sample prediction and construction process

Inputs to this process are

– a variable bitDepth specifying the bit depth,

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a list ipred8x8 with 4 elements specifying Intra_8x8 prediction modes for the current macroblock,

– a 16x16 array mbRes containing residual sample values for the current macroblock,

– a (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$) array picSamples containing constructed sample values for the current layer representation.

Outputs of this process is a modified version of the array picSamples.

Let mbSamples be a 16x16 array containing constructed intra sample values for the current macroblock. All elements of mbSamples are initially set equal to 0.

The 8x8 blocks indexed by c8x8BlkIdx = 0..3 are processed in increasing order of c8x8BlkIdx, and for each 8x8 block, the following ordered steps are specified.

1. The Intra_8x8 sample prediction process as specified in subclause 8.3.2.2 is invoked with c8x8BlkIdx and picSamples as the inputs and the outputs are intra prediction sample values as an 8x8 array pred8x8 with elements pred8x8[x, y]. For this invocation of the process in subclause 8.3.2.2, the modifications specified in items a) through f) of subclause G.8.3.2 apply. Additionally in subclause 8.3.2.2.4, which may be invoked as part of the process specified in subclause 8.3.2.2, the variable BitDepth$_Y$ is replaced by bitDepth.

2. The inverse 8x8 luma block scanning process as specified in subclause 6.4.5 is invoked with c8x8BlkIdx as the input and the output is assigned to (xP, yP).

3. For x = xP..(xP + 7) and y = yP..(yP + 7) and with Clip(a) specifying Clip3(0, (1 << bitDepth) – 1, a), the elements mbSamples[x, y] of the 16x16 array mbSamples are derived by

   mbSamples[x, y] = Clip(pred8x8[x – xP, y – yP] + mbRes[x, y]) (G-99)

4. The picture sample array construction process for a signal component as specified in subclause G.8.5.4.3 is invoked with fieldMbFlag[CurrMbAddr], mbW set equal to 16, mbH set equal to 16, mbSamples, and picSamples as the inputs and the output is a modified version of the array picSamples.

   NOTE – When c8x8BlkIdx is less than 3, the array mbSamples does only contain constructed intra samples for 8x8 blocks with c8x8BlkIdx less than or equal to the current value of c8x8BlkIdx.

G.8.3.2.1.4 SVC Intra_16x16 sample prediction and construction process

Inputs to this process are

– a variable bitDepth specifying the bit depth,

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a variable ipred16x16 specifying the Intra_16x16 prediction mode for the current macroblock,

– a 16x16 array mbRes containing residual sample values for the current macroblock,

– a (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$) array picSamples containing constructed sample values for the current layer representation.

Outputs of this process is a modified version of the array picSamples.

The SVC Intra_16x16 sample prediction and construction process proceeds in the following ordered steps.

1. The Intra_16x16 prediction process for luma samples as specified in subclause 8.3.3 is invoked with picSamples as the input and the outputs are intra prediction sample values as a 16x16 array pred16x16 with elements pred16x16[x, y]. For this invocation of the process in subclause 8.3.3, the modifications specified in items a) through f) of subclause G.8.3.2 apply. Additionally in subclause 8.3.3.3, which may be invoked as part of the process specified in subclause 8.3.3, the variable BitDepth$_Y$ is replaced by bitDepth.

2. With Clip(a) specifying Clip3(0, (1 << bitDepth) – 1, a), the 16x16 array mbSamples is derived by

   mbSamples[x, y] = Clip(pred16x16[x, y] + mbRes[x, y]) with x, y = 0..15 (G-100)

3. The picture sample array construction process for a signal component as specified in subclause G.8.5.4.3 is invoked with fieldMbFlag[CurrMbAddr], mbW set equal to 16, mbH set equal to 16, mbSamples, and picSamples as the inputs and the output is a modified version of the array picSamples.

G.8.3.2.2 SVC intra prediction and construction process for chroma samples

Inputs to this process are

- a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,
- a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,
- a one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,
- a list ipred4x4 with 16 elements specifying Intra_4x4 prediction modes for the current macroblock,
- a list ipred8x8 with 4 elements specifying Intra_8x8 prediction modes for the current macroblock,
- a variable ipred16x16 specifying the Intra_16x16 prediction mode for the current macroblock,
- a variable ipredChroma specifying the intra chroma prediction mode for the current macroblock,
- two (MbWidthC)x(MbHeightC) arrays $mbRes_{Cb}$ and $mbRes_{Cr}$ containing residual chroma sample values for the current macroblock,
- two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays $picSamples_{Cb}$ and $picSamples_{Cr}$ containing constructed sample values for the current layer representation.

Outputs of this process are modified versions of the arrays $picSamples_{Cb}$ and $picSamples_{Cr}$.

Depending on ChromaArrayType, the following applies.

- If ChromaArrayType is equal to 1 or 2, the following applies.
  - If mbType[CurrMbAddr] is equal to I_PCM, the SVC construction process for chroma samples of I_PCM macroblock as specified in subclause G.8.3.2.2.1 is invoked with fieldMbFlag, sTCoeff, $picSamples_{Cb}$, and $picSamples_{Cr}$ as the inputs and the outputs are modified versions of $picSamples_{Cb}$ and $picSamples_{Cr}$.
  - Otherwise (mbType[CurrMbAddr] is not equal to I_PCM), the SVC intra prediction and construction process for chroma samples with ChromaArrayType equal to 1 or 2 as specified in subclause G.8.3.2.2.2 is invoked with sliceIdc, fieldMbFlag, mbType, ipredChroma, $mbRes_{Cb}$, $mbRes_{Cr}$, $picSamples_{Cb}$, and $picSamples_{Cr}$ as the inputs and the outputs are modified versions of the arrays $picSamples_{Cb}$ and $picSamples_{Cr}$.
- Otherwise (ChromaArrayType is equal to 3), for CX being replaced by Cb and Cr, the SVC intra prediction and construction process for luma samples or chroma samples with ChromaArrayType equal to 3 as specified in subclause G.8.3.2.1 is invoked with $BitDepth_C$, sliceIdc, fieldMbFlag, mbType, ipred4x4, ipred8x8, ipred16x16, $mbRes_{CX}$, and $picSamples_{CX}$ as the inputs and the output is a modified version of the array $picSamples_{CX}$.

G.8.3.2.2.1 SVC construction process for chroma samples of I_PCM macroblocks

Inputs to this process are

- a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,
- two (MbWidthC)x(MbHeightC) arrays $mbRes_{Cb}$ and $mbRes_{Cr}$ containing residual chroma sample values for the current macroblock,
- two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays $picSamples_{Cb}$ and $picSamples_{Cr}$ containing constructed chroma sample values for the current layer representation.

Outputs of this process are modified versions of the arrays $picSamples_{Cb}$ and $picSamples_{Cr}$.

For CX being replaced by Cb and Cr, the picture sample array construction process for a signal component as specified in subclause G.8.5.4.3 is invoked with fieldMbFlag[CurrMbAddr], mbW set equal to MbWidthC, mbH set equal to MbHeightC, $mbRes_{CX}$, and $picSamples_{CX}$ as the inputs and the output is a modified version of the array $picSamples_{CX}$.

G.8.3.2.2.2 SVC intra prediction and construction process for chroma samples with ChromaArrayType equal to 1 or 2

This process is only invoked when ChromaArrayType is equal to 1 or 2.

Inputs to this process are

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a variable ipredChroma specifying the intra chroma prediction mode for the current macroblock,

– two (MbWidthC)x(MbHeightC) arrays $mbRes_{Cb}$ and $mbRes_{Cr}$ containing residual chroma sample values for the current macroblock,

– two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays $picSamples_{Cb}$ and $picSamples_{Cr}$ containing constructed chroma sample values for the current layer representation.

Outputs of this process are modified versions of the arrays $picSamples_{Cb}$ and $picSamples_{Cr}$.

The SVC intra prediction and construction process for chroma samples with ChromaArrayType equal to 1 or 2 proceeds in the following ordered steps.

1. The intra prediction process for chroma samples as specified in subclause 8.3.4 is invoked with $picSamples_{Cb}$ and $picSamples_{Cr}$ as the inputs and the outputs are intra prediction chroma sample values as two (MbWidthC)x(MbHeightC) arrays $pred_{Cb}$ and $pred_{Cr}$ with elements $pred_{Cb}[x, y]$ and $pred_{Cr}[x, y]$, respectively. For this invocation of the process in subclause 8.3.4, the modifications specified in items a) through f) of subclause G.8.3.2 apply.

2. For CX being replaced by Cb and Cr, the (MbWidthC)x(MbHeightC) array $mbSamples_{CX}$ is derived by

$$mbSamples_{CX}[x, y] = Clip1_C(pred_{CX}[x, y] + mbRes_{CX}[x, y]) \quad \text{with } x = 0..(MbWidthC - 1) \text{ and } y = 0..(MbHeightC - 1) \quad \text{(G-101)}$$

3. For CX being replaced by Cb and Cr, the picture sample array construction process for a signal component as specified in subclause G.8.5.4.3 is invoked with fieldMbFlag[CurrMbAddr], mbW set equal to MbWidthC, mbH set equal to MbHeightC, $mbSamples_{CX}$, and $picSamples_{CX}$ as the inputs and the output is a modified version of the array $picSamples_{CX}$.

G.8.4 SVC Inter prediction process

Subclause G.8.4.1 specifies the SVC derivation process for motion vector components and reference indices.

Subclause G.8.4.2 specifies the SVC decoding process for Inter prediction samples

G.8.4.1 SVC derivation process for motion vector components and reference indices

Inputs to this process are

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a (PicSizeInMbs)x4 array subMbType specifying sub-macroblock types for the macroblocks of the current layer representation,

– two (PicSizeInMbs)x4 arrays predFlagL0 and predFlagL1 specifying prediction utilization flags for the macroblocks of the current layer representation,

– two (PicSizeInMbs)x4 arrays refIdxL0 and refIdxL1 specifying reference indices for the macroblocks of the current layer representation,

– two (PicSizeInMbs)x4x4x2 arrays mvL0 and mvL1 specifying motion vector components for the macroblocks of the current layer representation,

– a one-dimensional array mvCnt with PicSizeInMbs elements specifying the number of motion vectors for the macroblocks of the current layer representation,

– two 2x2 arrays refIdxILPredL0 and refIdxILPredL1 specifying inter-layer reference index predictors for the current macroblock,

– two 4x4x2 arrays mvILPredL0 and mvILPredL1 specifying inter-layer motion vector predictors for the current macroblock,

– when DQId is equal to 0 and (slice_type % 5) is equal to 1, the reference list refPicList1.

Outputs of this process are

– modified versions of the arrays predFlagL0 and predFlagL1,

– modified versions of the arrays refIdxL0 and refIdxL1,

– modified versions of the arrays mvL0 and mvL1,

– a modified version of the array mvCnt.

Depending on mbType[CurrMbAddr], the following applies.

– If mbType[CurrMbAddr] is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL, the arrays predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, and mvCnt are modified by

predFlagLX[CurrMbAddr][m] = 0 with X = 0..1, m = 0..3 (G-102)
refIdxLX[CurrMbAddr][m] = –1 with X = 0..1, m = 0..3 (G-103)
mvLX[CurrMbAddr][m][s][c] = 0 with X = 0..1, m = 0..3, s = 0..3, c = 0..1 (G-104)
mvCnt[CurrMbAddr] = 0 (G-105)

– Otherwise (mbType[CurrMbAddr] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL), the arrays predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, and mvCnt are modified as specified by the following text.

The variable isDirectFlag is derived as follows.

– If any of the following conditions is true, isDirectFlag is set equal to 1.

  – mbType[CurrMbAddr] is equal to B_Skip or B_Direct_16x16

  – mbType[CurrMbAddr] is equal to B_8x8 and subMbType[CurrMbAddr][mbPartIdx] is equal to B_Direct_8x8

– Otherwise, isDirectFlag is set equal to 0.

The variable numMbPart is derived as follows.

– If mbType[CurrMbAddr] is equal to B_Skip or B_Direct_16x16 and DQId is equal to 0 (nal_unit_type is not equal to 20), numMbPart is set equal to 4.

– Otherwise, if mbType[CurrMbAddr] is equal to B_Skip or B_Direct_16x16 (and DQId is greater than 0 and nal_unit_type is equal to 20), numMbPart is set equal to 1.

– Otherwise (mbType[CurrMbAddr] is not equal to B_Skip or B_Direct_16x16), numMbPart is set equal to NumMbPart(mbType[CurrMbAddr]).

The macroblock partition index mbPartIdx proceeds over the values 0..(numMbPart – 1), and for each value of mbPartIdx the following ordered steps are specified.

1. The variable numSubMbPart is derived as follows.

   – If isDirectFlag is equal to 1 and DQId is equal to 0 (nal_unit_type is not equal to 20), numSubMbPart is set equal to 4.

   – Otherwise, if isDirectFlag is equal to 1 (and DQId is greater than 0 and nal_unit_type is equal to 20), numSubMbPart is set equal to 1.

   – Otherwise (isDirectFlag is equal to 0), numSubMbPart is set equal to NumSubMbPart(subMbType[CurrMbAddr][mbPartIdx]).

2. The sub-macroblock partition index subMbPartIdx proceeds over values 0..(numSubMbPart – 1), and for each value of subMbPartIdx the SVC derivation process for luma motion vector components and reference indices of a macroblock or sub-macroblock partition as specified in subclause G.8.4.1.1 is invoked with mbPartIdx, subMbPartIdx, isDirectFlag, sliceIdc, fieldMbFlag, mbType, subMbType, predFlagL0, predFlagL1, refIdxL0,

refIdxL1, mvL0, mvL1, mvCnt, refIdxILPredL0, refIdxILPredL1, mvILPredL0, mvILPredL1, and, when DQId is equal to 0 and (slice_type % 5) is equal to 1, the reference picture list refPicList1 as the inputs and the outputs are modified versions of the arrays predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, and mvCnt.

G.8.4.1.1 SVC derivation process for luma motion vector components and reference indices of a macroblock or sub-macroblock partition

This subclause is only invoked when mbType[CurrMbAddr], which is specified as input to this subclause, is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL.

Inputs to this process are

– a variable mbPartIdx specifying the current macroblock partition,

– a variable subMbPartIdx specifying the current sub-macroblock partition,

– a variable isDirectFlag specifying whether the current macroblock partition is coded in direct mode,

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a (PicSizeInMbs)x4 array subMbType specifying sub-macroblock types for the macroblocks of the current layer representation,

– two (PicSizeInMbs)x4 arrays predFlagL0 and predFlagL1 specifying prediction utilization flags for the macroblocks of the current layer representation,

– two (PicSizeInMbs)x4 arrays refIdxL0 and refIdxL1 specifying reference indices for the macroblocks of the current layer representation,

– two (PicSizeInMbs)x4x4x2 arrays mvL0 and mvL1 specifying motion vector components for the macroblocks of the current layer representation,

– a one-dimensional array mvCnt with PicSizeInMbs elements specifying the number of motion vectors for the macroblocks of the current layer representation,

– two 2x2 arrays refIdxILPredL0 and refIdxILPredL1 specifying inter-layer reference index predictors for the current macroblock,

– two 4x4x2 arrays mvILPredL0 and mvILPredL1 specifying inter-layer motion vector predictors for the current macroblock,

– when DQId is equal to 0 and (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Outputs of this process are

– modified versions of the arrays predFlagL0 and predFlagL1,

– modified versions of the arrays refIdxL0 and refIdxL1,

– modified versions of the arrays mvL0 and mvL1,

– a modified version of the array mvCnt.

For all processes specified in clauses 6 or 8 that are invoked from the process specified in this subclause or a child process of the process specified in this subclause, the following modifications apply.

a) In subclauses 6.4.11.2 and 8.4.1.3.2, a macroblock with address mbAddr is treated as field macroblock when fieldMbFlag[mbAddr] is equal to 1, and it is treated as frame macroblock when fieldMbFlag[mbAddr] is equal to 0. In particular, the current macroblock is treated as field macroblock when fieldMbFlag[CurrMbAddr] is equal to 1, and it is treated as frame macroblock when fieldMbFlag[CurrMbAddr] is equal to 0.

b) In subclause 6.4.7, a macroblock with address mbAddr is treated to belong to a different slice than the current macroblock CurrMbAddr, when sliceIdc[mbAddr] is not equal to sliceIdc[CurrMbAddr].

c) In subclause 6.4.11.2, a macroblock mbAddr is treated as top macroblock when (mbAddr % 2) is equal to 0, and it is treated as bottom macroblock when (mbAddr % 2) is equal to 1.

d) In subclauses 6.4.2.1, 6.4.2.2, 6.4.10.7, 8.4.1.1, 8.4.1.3, any occurrence of mb_type is replaced by mbType[CurrMbAddr] with mbType being the array mbType that is input to this subclause.

e) In subclauses 6.4.2.2 and 6.4.10.7, any occurrence of sub_mb_type is replaced by subMbType[CurrMbAddr] with subMbType being the array subMbType that is input to this subclause.

f) In subclause 6.4.10.7, the macroblock partitioning of the macroblock mbAddrN that is used for determining the macroblock partition index mbPartIdxN and the sub-macroblock partition index subMbPartN based on a luma location (xW, yW) is the macroblock partitioning given by mbType[mbAddrN] and the specification in subclause G.8.4.1.

g) In subclause 6.4.10.7, a macroblock partition or sub-macroblock partition given by mbAddrN, mbPartIdxN, and subMbPartIdxN is treated as not yet decoded when mbAddrN is equal to CurrMbAddr and (4 * mbPartIdxN + subMbPartIdxN) is greater than (4 * mbPartIdx + subMbPartIdx).

h) In subclause 8.4.1.3.2, a macroblock with mbAddrN is treated as coded in Intra prediction mode when mbType[mbAddrN] is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL.

i) In subclause 8.4.1.3.2, the variable predFlagLX of a macroblock or sub-macroblock partition given by mbAddrN\mbPartIdxN\subMbPartIdxN is replaced by predFlagLX[mbAddrN][mbPartIdxN] with predFlagLX being the array predFlagLX that is input to this subclause.

j) In subclause 8.4.1.3.2, the motion vector MvLX[mbPartIdxN][subMbPartIdxN] and the reference index RefIdxLX[mbPartIdxN] of a macroblock or sub-macroblock partition given by mbAddrN\mbPartIdxN\subMbPartIdxN are replaced by mvLX[mbAddrN][mbPartIdxN][subMbPartIdxN] and refIdxLX[mbAddrN][mbPartIdxN], respectively, with mvLX and refIdxLX being the arrays mvLX and refIdxLX, respectively, that are input to this subclause.

k) In subclause 8.4.1.2.1, any occurrence of RefPicList1[0] is replaced by refPicList1[0] with refPicList1[0] being the first layer field (when field_pic_flag is equal to 1) or the first layer frame or layer complementary field pair (when field_pic_flag is equal to 0) in the reference picture list refPicList1 that is specified as input to this subclause. The reference picture list refPicList1 is a reference list of layer pictures that correspond to layer representations with DQId equal to 0 of previously decoded access units.

l) In subclause 8.4.1.2.1, the current picture CurrPic represents the current layer picture with DQId equal to 0 and variable colPic specifies the layer picture for the layer representation with DQId equal to 0 of a previously decoded access unit.

m) In subclause 8.4.1.2.1, all picture order count values are picture order count value for the dependency representation with dependency_id equal to 0.

n) In subclause 8.4.1.2.1, the modification b) specified in subclause G.8.2 applies with currDependencyId being equal to 0.

o) In subclause 8.4.1.2.1, for deriving the variable fieldDecodingFlagX, the macroblock mbAddrX is treated as field macroblock when fieldMbColPicFlag[mbAddrX] is equal to 1, it is treated as frame macroblock when fieldMbColPicFlag[mbAddrX] is equal to 0. The array fieldMbColPicFlag specifies the array fieldMbFlag that was derived by the process in subclause G.8.1.5.1 for the layer representation with DQId equal to 0.

p) In subclause 8.4.1.2.1, the variables PredFlagL0, PredFlagL1, RefIdxL0, RefIdxL1, MvL0, and MvL1 for the macroblock mbAddrCol inside the picture colPic are replaced with the predFlagL0[mbAddrCol], predFlagL1[mbAddrCol], refIdxL0[mbAddrCol], refIdxL1[mbAddrCol], mvL0[mbAddrCol], and mvL1[mbAddrCol], respectively, that have been derived for the layer picture colPic that is associated with DQId equal to 0.

q) In subclause 8.4.1.2.1, the macroblock mbAddrCol is interpreted as coded in Intra macroblock prediction mode when mbType[mbAddrCol] that has been derived when for the layer picture colPic that is associated with DQId equal to 0 is equal to I_16x16, I_8x8, I_4x4, or I_PCM.

r) In subclause 8.4.1.2.2, the co-located macroblock is treated as field macroblock when fieldMbColPicFlag[mbAddrCol] is equal to 1, it is treated as frame macroblock when fieldMbColPicFlag[mbAddrCol] is equal to 0. The array fieldMbColPicFlag specifies the array fieldMbFlag that was derived by the process in subclause G.8.1.5.1 for the layer representation with DQId equal to 0. The macroblock address mbAddrCol is the macroblock address of the co-located macroblock as derived in subclause 8.4.1.2.1.

The reference index predictors refIdxPredL0 and refIdxPredL1, the motion vector predictors mvPredL0 and mvPredL1, and the variable mvCntInc are derived as follows.

– If mbType[CurrMbAddr] is equal to P_Skip, the reference index predictor refIdxPredL1 is set equal to –1, both components of the motion vector predictor mvPredL1 are set equal to 0, the variable mvCntInc is set equal to 1, and the derivation process for luma motion vectors for skipped macroblocks in P slices as specified in subclause 8.4.1.1 is invoked with the outputs being assigned to the motion vector predictor mvPredL0 and the reference index predictor refIdxPredL0. For this invocation of the process in subclause 8.4.1.1, the modifications specified above in items a) through j) of this subclause apply.

– Otherwise, if isDirectFlag is equal to 1 and DQId is equal to 0 (nal_unit_type is not equal to 20), the derivation process for spatial direct luma motion vector and reference index prediction mode as specified in subclause 8.4.1.2.2 is invoked with mbPartIdx and subMbPartIdx as the inputs and the output variables refIdxL0, refIdxL1, mvL0, mvL1, and subMvCnt are assigned to the reference index predictors refIdxPredL0 and refIdxPredL1, the motion vectors predictors mvPredL0 and mvPredL1, and the variable subMvCnt, respectively. For this invocation of the process in subclause 8.4.1.2.2, the modifications specified above in items a) through r) of this subclause apply.

  NOTE – When the current subclause is invoked, direct_spatial_mv_pred_flag is always equal to 1.

– Otherwise, if isDirectFlag is equal to 1 (and DQId is greater than 0 and nal_unit_type is equal to 20), the SVC derivation process for luma motion vectors and reference indices for B_Skip, B_Direct_16x16, and B_Direct_8x8 in NAL units with nal_unit_type equal to 20 as specified in subclause G.8.4.1.2 is invoked with mbPartIdx, fieldMbFlag, mbType, subMbType, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, and mvL1 as the inputs and the outputs are refIdxPredL0, refIdxPredL1, mvPredL0, mvPredL1, and mvCntInc.

– Otherwise, the variable mvCntInc is initially set equal to 0, and for X being replaced by 0 and 1, the following applies.

  – If any of the following conditions is true, refIdxPredLX is set equal to –1 and both components of mvPredLX are set equal to 0.

    – mbType[CurrMbAddr] is not equal to P_8x8, P_8x8ref0, or B_8x8 and MbPartPredMode(mbType[CurrMbAddr], mbPartIdx) is not equal to Pred_LX or BiPred

    – mbType[CurrMbAddr] is equal to P_8x8, P_8x8ref0, or B_8x8 and SubMbPartPredMode(subMbType[CurrMbAddr][mbPartIdx]) is not equal to Pred_LX or BiPred

  – Otherwise, if base_mode_flag is equal to 1 or motion_prediction_flag_lX[mbPartIdx] is equal to 1, the following ordered steps are specified.

    1. The inverse macroblock partition scanning process as specified in subclause 6.4.2.1 is invoked with mbPartIdx as the input and the output is assigned to (xP, yP). For this invocation of the process in subclause 6.4.2.1, the modification specified above in item d) of this subclause applies.

    2. Inverse sub-macroblock partition scanning process as specified in subclause 6.4.2.2 is invoked with mbPartIdx and subMbPartIdx as the inputs and the output is assigned to (xS, yS). For this invocation of the process in subclause 6.4.2.2, the modifications specified above in items d) and e) of this subclause apply.

    3. The reference index predictor refIdxPredLX and the motion vector predictor mvPredLX are derived by

$$\begin{aligned} \text{refIdxPredLX} &= \text{refIdxILPredLX}[\ (xP + xS) / 8, (xP + xS) / 8\ ] \\ \text{mvPredLX}[\ c\ ] &= \text{mvILPredLX}[\ (xP + xS) / 4, (xP + xS) / 4\ ][\ c\ ] \quad \text{with } c = 0..1 \end{aligned} \tag{G-106}$$

       The bitstream shall not contain data that result in refIdxPredLX less than 0.

    4. mvCntInc is set equal to (mvCntInc + 1).

  – Otherwise, the following ordered steps are specified.

    1. Depending on mbType[CurrMbAddr], the reference index predictor refIdxPredLX is derived as follows.

       – If mbType[CurrMbAddr] is equal to P_8x8ref0, refIdxPredLX is set equal to 0.

       – Otherwise (mbType[CurrMbAddr] is not equal to P_8x8ref0), refIdxPredLX is set equal to ref_idx_lX[mbPartIdx].

    2. The derivation process for luma motion vector prediction as specified in subclause 8.4.1.3 is invoked with mbPartIdx, subMbPartIdx, refIdxPredLX, and currSubMbType set equal to

subMbType[CurrMbAddr][mbPartIdx] as the inputs and the output is assigned to mvPredLX. For this invocation of the process in subclause 8.4.1.3, the modifications specified in items a) through j) of this subclause apply

3. mvCntInc is set equal to (mvCntInc + 1).

For X being replaced by 0 and 1, the arrays refIdxLX, predFlagLX, and mvLX are modified by applying the following ordered steps.

1. When subMbPartIdx is equal to 0, the arrays refIdxLX and predFlagLX are modified by

$$refIdxLX[CurrMbAddr][mbPartIdx] = refIdxPredLX \quad \text{(G-107)}$$
$$predFlagLX[CurrMbAddr][mbPartIdx] = (refIdxPredLX < 0 \ ? \ 0 \ : \ 1) \quad \text{(G-108)}$$

2. The array mvLX is modified by.

$$mvLX[CurrMbAddr][mbPartIdx][subMbPartIdx][c] = mvPredLX[c] \quad \text{with } c = 0..1 \quad \text{(G-109)}$$

3. When predFlagLX[CurrMbAddr][mbPartIdx] is equal to 1, base_mode_flag is equal to 0, isDirectFlag is equal to 0, and mbType[CurrMbAddr] is not equal to P_Skip, the array mvLX is modified by

$$mvLX[CurrMbAddr][mbPartIdx][subMbPartIdx][c] += mvd\_lX[mbPartIdx][subMbPartIdx][c] \quad \text{with } c = 0..1 \quad \text{(G-110)}$$

The array mvCnt is modified as follows.

– If mbPartIdx is equal to 0 and subMbPartIdx is equal to 0, mvCnt[CurrMbAddr] is set equal to mvCntInc.

– Otherwise (mbPartIdx is greater than 0 or subMbPartIdx is greater than 0), the array mvCnt is modified by

$$mvCnt[CurrMbAddr] += mvCntInc \quad \text{(G-111)}$$

G.8.4.1.2 SVC derivation process for luma motion vectors and reference indices for B_Skip, B_Direct_16x16, and B_Direct_8x8 in NAL units with nal_unit_type equal to 20

Inputs to this process are

– a variable mbPartIdx specifying the current macroblock partition,

– a one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a (PicSizeInMbs)x4 array subMbType specifying sub-macroblock types for the macroblocks of the current layer representation,

– two (PicSizeInMbs)x4 arrays predFlagL0 and predFlagL1 specifying prediction utilization flags for the macroblocks of the current layer representation,

– two (PicSizeInMbs)x4 arrays refIdxL0 and refIdxL1 specifying reference indices for the macroblocks of the current layer representation,

– two (PicSizeInMbs)x4x4x2 arrays mvL0 and mvL1 specifying motion vector components for the macroblocks of the current layer representation.

Outputs of this process are

– the reference index predictors refIdxPredL0 and refIdxPredL1,

– the motion vector predictors mvPredL0 and mvPredL1,

– the variable mvCntInc.

The variable currSubMbType is derived as follows.

– If mbType[CurrMbAddr] is equal to B_Skip or B_Direct_16x16, currSubMbType is marked as "unspecified".

– Otherwise (mbType[CurrMbAddr] is equal to B_8x8 and subMbType[CurrMbAddr][mbPartIdx] is equal to B_Direct_8x8), currSubMbType is set equal to B_Bi_8x8.

NOTE – The variable currSubMbType is only used for deriving the variable predPartWidth in subclause 6.4.10.7, which specifies the partition width of the current macroblock or sub-macroblock partition for determining neighbouring partitions that are used for motion vector prediction. Inside subclause 6.4.10.7, the variable predPartWidth is set equal to 16 when the current macroblock is coded with macroblock type equal to B_Skip or B_Direct_16x16 or the current sub-macroblock is coded with sub-macroblock type equal B_Direct_8x8. When the current subclause is invoked for a sub-macroblock coded with sub-macroblock type equal to B_Direct_8x8 (the current subclause is only invoked for NAL units with nal_unit_type equal to 20), currSubMbType is set equal to B_Bi_8x8 in order to set the variable predPartWidth equal to 8 in subclause 6.4.10.7.

For X being replaced by 0 and 1, the reference index predictor refIdxPredLX is derived by applying the following ordered steps.

1. The derivation process for motion data of neighbouring partitions as specified in subclause 8.4.1.3.2 is invoked with mbPartIdx, subMbPartIdx set equal to 0, currSubMbType, and listSuffixFlag set equal to X as the inputs and the outputs are the reference indices refIdxLXN with N being replaced by A, B, and C. For this invocation of the process in subclause 8.4.1.3.2, the modifications specified in items a) through j) of subclause G.8.4.1.1 apply.
2. The reference index predictor refIdxPredLX is derived by

$$refIdxPredLX = MinPositive(refIdxLXA, MinPositive(refIdxLXB, refIdxLXC)) \quad \text{(G-112)}$$

with

$$MinPositive(x, y) = \begin{cases} Min(x, y) & \text{if } x >= 0 \text{ and } y >= 0 \\ Max(x, y) & \text{otherwise} \end{cases} \quad \text{(G-113)}$$

When both reference index predictors refIdxPredL0 and refIdxPredL1 are less than 0, refIdxPredL0 and refIdxPredL1 are set equal to 0.

For X being replaced by 0 and 1, the motion vector predictor mvPredLX is derived as follows.

– If refIdxPredLX is greater than or equal to 0, the derivation process for luma motion vector prediction as specified in subclause 8.4.1.3 is invoked with mbPartIdx, subMbPartIdx set equal to 0, refIdxPredLX, and currSubMbType as the inputs and the output is assigned to mvPredLX. For this invocation of the process in subclause 8.4.1.3, the modifications specified in items a) through j) of subclause G.8.4.1.1 apply.

– Otherwise, both components of the motion vector mvPredLX are set equal to 0.

The variable mvCntInc is derived as specified by the following ordered steps.

1. mvCntInc is set equal to 0.
2. When refIdxPredL0 is greater than or equal to 0, mvCntInc is set equal to (mvCntInc + 1).
3. When refIdxPredL1 is greater than or equal to 0, mvCntInc is set equal to (mvCntInc + 1).

G.8.4.2 SVC decoding process for Inter prediction samples

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable mbType specifying the macroblock type for the current macroblock,

– a list subMbType with 4 elements specifying the sub-macroblock types for the current macroblock,

– two lists predFlagL0 and predFlagL1 with 4 elements specifying prediction utilization flags for the current macroblock,

– two lists refIdxL0 and refIdxL1 with 4 elements specifying reference indices for the current macroblock,

– two 4x4x2 arrays mvL0 and mvL1 specifying motion vectors components for the current macroblock,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation,

– the reference picture lists refPicList0 and refPicList1 (when available),

– a (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$) array picSamples$_L$ of luma sample values,

– when ChromaArrayType is not equal to 0, two (PicWidthInSamples$_C$)x(PicHeightInSamples$_C$) arrays picSamples$_{Cb}$ and picSamples$_{Cr}$ of chroma sample values.

Outputs of this process are

– a modified version of the array of luma sample values picSamples$_L$,

– when ChromaArrayType is not equal to 0, modified versions of the two arrays of chroma sample values picSamples$_{Cb}$ and picSamples$_{Cr}$.

For all processes specified in clauses 6 or 8 that are invoked from the process specified in this subclause or a child process of the process specified in this subclause, the following modifications apply.

a) In subclauses 8.4.3, 8.4.1.4, and 8.4.2.1, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1, and it is treated as frame macroblock when fieldMbFlag is equal to 0. When field_pic_flag is equal to 0 and the current macroblock CurrMbAddr is a field macroblock, its parity is equal to top when (CurrMbAddr % 2) is equal to 0 and its parity is equal to bottom when (CurrMbAddr % 2) is equal to 1.

b) In subclauses 8.4.3 and 8.4.2.1, any occurrence of RefPicList0 or RefPicList1 is replaced with refPicList0 or refPicList1, respectively, with refPicList0 and refPicList1 being the reference picture lists specified as inputs to this subclause.

c) In subclause 8.4.1.4, the reference picture referred by refIdxLX is specified by refPicListX[refIdxLX] with refPicList0 and refPicList1 specified as inputs to this subclause.

d) In subclauses 8.4.2.2.1 and 8.4.2.2.2, any occurrence of mb_field_decoding_flag is replaced by fieldMbFlag.

Let predMb$_L$ be a 16x16 array of luma prediction samples for the macroblock mbAddr.

When ChromaArrayType is not equal to 0, let predMb$_{Cb}$ and predMb$_{Cr}$ be two (MbWidthC)x(MbHeightC) arrays of chroma prediction samples for the macroblock mbAddr.

The variable isDirectFlag is derived as follows.

– If any of the following conditions is true, isDirectFlag is set equal to 1.

  – mbType is equal to B_Skip or B_Direct_16x16

  – mbType is equal to B_8x8 and subMbType[mbPartIdx] is equal to B_Direct_8x8

– Otherwise, isDirectFlag is set equal to 0.

The variable numMbPart is derived as follows.

– If mbType is equal to B_Skip or B_Direct_16x16 and DQId is equal to 0 (nal_unit_type is not equal to 20), numMbPart is set equal to 4.

– Otherwise, if mbType is equal to B_Skip or B_Direct_16x16 (and DQId is greater than 0 and nal_unit_type is equal to 20), numMbPart is set equal to 1.

– Otherwise (mbType is not equal to B_Skip or B_Direct_16x16), numMbPart is set equal to NumMbPart(mbType).

The macroblock partition index mbPartIdx proceeds over the values 0..(numMbPart – 1), and for each value of mbPartIdx the following ordered steps are specified.

1. The SVC derivation process for prediction weights as specified in subclause G.8.4.2.1 is invoked with fieldMbFlag, refIdxL0[mbPartIdx], refIdxL1[mbPartIdx], predFlagL0[mbPartIdx], predFlagL1[mbPartIdx], refPicList0, and refPicList1 (when available) as inputs and the outputs are assigned to logWD$_L$, w$_{0L}$, w$_{1L}$, o$_{0L}$, o$_{1L}$, and when ChromaArrayType is not equal to 0, logWD$_C$, w$_{0C}$, w$_{1C}$, o$_{0C}$, o$_{1C}$ with C being replaced by Cb and Cr.

2. The luma location (xP, yP) is derived as follows.

– If mbType is equal to B_Skip or B_Direct_16x16, xP is set equal to (8 * (mbPartIdx % 2)) and yP is set equal to (8 * (mbPartIdx / 2)).

– Otherwise (mbType is not equal to B_Skip or B_Direct_16x16), the inverse macroblock partition scanning process as specified in subclause 6.4.2.1 is invoked with mbPartIdx as the input and the output is assigned to (xP, yP). For this invocation of the process in subclause 6.4.2.1, any occurrence of mb_type is replaced by mbType.

3. The variable numSubMbPart is derived as follows.

   – If isDirectFlag is equal to 1 and DQId is equal to 0 (nal_unit_type is not equal to 20), numSubMbPart is set equal to 4.

   – Otherwise, if isDirectFlag is equal to 1 (and DQId is greater than 0 and nal_unit_type is equal to 20), numSubMbPart is set equal to 1.

   – Otherwise (isDirectFlag is equal to 0), numSubMbPart is set equal to NumSubMbPart(subMbType[mbPartIdx])

4. The sub-macroblock partition index proceeds over values 0..(numSubMbPart – 1), and for each value of subMbPartIdx the following ordered steps are specified.

   a. The variables partWidth and partHeight are derived as follows.

      – If isDirectFlag is equal to 1 and DQId is equal to 0 (nal_unit_type is not equal to 20), partWidth and partHeight are set equal to 4.

      – Otherwise, if isDirectFlag is equal to 1 (and DQId is greater than 0 and nal_unit_type is equal to 20), the following applies.

         – If mbType is equal to B_Skip or B_Direct_16x16, partWidth and partHeight are set equal to 16.

         – Otherwise (mbType is equal to B_8x8 and subMbType[mbPartIdx] is equal to B_Direct_8x8), partWidth and partHeight are set equal to 8.

      – Otherwise (isDirectFlag is equal to 0), the following applies.

         – If mbType is not equal to P_8x8, P_8x8ref0, or B_8x8, partWidth and partHeight are derived by

            partWidth = MbPartWidth(mbType) (G-114)
            partHeight = MbPartHeight(mbType) (G-115)

         – Otherwise (mbType is equal to P_8x8, P_8x8ref0, or B_8x8), partWidth and partHeight are derived by

            partWidth = SubMbPartWidth(subMbType[mbPartIdx]) (G-116)
            partHeight = SubMbPartHeight(subMbType[mbPartIdx]) (G-117)

   b. When ChromaArrayType is not equal to 0, the variables partWidthC and partHeightC are derived by

      partWidthC = partWidth / SubWidthC (G-118)
      partHeightC = partHeight / SubWidthC (G-119)

   c. For X being replaced by 0 and 1, when ChromaArrayType is not equal to 0 and predFlagLX[mbPartIdx] is equal to 1, the derivation process for chroma motion vectors as specified in subclause 8.4.1.4 is invoked with mvLX[mbPartIdx][subMbPartIdx] and refIdxLX[mbPartIdx] as the inputs and the output is the chroma motion vector mvCLX. For this invocation of the process in subclause 8.4.1.4, the modifications specified above in items a) and c) of this subclause apply.

   d. The decoding process for Inter prediction samples as specified in subclause 8.4.2 is invoked with mbPartIdx, subMbPartIdx, partWidth and partHeight, partWidthC and partHeightC (if available), luma motion vectors mvL0[mbPartIdx][subMbPartIdx] and mvL1[mbPartIdx][subMbPartIdx], chroma motion vectors mvCL0 and mvCL1 (if available), reference indices refIdxL0[mbPartIdx] and refIdxL1[mbPartIdx], prediction utilization flags predFlagL0[mbPartIdx] and predFlagL1[mbPartIdx] as well as variables for weighted prediction $logWD_L$, w_{0L}, w_{1L}, o_{1L}, o_{0L}, and when ChromaArrayType is not equal to 0, $logWD_C$, w_{0C}, w_{1C}, o_{1C}, and o_{0C} (with C being replaced by Cb and Cr) as the inputs and the outputs are a (partWidth)x(partHeight) array $predPart_L$ of luma prediction samples and, when ChromaArrayType is not equal to 0, two (partWidthC)x(partHeightC) arrays $predPart_{Cb}$ and $predPart_{Cr}$ of chroma prediction samples. For this invocation of the process in subclause 8.4.2, the modifications specified above in items a), b), and d) of this subclause apply.

e. The luma location (xS, yS) is derived as follows.

– If mbType is not equal to B_8x8 or subMbType[mbPartIdx] is equal to B_Direct_8x8, xS is set equal to (4 * (subMbPartIdx % 2)) and yP is set equal to (4 * (subMbPartIdx / 2)).

– Otherwise (mbType is equal to B_8x8 and subMbType[mbPartIdx] is not equal to B_Direct_8x8), the inverse sub-macroblock partition scanning process as specified in subclause 6.4.2.2 is invoked with mbPartIdx and subMbPartIdx as the inputs and the output is assigned to (xS, yS). For this invocation of the process in subclause 6.4.2.2, any occurrence of mb_type is replaced by mbType and any occurrence of sub_mb_type is replaced by subMbType.

f. For x = 0..(partWidth – 1) and y = 0..(partHeight – 1), the 16x16 array $predMb_L$ is modified by

$$predMb_L[xP + xS + x, yP + yS + y] = predPart_L[x, y] \quad \text{(G-120)}$$

g. When ChromaArrayType is not equal to 0, for x = 0..(partWidthC – 1) and y = 0..(partHeightC – 1), the (MbWidthC)x(MbHeightC) arrays $predMb_{Cb}$ and $predMb_{Cr}$ are modified by

$$predMb_{Cb}[(xP + xS) / SubWidthC + x, (yP + yS) / SubHeightC + y] = predPart_{Cb}[x, y] \quad \text{(G-121)}$$
$$predMb_{Cr}[(xP + xS) / SubWidthC + x, (yP + yS) / SubHeightC + y] = predPart_{Cr}[x, y] \quad \text{(G-122)}$$

When base_mode_flag is equal to 1, quality_id is equal to 0, MbaffFrameFlag is equal to 0, RefLayerMbaffFrameFlag is equal to 0, and RestrictedSpatialResolutionChangeFlag is equal to 0, the intra-inter prediction combination process specified in subclause G.8.4.2.2 is invoked with fieldMbFlag, refLayerFieldMbFlag, refLayerMbType, $predMb_L$, $picSamples_L$, and, when ChromaArrayType is not equal to 0, $predMb_{Cb}$, $predMb_{Cr}$, $picSamples_{Cb}$, and $picSamples_{Cr}$ as the inputs, and the outputs are a modified version of $predMb_L$ and, when ChromaArrayType is not equal to 0, modified versions of $predMb_{Cb}$ and $predMb_{Cr}$.

The picture sample array construction process as specified in subclause G.8.5.4.1 is invoked with fieldMbFlag, $predMb_L$, $picSamples_L$, and, when ChromaArrayType is not equal to 0, $predMb_{Cb}$, $predMb_{Cr}$, $picSamples_{Cb}$, and $picSamples_{Cr}$ as the inputs and the outputs are a modified version of $picSamples_L$ and, when ChromaArrayType is not equal to 0, modified versions of $picSamples_{Cb}$, and $picSamples_{Cr}$.

G.8.4.2.1 SVC derivation process for prediction weights

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– the reference indices refIdxL0 and refIdxL1 for the current macroblock partition,

– the prediction list utilization flags predFlagL0 and predFlagL1 for the current macroblock partition,

– the reference picture lists refPicList0 and refPicList1 (when available).

Outputs of this process are

– variables for weighted prediction of luma samples $logWD_L$, w_{0L}, w_{1L}, o_{0L}, o_{1L}.

– when ChromaArrayType is not equal to 0 (monochrome), variables for weighted prediction of chroma samples $logWD_C$, w_{0C}, w_{1C}, o_{0C}, o_{1C} with C being replaced by Cb and Cr.

Depending on base_pred_weight_table_flag the following applies.

– If base_pred_weight_table_flag is equal to 0, the derivation process for prediction weights as specified in subclause 8.4.3 is invoked with refIdxL0, refIdxL1, predFlagL0, and predFlagL1 as inputs and the outputs are assigned to $logWD_L$, w_{0L}, w_{1L}, o_{0L}, o_{1L}, and when ChromaArrayType is not equal to 0, $logWD_C$, w_{0C}, w_{1C}, o_{0C}, o_{1C} with C being replaced by Cb and Cr. For this invocation of the process in subclause 8.4.3, the modifications specified in items a) and b) of subclause G.8.4.2 apply.

– Otherwise (base_pred_weight_table_flag is equal to 1), for X being replaced by 0 and 1, the following ordered steps are specified.

1. Let baseSlice be any slice of the layer representation with DQId equal to the value of ref_layer_dq_id.

2. Let refLayerLumaLogWD, aRefLayerLumaWeightLX[], and aRefLayerLumaOffsetLX[] be variables that are set equal to the values of the syntax elements luma_log2_weight_denom, luma_weight_lX[], and luma_offset_lX[], respectively, of baseSlice.

3. When ChromaArrayType is not equal to 0, let refLayerChromaLogWD, aRefLayerChromaWeightLX[][], and aRefLayerChromaOffsetLX[][] be variables that are set equal to the values of the syntax elements chroma_log2_weight_denom, chroma_weight_lX[], and chroma_offset_lX[], respectively, of baseSlice.

4. The variable refIdxLXWP is derived as follows

   – If MbaffFrame is equal to 1 and fieldMbFlag is equal to 1,

   $$refIdxLXWP = refIdxLX >> 1 \quad \text{(G-123)}$$

   – Otherwise (MbaffFrameFlag is equal to 0 or fieldMbFlag is equal to 0),

   $$refIdxLXWP = refIdxLX \quad \text{(G-124)}$$

5. The variables $logWD_Y$, w_{XY}, o_{XY} are derived by

   $$logWD_Y = baseLumaLogWD \quad \text{(G-125)}$$
   $$w_{XY} = aRefLayerLumaWeightLX[\ refIdxLXWP\ ] \quad \text{(G-126)}$$
   $$o_{XY} = aRefLayerLumaOffsetLX[\ refIdxLXWP\ ] * (\ 1 << (\ BitDepth_Y - 8\ )\ ) \quad \text{(G-127)}$$

6. When ChromaArrayType is not equal to 0, the variables $logWD_C$, w_{XC}, o_{XC} (with C being replaced by Cb and Cr and iCbCr = 0 for Cb and iCbCr = 1 for Cr) are derived by

   $$logWD_C = baseChromaLogWD \quad \text{(G-128)}$$
   $$w_{XC} = aRefLayerChromaWeightLX[\ refIdxLXWP\ ][\ iCbCr\ ] \quad \text{(G-129)}$$
   $$o_{XC} = aRefLayerChromaOffsetLX[\ refIdxLXWP\ ][\ iCbCr\ ] * (\ 1 << (\ BitDepth_C - 8\ )\ ) \quad \text{(G-130)}$$

7. When base_pred_weight_table_flag is equal to 1 and predFlagL0 and predFlagL1 are equal to 1, the following constraint shall be obeyed for C equal to L and, when ChromaArrayType is not equal to 0, Cb and Cr

   $$-128 <= w_{0C} + w_{1C} <= (\ (\ logWD_C == 7\ )\ ?\ 127 : 128\ ) \quad \text{(G-131)}$$

G.8.4.2.2 Intra-inter prediction combination process

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation,

– a 16x16 array $predMb_L$ of luma inter prediction samples for the current macroblock,

– a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array $picSamples_L$ of luma sample values,

– when ChromaArrayType is not equal to 0, two (MbWidthC)x(MbHeightC) arrays $predMb_{Cb}$ and $predMb_{Cr}$ of chroma prediction samples for the macroblock mbAddr,

– when ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays $picSamples_{Cb}$ and $picSamples_{Cr}$ of chroma sample values.

Outputs of this process are

– a modified version of the array $predMb_L$ of luma prediction samples for the macroblock mbAddr,

– when ChromaArrayType is not equal to 0, modified versions of the two arrays $predMb_{Cb}$ and $predMb_{Cr}$ of chroma prediction samples for the macroblock mbAddr.

Let $predMbTemp_L$ be a 16x16 array and, when ChromaArrayType is not equal to 0, let $predMbTemp_{Cb}$ and $predMbTemp_{Cr}$ be two (MbWidthC)x(MbHeightC) arrays. The macroblock sample array extraction process as specified in subclause G.8.5.4.2 is invoked with fieldMbFlag, $picSamples_L$, and when ChromaArrayType is not equal to 0,

$picSamples_{Cb}$ and $picSamples_{Cr}$ as the inputs and the outputs are assigned to $predMbTemp_L$, and when ChromaArrayType is not equal to 0, $predMbTemp_{Cb}$ and $predMbTemp_{Cr}$.

For x proceeding over the values 0..15 and y proceeding over the values 0..15, the following ordered steps are specified.

1. The derivation process for reference layer macroblocks as specified in subclause G.6.1 is invoked with (x, y), fieldMbFlag, refLayerFieldMbFlag, and refLayerMbType as the inputs and the outputs are assigned to mbAddrRefLayer and (xRef, yRef).
2. When refLayerMbType[mbAddrRefLayer] is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL, the following applies.
   a. The prediction luma sample $predMb_L[x, y]$ is modified by

$$predMb_L[x, y] = predMbTemp_L[x, y] \quad \text{(G-132)}$$

   b. When ChromaArrayType is not equal to 0, (x % SubWidthC) is equal to 0, and (y % SubHeightC) is equal to 0, the prediction chroma sample $predMb_{Cb}[x, y]$ and $predMb_{Cr}[x, y]$ are modified by

$$predMb_{Cb}[x, y] = predMbTemp_{Cb}[x, y] \quad \text{(G-133)}$$
$$predMb_{Cr}[x, y] = predMbTemp_{Cr}[x, y] \quad \text{(G-134)}$$

G.8.5 SVC transform coefficient decoding and sample array construction processes

Subclause G.8.5.1 specifies the transform coefficient scaling and refinement process.

Subclause G.8.5.2 specifies the transform coefficient level scaling process prior to transform coefficient refinement.

Subclause G.8.5.3 specifies the residual construction and accumulation process.

Subclause G.8.5.4 specifies the sample array accumulation process.

Subclause G.8.5.5 specifies the sample array re-initialisation process.

G.8.5.1 Transform coefficient scaling and refinement process

Inputs to this process are

– a variable refinementFlag specifying whether the transform coefficients for the current macroblock are combined with the existent transform coefficients for the current macroblock, which were obtained from the reference layer representation,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable cTrafo specifying the transform type,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements,

– a list of transform coefficient level values tCoeffLevel with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are

– a modified version of the list sTCoeff,

– a modified version of the list tCoeffLevel.

The scaling functions and, when ChromaArrayType is not equal to 0, the chroma quantisation parameters QP'_{Cb} and QP'_{Cr} are derived by invoking the derivation process for chroma quantisation parameters and scaling function as specified in subclause 8.5.8.

When refinementFlag is equal to 0, all (256 + 2 * MbWidthC * MbHeightC) elements of the lists sTCoeff and tCoeffLevel are set equal to 0.

The refinement process for luma transform coefficients as specified in subclause G.8.5.1.1 is invoked with fieldMbFlag, cTrafo, sTCoeff, and tCoeffLevel as the inputs and the outputs are modified versions of the lists sTCoeff and tCoeffLevel.

When ChromaArrayType is not equal to 0, the refinement process for chroma transform coefficients as specified in subclause G.8.5.1.2 is invoked with fieldMbFlag, cTrafo, sTCoeff, and tCoeffLevel as the inputs and the outputs are modified versions of the lists sTCoeff and tCoeffLevel.

G.8.5.1.1 Refinement process for luma transform coefficients or chroma transform coefficients with ChromaArrayType equal to 3

Inputs to this process are

– a variable iYCbCr specifying the colour component (when present),

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable cTrafo specifying the transform type,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements,

– a list of transform coefficient level values tCoeffLevel with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are

– a modified version of the list sTCoeff,

– a modified version of the list tCoeffLevel.

When iYCbCr is not present as input to this subclause, it is inferred to be equal to 0.

Depending on iYCbCr, the variables bitDepth, qP, cO, coeffLevel, coeffLevel8x8, coeffDCLevel, and coeffACLevel are derived as follows.

– If iYCbCr is equal to 0, bitDepth is set equal to $BitDepth_Y$, qP is set equal to QP'_Y, cO is set equal to 0, coeffLevel is set equal to LumaLevel, coeffLevel8x8 is set equal to LumaLevel8x8, coeffDCLevel is set equal to Intra16x16DCLevel, and coeffACLevel is set equal to Intra16x16ACLevel.

– Otherwise, if iYCbCr is equal to 1, bitDepth is set equal to $BitDepth_C$, qP is set equal to QP'_{Cb}, cO is set equal to 256, coeffLevel is set equal to CbLevel, coeffLevel8x8 is set equal to CbLevel8x8, coeffDCLevel is set equal to CbIntra16x16DCLevel, and coeffACLevel is set equal to CbIntra16x16ACLevel.

– Otherwise (iYCbCr is equal to 2), bitDepth is set equal to $BitDepth_C$, qP is set equal to QP'_{Cr}, cO is set equal to (256 + MbWidthC * MbHeightC), coeffLevel is set equal to CrLevel, coeffLevel8x8 is set equal to CrLevel8x8, coeffDCLevel is set equal to CrIntra16x16DCLevel, and coeffACLevel is set equal to CrIntra16x16ACLevel.

Depending on cTrafo, the following applies.

– If cTrafo is equal to T_PCM, the assignment process for luma transform coefficient values or chroma transform coefficient values with ChromaArrayType equal to 3 for I_PCM macroblocks as specified in subclause G.8.5.1.1.1 is invoked with iYCbCr, sTCoeff, and tCoeffLevel as the inputs and the outputs are modified versions of sTCoeff and tCoeffLevel.

– Otherwise, if cTrafo is equal to T_4x4, the refinement process for transform coefficients of residual 4x4 blocks as specified in subclause G.8.5.1.1.2 is invoked with fieldMbFlag, bitDepth, qP, cO, coeffLevel, sTCoeff, and tCoeffLevel as the inputs and the outputs are modified versions of the lists sTCoeff and tCoeffLevel.

– Otherwise, if cTrafo is equal to T_8x8, the refinement process for transform coefficients of residual 8x8 blocks as specified in subclause G.8.5.1.1.3 is invoked with fieldMbFlag, bitDepth, qP, cO, coeffLevel8x8, sTCoeff, and tCoeffLevel as the inputs and the outputs are modified versions of the lists sTCoeff and tCoeffLevel.

– Otherwise (cTrafo is equal to T_16x16), the refinement process for transform coefficients of Intra_16x16 macroblocks as specified in subclause G.8.5.1.1.4 is invoked with fieldMbFlag, bitDepth, qP, cO, coeffDCLevel, coeffACLevel, coeffLevel8x8, sTCoeff, and tCoeffLevel as the inputs and the outputs are modified versions of the lists sTCoeff and tCoeffLevel.

G.8.5.1.1.1 Assignment process for luma transform coefficient values or chroma transform coefficient values with ChromaArrayType equal to 3 for I_PCM macroblocks

Inputs to this process are

– a variable iYCbCr specifying the colour component,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements,

– a list of transform coefficient level values tCoeffLevel with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are

– a modified version of the list sTCoeff,

– a modified version of the list tCoeffLevel.

Depending on iYCbCr, the variables cO, cListOffset and pcmSample are derived by

cO = iYCbCr * 256
cListOffset = (iYCbCr == 0 ? 0 : (iYCbCr – 1) * 256) (G-135)
pcmSample = (iYCbCr == 0 ? pcm_luma_samples : pcm_chroma_samples) (G-136)

When base_mode_flag is equal to 0, the lists tCoeffLevel and sTCoeff are modified by

tCoeffLevel[cO + k] = 0 with k = 0..255 (G-137)

sTCoeff[cO + k] = pcmSample[cListOffset + k] with k = 0..255 (G-138)

G.8.5.1.1.2 Refinement process for transform coefficients of residual 4x4 blocks

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable bitDepth specifying the bit depth,

– a variable qP specifying the quantisation parameter value,

– a variable cO specifying the first coefficient index in the list of scaled transform coefficient values sTCoeff and in the list of transform coefficient values tCoeffLevel,

– a variable coeffLevel representing LumaLevel, CbLevel, or CrLevel,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements,

– a list of transform coefficient level values tCoeffLevel with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are

– a modified version of the list sTCoeff,

– a modified version of the list tCoeffLevel.

Depending on tcoeff_level_prediction_flag, the following applies.

– If tcoeff_level_prediction_flag is equal to 1, the list sTCoeff is modified by

sTCoeff[cO + k] = 0 with k = 0..255 (G-139)

– Otherwise (tcoeff_level_prediction_flag is equal to 0), the list tCoeffLevel is modified by

tCoeffLevel[cO + k] = 0 with k = 0..255 (G-140)

For each residual 4x4 block indexed by c4x4BlkIdx = 0..15, the following ordered steps are specified.

1. The inverse scanning process for transform coefficients as specified in subclause 8.5.6 is invoked with coeffLevel[c4x4BlkIdx] as the input and the outputs are transform coefficient level values as a 4x4 array c with elements c_{ij}. For this invocation of the process in subclause 8.5.6, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1, and it is treated as frame macroblock when fieldMbFlag is equal to 0.

2. The list tCoeffLevel and the 4x4 array c are modified by

tCoeffLevel[cO + 16 * c4x4BlkIdx + 4 * i + j] += c_{ij} with i, j = 0..3 (G-141)

c_{ij} = tCoeffLevel[cO + 16 * c4x4BlkIdx + 4 * i + j] with i, j = 0..3 (G-142)

3. The scaling process for residual 4x4 blocks as specified in subclause 8.5.11.1 is invoked with bitDepth, qP, and the 4x4 array c as the inputs and the outputs are scaled transform coefficient values as a 4x4 array d with elements d_{ij}. For this invocation of the process in subclause 8.5.11.1, the array c is treated as not relating to a luma residual block coded using the Intra_16x16 prediction mode and as not relating to a chroma residual block.

4. The list sTCoeff is modified by

sTCoeff[cO + 16 * c4x4BlkIdx + 4 * i + j] += d_{ij} with i, j = 0..3 (G-143)

The bitstream shall not contain data that result in any element sTCoeff[cO + k] with k = 0..255 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

The bitstream shall not contain data that result in any element tCoeffLevel[cO + k] with k = 0..255 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

G.8.5.1.1.3 Refinement process for transform coefficients of residual 8x8 blocks

Inputs to this process are

- a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,
- a variable bitDepth specifying the bit depth,
- a variable qP specifying the quantisation parameter value,
- a variable cO specifying the first coefficient index in the list of scaled transform coefficient values sTCoeff and in the list of transform coefficient values tCoeffLevel,
- a variable coeffLevel8x8 representing LumaLevel8x8, CbLevel8x8, or CrLevel8x8,
- a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements,
- a list of transform coefficient level values tCoeffLevel with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are

- a modified version of the list sTCoeff,
- a modified version of the list tCoeffLevel.

Depending on tcoeff_level_prediction_flag, the following applies.

- If tcoeff_level_prediction_flag is equal to 1, the list sTCoeff is modified by

  sTCoeff[cO + k] = 0 with k = 0..255 (G-144)

- Otherwise (tcoeff_level_prediction_flag is equal to 0), the list tCoeffLevel is modified by

  tCoeffLevel[cO + k] = 0 with k = 0..255 (G-145)

For each residual 8x8 block indexed by c8x8BlkIdx = 0..3, the following ordered steps are specified.

1. The inverse scanning process for 8x8 transform coefficients as specified in subclause 8.5.7 is invoked with coeffLevel8x8[c8x8BlkIdx] as the input and the outputs are transform coefficient level values as an 8x8 array c with elements c_{ij}. For this invocation of the process in subclause 8.5.7, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1, and it is treated as frame macroblock when fieldMbFlag is equal to 0.
2. The list tCoeffLevel and the 8x8 array c are modified by

   $$tCoeffLevel[cO + 64 * c8x8BlkIdx + 8 * i + j] \mathrel{+}= c_{ij} \quad \text{with } i, j = 0..7 \qquad \text{(G-146)}$$

   $$c_{ij} = tCoeffLevel[cO + 64 * c8x8BlkIdx + 8 * i + j] \quad \text{with } i, j = 0..7 \qquad \text{(G-147)}$$

3. The scaling process for residual 8x8 blocks as specified in subclause 8.5.12.1 is invoked with bitDepth, qP, and the 8x8 array c as the inputs and the outputs are scaled transform coefficient values as an 8x8 array d with elements d_{ij}.
4. The list sTCoeff is modified by

   $$sTCoeff[cO + 64 * c8x8BlkIdx + 8 * i + j] \mathrel{+}= d_{ij} \quad \text{with } i, j = 0..7 \qquad \text{(G-148)}$$

The bitstream shall not contain data that result in any element sTCoeff[cO + k] with k = 0..255 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

The bitstream shall not contain data that result in any element tCoeffLevel[cO + k] with k = 0..255 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

G.8.5.1.1.4 Refinement process for transform coefficients of Intra_16x16 macroblocks

This process is only invoked when base_mode_flag is equal to 0 or tcoeff_level_prediction_flag is equal to 1.

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable bitDepth specifying the bit depth,

– a variable qP specifying the quantisation parameter value,

– a variable cO specifying the first coefficient index in the list of scaled transform coefficient values sTCoeff and in the list of transform coefficient values tCoeffLevel,

– a variable coeffDCLevel representing Intra16x16DCLevel, CbIntra16x16DCLevel, or CrIntra16x16DCLevel,

– a variable coeffACLevel representing Intra16x16ACLevel, CbIntra16x16ACLevel, or CrIntra16x16ACLevel,

– a variable coeffLevel representing LumaLevel, CbLevel, or CrLevel,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements,

– a list of transform coefficient level values tCoeffLevel with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are

– a modified version of the list sTCoeff,

– a modified version of the list tCoeffLevel.

NOTE 1 – When tcoeff_level_prediction_flag is equal to 0, this subclause is always invoked as part of an invocation of subclause G.8.5.1 with refinementFlag equal to 0, in which case all elements of the list tCoeffLevel are set equal to 0 before invoking this subclause.

For the DC transform coefficients of all residual 4x4 blocks, the following ordered steps are specified.

1. Depending on base_mode_flag, the 4x4 array c with elements c_{ij} is derived as follows.

   – If base_mode_flag is equal to 0, the inverse scanning process for transform coefficients as specified in subclause 8.5.6 is invoked with coeffDCLevel as the input and the outputs are DC transform coefficient level values for all residual 4x4 blocks as a 4x4 array c with elements c_{ij}. For this invocation of the process in subclause 8.5.6, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1, and it is treated as frame macroblock when fieldMbFlag is equal to 0.

   – Otherwise (base_mode_flag is equal to 1), the 4x4 array c with elements c_{ij} containing DC transform coefficient level values is derived by

   $$c_{ij} = coeffLevel[\ 8 * (i / 2) + 4 * (j / 2) + 2 * (i \% 2) + (j \% 2)\ ][\ 0\ ] \quad \text{with } i, j = 0..3 \quad \text{(G-149)}$$

2. The list tCoeffLevel and the 4x4 array c are modified by

   $$tCoeffLevel[\ cO + 128 * (i / 2) + 64 * (j / 2) + 32 * (i \% 2) + 16 * (j \% 2)\ ] \mathrel{+}= c_{ij} \quad \text{with } i, j = 0..3 \quad \text{(G-150)}$$

   $$c_{ij} = tCoeffLevel[\ cO + 128 * (i / 2) + 64 * (j / 2) + 32 * (i \% 2) + 16 * (j \% 2)\ ] \quad \text{with } i, j = 0..3 \quad \text{(G-151)}$$

3. The scaling and transformation process for DC transform coefficients for Intra_16x16 macroblock type as specified in subclause 8.5.9 is invoked with bitDepth, qP, and c as the inputs and the output is the 4x4 array d with elements d_{ij} representing scaled DC transform coefficient values for all residual 4x4 blocks.

4. The list sTCoeff is modified by

   $$sTCoeff[\ cO + 128 * (i / 2) + 64 * (j / 2) + 32 * (i \% 2) + 16 * (j \% 2)\ ] = d_{ij} \quad \text{with } i, j = 0..3 \quad \text{(G-152)}$$

For each residual 4x4 block indexed by c4x4BlkIdx = 0..15, the following ordered steps are specified.

1. Depending on base_mode_flag, the variable c4x4List, which is a list of 16 entries, is derived as follows.

   – If base_mode_flag is equal to 0, the following applies.

   $$c4x4List[\ k\ ] = (\ k == 0\ ?\ 0\ :\ coeffACLevel[\ c4x4BlkIdx\ ][\ k - 1\ ]\ ) \quad \text{with } k = 0..15 \quad \text{(G-153)}$$

   – Otherwise (base_mode_flag is equal to 1), the following applies.

   $$c4x4List[\ k\ ] = (\ k == 0\ ?\ 0\ :\ coeffLevel[\ c4x4BlkIdx\ ][\ k\ ]\ ) \quad \text{with } k = 0..15 \quad \text{(G-154)}$$

2. The inverse scanning process for transform coefficients as specified in subclause 8.5.6 is invoked with c4x4List as the input and the outputs are transform coefficient level values as a 4x4 array e with elements e_{ij}. For this invocation of the process in subclause 8.5.6, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1, and it is treated as frame macroblock when fieldMbFlag is equal to 0.

3. The list tCoeffLevel and the 4x4 array e are modified by

$$tCoeffLevel[\ cO + 16 * c4x4BlkIdx + 4 * i + j\ ] \mathrel{+}= e_{ij} \quad \text{with } i, j = 0..3 \text{ and } i + j > 0 \qquad \text{(G-155)}$$

$$e_{ij} = tCoeffLevel[\ cO + 16 * c4x4BlkIdx + 4 * i + j\ ] \quad \text{with } i, j = 0..3 \text{ and } i + j > 0 \qquad \text{(G-156)}$$

4. The scaling process for residual 4x4 blocks as specified in subclause 8.5.11.1 is invoked with bitDepth, qP, and the 4x4 array e as the inputs and the outputs are scaled transform coefficient values as a 4x4 array d with elements d_{ij}. During the process in subclause 8.5.11.1, the array e is treated as relating to a luma residual block coded using the Intra_16x16 prediction mode.

5. The list sTCoeff is modified by

$$sTCoeff[\ cO + 16 * c4x4BlkIdx + 4 * i + j\ ] = d_{ij} \quad \text{with } i, j = 0..3 \text{ and } i + j > 0 \qquad \text{(G-157)}$$

NOTE 2 – The elements tCoeffLevel[cO + 16* c4x4BlkIdx] and sTCoeff[cO + 16* c4x4BlkIdx] are not modified during the process for a residual 4x4 block with index c4x4BlkIdx.

The bitstream shall not contain data that result in any element tCoeffLevel[cO + 16* b + k] with b = 0..15 and k = 1..15 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

NOTE 3 – The elements tCoeffLevel[cO + 16* b] with b = 0..15 can exceed the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

G.8.5.1.2 Refinement process for chroma transform coefficients

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable cTrafo specifying the transform type,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements,

– a list of transform coefficient level values tCoeffLevel with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are

– a modified version of the list sTCoeff,

– a modified version of the list tCoeffLevel.

For both chroma components indexed by iCbCr = 0..1, the following applies.

– If ChromaArrayType is equal to 1 or 2, the following applies.

  – If cTrafo is equal to T_PCM, the assignment process for chroma transform coefficient values for I_PCM macroblocks as specified in subclause G.8.5.1.2.1 is invoked with iCbCr, sTCoeff, and tCoeffLevel as the inputs and the outputs are modified versions of sTCoeff and tCoeffLevel.

  – Otherwise (cTrafo is not equal to T_PCM), the refinement process for chroma transform coefficients with ChromaArrayType equal to 1 or 2 as specified in subclause G.8.5.1.2.2 is invoked with iCbCr, fieldMbFlag, sTCoeff, and tCoeffLevel as the inputs and the outputs are modified versions of the lists sTCoeff and tCoeffLevel.

– Otherwise (ChromaArrayType is equal to 3), the refinement process for luma transform coefficients or chroma transform coefficients with ChromaArrayType equal to 3 as specified in subclause G.8.5.1.1 is invoked with iYCbCr set equal to (1 + iCbCr), fieldMbFlag, cTrafo, sTCoeff, and tCoeffLevel as the inputs and the outputs are modified versions of the lists sTCoeff and tCoeffLevel.

G.8.5.1.2.1 Assignment process for chroma transform coefficient values for I_PCM macroblocks

Inputs to this process are

– a variable iCbCr specifying the chroma component,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements,

– a list of transform coefficient level values tCoeffLevel with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are

– a modified version of the list sTCoeff,

– a modified version of the list tCoeffLevel.

The variable numC is set equal to (MbWidthC * MbHeightC) and the variable cCO is set equal to (iCbCr * numC).

When base_mode_flag is equal to 0, the lists tCoeffLevel and sTCoeff are modified by

$$tCoeffLevel[256 + cCO + k] = 0 \quad \text{with } k = 0..(numC - 1) \tag{G-158}$$

$$sTCoeff[256 + cCO + k] = pcm\_sample\_chroma[cCO + k] \quad \text{with } k = 0..(numC - 1) \tag{G-159}$$

G.8.5.1.2.2 Refinement process for chroma transform coefficients with ChromaArrayType equal to 1 or 2

This process is only invoked when ChromaArrayType is equal to 1 or 2.

Inputs to this process are

– a variable iCbCr specifying the chroma component,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements,

– a list of transform coefficient level values tCoeffLevel with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are

– a modified version of the list sTCoeff,

– a modified version of the list tCoeffLevel.

The variables nW, nH, numB, cO, and qP are derived by

$$nW = MbWidthC / 4 \tag{G-160}$$
$$nH = MbHeightC / 4 \tag{G-161}$$
$$numB = nW * nH \tag{G-162}$$
$$cO = 256 + (iCbCr * MbWidthC * MbHeightC) \tag{G-163}$$
$$qP = (iCbCr == 0 \ ? \ QP'_{Cb} \ : \ QP'_{Cr}) \tag{G-164}$$

Depending on tcoeff_level_prediction_flag, the following applies.

– If tcoeff_level_prediction_flag is equal to 1, the list sTCoeff is modified by

$$sTCoeff[cO + k] = 0 \quad \text{with } k = 0..(MbWidthC * MbHeightC - 1) \tag{G-165}$$

– Otherwise (tcoeff_level_prediction_flag is equal to 0), the list tCoeffLevel is modified by

$$tCoeffLevel[cO + k] = 0 \quad \text{with } k = 0..(MbWidthC * MbHeightC - 1) \tag{G-166}$$

For the chroma DC transform coefficients of all residual 4x4 chroma blocks, the following ordered steps are specified.

1. Depending ChromaArrayType, the (nW)x(nH) array c with elements c_{ij} is derived as follows.

   – If ChromaArrayType is equal to 1,

   $$c_{ij} = ChromaDCLevel[iCbCr][2 * i + j] \quad \text{with } i = 0..(nH - 1),\ j = 0..(nW - 1) \tag{G-167}$$

   – Otherwise (ChromaArrayType is equal to 2),

   $$c_{ij} = ChromaDCLevel[iCbCr][scan422ChromaDC[2 * i + j]] \quad \text{with } i = 0..(nH - 1),\ j = 0..(nW - 1), \text{ and } scan422ChromaDC = \{ 0, 2, 1, 5, 3, 6, 4, 7 \} \tag{G-168}$$

2. The list tCoeffLevel and the (nW)x(nH) array c are modified by

   $$tCoeffLevel[cO + 32 * i + 16 * j] \mathrel{+}= c_{ij} \quad \text{with } i = 0..(nH - 1),\ j = 0..(nW - 1) \tag{G-169}$$

   $$c_{ij} = tCoeffLevel[cO + 32 * i + 16 * j] \quad \text{with } i = 0..(nH - 1),\ j = 0..(nW - 1) \tag{G-170}$$

3. The variable qP_{DC} is derived by

$$qP_{DC} = (\text{ChromaArrayType} == 1 \ ? \ qP \ : \ qP + 3) \quad \text{(G-171)}$$

4. The (nW)x(nH) array d with elements d_{ij} representing scaled chroma DC transform coefficient values for all residual 4x4 chroma blocks is derived by

$$d_{ij} = c_{ij} * (\text{LevelScale}(qP_{DC} \% 6, 0, 0) << (qP_{DC} / 6)) \quad \text{with } i = 0..(nH - 1),\ j = 0..(nW - 1) \quad \text{(G-172)}$$

5. The list sTCoeff is modified by

$$\text{sTCoeff}[cO + 32 * i + 16 * j] \mathrel{+}= d_{ij} \quad \text{with } i = 0..(nH - 1),\ j = 0..(nW - 1) \quad \text{(G-173)}$$

For each residual 4x4 chroma block indexed by c4x4BlkIdx = 0..numB – 1, the following ordered steps are specified.

1. The variable c4x4List, which is a list of 16 entries, is derived by

$$\text{c4x4List}[k] = (k == 0 \ ? \ 0 \ : \ \text{ChromaACLevel}[\text{iCbCr}][\text{c4x4BlkIdx}][k - 1]) \quad \text{with } k = 0..15 \quad \text{(G-174)}$$

2. The inverse scanning process for transform coefficients as specified in subclause 8.5.6 is invoked with c4x4List as the input and the outputs are chroma transform coefficient level values as a 4x4 array e with elements e_{ij}. During the process in subclause 8.5.6, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1, and it is treated as frame macroblock when fieldMbFlag is equal to 0.

3. The list tCoeffLevel and the 4x4 array e are modified by

$$\text{tCoeffLevel}[cO + 16 * \text{c4x4BlkIdx} + 4 * i + j] \mathrel{+}= e_{ij} \quad \text{with } i, j = 0..3 \text{ and } i + j > 0 \quad \text{(G-175)}$$

$$e_{ij} = \text{tCoeffLevel}[cO + 16 * \text{c4x4BlkIdx} + 4 * i + j] \quad \text{with } i, j = 0..3 \text{ and } i + j > 0 \quad \text{(G-176)}$$

4. The scaling process for residual 4x4 blocks as specified in subclause 8.5.11.1 is invoked with BitDepth_C, qP, and the 4x4 array e as the inputs and the outputs are scaled chroma transform coefficient values as a 4x4 array d of with elements d_{ij}. During the process in subclause 8.5.11.1, the array e is treated as relating to a chroma residual block.

5. The list sTCoeff is modified by

$$\text{sTCoeff}[cO + 16 * \text{c4x4BlkIdx} + 4 * i + j] \mathrel{+}= d_{ij} \quad \text{with } i, j = 0..3 \text{ and } i + j > 0 \quad \text{(G-177)}$$

NOTE 1 – The elements tCoeffLevel[cO + 16* c4x4BlkIdx] and sTCoeff[cO + 16* c4x4BlkIdx] are not modified during the process for a residual 4x4 chroma block with index c4x4BlkIdx.

The bitstream shall not contain data that result in any element sTCoeff[cO + 16* b + k] with b = 0..(numB – 1) and k = 1..15 that exceeds the range of integer values from $-2^{(7 + \text{BitDepth}_C)}$ to $2^{(7 + \text{BitDepth}_C)}-1$, inclusive.

The bitstream shall not contain data that result in any element tCoeffLevel[cO + 16* b + k] with b = 0..(numB – 1) and k = 1..15 that exceeds the range of integer values from $-2^{(7 + \text{BitDepth}_C)}$ to $2^{(7 + \text{BitDepth}_C)}-1$, inclusive.

NOTE 2 – The elements tCoeffLevel[cO + 16* b] and sTCoeff[cO + 16* b] with b = 0..(numB – 1) can exceed the range of integer values from $-2^{(7 + \text{BitDepth}_C)}$ to $2^{(7 + \text{BitDepth}_C)}-1$, inclusive.

G.8.5.2 Transform coefficient level scaling process prior to transform coefficient refinement

Inputs to this process are

– a variable cTrafo specifying the luma transform type for the current macroblock,

– a list tCoeffLevel with (256 + 2 * MbWidthC * MbHeightC) elements specifying transform coefficient level values for the current macroblock,

– a variable tQP_Y specifying the luma quantisation parameter for the current macroblock,

– a variable $refQP_Y$ specifying the quantisation parameter for the macroblock of the reference layer representation,

– when ChromaArrayType is not equal to 0, two variables tQP_{Cb} and tQP_{Cr} specifying chroma quantisation parameters for the current macroblock,

– when ChromaArrayType is not equal to 0, two variables $refQP_{Cb}$ and $refQP_{Cr}$ specifying chroma quantisation parameters for the macroblock of the reference layer representation.

Output of this process is a modified version of the list tCoeffLevel.

Table G-5 specifies the scale values cS for transform coefficient level scaling.

Table G-5 – Scale values cS for transform coefficient level scaling

(refQP – cQP + 54) % 6	scale value cS
0	8
1	9
2	10
3	11
4	13
5	14

The variable iYCbCr proceeds over the values from 0 to (ChromaArrayType = = 0 ? 0 : 2), inclusive, and for each value of iYCbCr, the following ordered steps are specified.

1. The variables cO, iMax, cQP, and refQP are derived by

$$cO = (iYCbCr = = 0 ? 0 : 256 + (iYCbCr – 1) * MbWidthC * MbHeightC) \quad \text{(G-178)}$$
$$iMax = (iYCbCr = = 0 ? 255 : MbWidthC * MbHeightC – 1) \quad \text{(G-179)}$$
$$cQP = (iYCbCr = = 0 ? tQP_Y : (iYCbCr = = 1 ? tQP_{Cb} : tQP_{Cr})) \quad \text{(G-180)}$$
$$refQP = (iYCbCr = = 0 ? refQP_Y : (iYCbCr = = 1 ? refQP_{Cb} : refQP_{Cr})) \quad \text{(G-181)}$$

2. The variable cS is set as specified in Table G-5 using the values of refQP and cQP.

3. The variable rShift is calculated by

$$rShift = (refQP – cQP + 54) / 6 \quad \text{(G-182)}$$

4. The list tCoeffLevel of transform coefficient level values is modified by

$$tCoeffLevel[cO + i] = ((cS * tCoeffLevel[cO + i]) << rShift) >> 12 \quad \text{with } i = 0..iMax \quad \text{(G-183)}$$

The following constraints shall be obeyed.

a) When cTrafo is equal to T_4x4 or T_8x8, the bitstream shall not contain data that result in any element tCoeffLevel[k] with k = 0..255 that exceeds the range of integer values from $–2^{(7 + BitDepth_Y)}$ to $2^{(7 + BitDepth_Y)}–1$, inclusive.

b) When cTrafo is equal to T_16x16, the bitstream shall not contain data that result in any element tCoeffLevel[16* b + k] with b = 0..15 and k = 1..15 that exceeds the range of integer values from $-2^{(7 + BitDepth_Y)}$ to $2^{(7 + BitDepth_Y)}–1$, inclusive.

NOTE 1 – When cTrafo is equal to T_16x16, the elements tCoeffLevel[16* b] with b = 0..15 can exceed the range of integer values from $–2^{(7 + BitDepth_Y)}$ to $2^{(7 + BitDepth_Y)}–1$, inclusive.

c) When ChromaArrayType is equal to 1 or 2 and cTrafo is not equal to T_PCM, the bitstream shall not contain data that result in any element tCoeffLevel[256 + 16* b + k] with b = 0..(MbWidthC * MbHeightC / 8 – 1), and k = 1..15 that exceeds the range of integer values from $–2^{(7 + BitDepth_C)}$ to $2^{(7 + BitDepth_C)}–1$, inclusive.

NOTE 2 – When ChromaArrayType is equal to 1 or 2 and cTrafo is not equal to T_IPCM, the elements tCoeffLevel[256 + 16* b] with b = 0..(MbWidthC * MbHeightC / 8 – 1) can exceed the range of integer values from $-2^{(7 + BitDepth_C)}$ to $2^{(7 + BitDepth_C)}–1$, inclusive.

d) When ChromaArrayType is equal to 3 and cTrafo is equal to T_4x4 or T_8x8, the bitstream shall not contain data that result in any element tCoeffLevel[256 + k] with k = 0..511 that exceeds the range of integer values from $–2^{(7 + BitDepth_C)}$ to $2^{(7 + BitDepth_C)}–1$, inclusive.

e) When ChromaArrayType is equal to 3 and cTrafo is T_16x16, the bitstream shall not contain data that result in any element tCoeffLevel[256 + 16* b + k] with b = 0..31 and k = 1..15 that exceeds the range of integer values from $–2^{(7 + BitDepth_C)}$ to $2^{(7 + BitDepth_C)}–1$, inclusive.

NOTE 3 – When ChromaArrayType is equal to 3 and cTrafo is equal to T_16x16, the elements tCoeffLevel[256 + 16* b] with b = 0..(MbWidthC * MbHeightC / 8 – 1) can exceed the range of integer values from $-2^{(7 + BitDepth_C)}$ to $2^{(7 + BitDepth_C)}–1$, inclusive.

NOTE 4 – When tQP_Y is less than 10 and cTrafo is equal to T_16x16, the range of values that can be represented by an alternative representation of the bitstream with entropy_coding_mode_flag equal to 0 and profile_idc equal to 66, 77, or 88, may not be sufficient to represent the full range of values of the elements tCoeffLevel[16 * b] with b = 0..15 that could be necessary to form a close approximation of the content of any possible source picture.

NOTE 5 – When ChromaArrayType is equal to 1 or 2 and tQP_{CX} with CX being replaced by Cb and Cr is less than 4, the range of values that can be represented by an alternative representation of the bitstream with entropy_coding_mode_flag equal to 0 and profile_idc equal to 66, 77, or 88, may not be sufficient to represent the full range of values of the elements tCoeffLevel[256 + 16 * b] with b = 0..(MbWidthC * MbHeightC / 8 – 1) that could be necessary to form a close approximation of the content of any possible source picture.

G.8.5.3 Residual construction and accumulation process

Inputs to this process are

- a variable accumulationFlag specifying whether the constructed residual sample values for the current macroblock are combined with the existent residual sample value for the macroblock,
- a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,
- a variable cTrafo specifying the transform type,
- a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements,
- a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array $picRes_L$ containing residual luma sample values for the current layer representation,
- when ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays $picRes_{Cb}$ and $picRes_{Cr}$ containing residual chroma sample values for the current layer representation.

Outputs of this process are

- a modified version of the array $picRes_L$,
- when ChromaArrayType is not equal to 0, modified versions of the arrays $picRes_{Cb}$ and $picRes_{Cr}$.

The construction process for luma residuals as specified in subclause G.8.5.3.1 is invoked with cTrafo and sTCoeff as the inputs and the outputs are residual luma sample values as a 16x16 array $mbRes_L$.

When ChromaArrayType is not equal to 0, the construction process for chroma residuals as specified in subclause G.8.5.3.2 is invoked with cTrafo and sTCoeff as the inputs and the outputs are residual chroma sample values as two (MbWidthC)x(MbHeightC) arrays $mbRes_{Cb}$ and $mbRes_{Cr}$.

When accumulationFlag is equal to 1, the following ordered steps are specified.

1. The macroblock sample array extraction process as specified in subclause G.8.5.4.2 is invoked with fieldMbFlag, $picRes_L$, and, when ChromaArrayType is equal to 0, $picRes_{Cb}$ and $picRes_{Cr}$ as the inputs and the outputs are a 16x16 array $refLayerMbRes_L$ and, when ChromaArrayType is not equal to 0, two (MbWidthC)x(MbHeightC) arrays $refLayerMbRes_{Cb}$ and $refLayerMbRes_{Cr}$.
2. All elements $mbRes_L[x, y]$ of the 16x16 array $mbRes_L$ with x, y = 0..15 are modified by

$$mbRes_L[x, y] = Clip3(yMin, yMax, mbRes_L[x, y] + refLayerMbRes_L[x, y]) \quad \text{(G-184)}$$

with

$$yMin = – (1 << BitDepth_Y) + 1 \quad \text{(G-185)}$$
$$yMax = (1 << BitDepth_Y) – 1 \quad \text{(G-186)}$$

3. When ChromaArrayType is not equal to 0, for CX being replaced by Cb and Cr, all elements $mbRes_{CX}[x, y]$ of the (MbWidthC)x(MbHeightC) array $mbRes_{CX}$ with x = 0..(MbWidthC – 1) and y = 0..(MbHeightC – 1) are modified by

$$mbRes_{CX}[x, y] = Clip3(cMin, cMax, mbRes_{CX}[x, y] + refLayerMbRes_{CX}[x, y]) \quad \text{(G-187)}$$

with

$$cMin = – (1 << BitDepth_C) + 1 \quad \text{(G-188)}$$
$$cMax = (1 << BitDepth_C) – 1 \quad \text{(G-189)}$$

The picture sample array construction process as specified in subclause G.8.5.4.1 is invoked with fieldMbFlag, $mbRes_L$, $picRes_L$, and, when ChromaArrayType is not equal to 0, $mbRes_{Cb}$, $mbRes_{Cr}$, $picRes_{Cb}$, and $picRes_{Cr}$ as the inputs and the

outputs are a modified version of the array $picRes_L$ and, when ChromaArrayType is not equal to 0, modified versions of the arrays $picRes_{Cb}$ and $picRes_{Cr}$.

G.8.5.3.1 Construction process for luma residuals or chroma residuals with ChromaArrayType equal to 3

Inputs to this process are

– a variable iYCbCr specifying the colour component (when present),

– a variable cTrafo specifying the transform type,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are residual sample values as a 16x16 array mbRes with elements mbRes[x, y].

When iYCbCr is not present as input to this subclause, it is inferred to be equal to 0.

Depending on iYCbCr, the variables bitDepth and cO are derived as follows.

– If iYCbCr is equal to 0, bitDepth is set equal to $BitDepth_Y$ and cO is set equal to 0.

– Otherwise, if iYCbCr is equal to 1, bitDepth is set equal to $BitDepth_C$ and cO is set equal to 256.

– Otherwise (iYCbCr is equal to 2), bitDepth is set equal to $BitDepth_C$ and cO is set equal to (256 + MbWidthC * MbHeightC).

Depending on cTrafo, the 16x16 array mbRes is derived as follows.

– If cTrafo is equal to T_PCM, the construction process for luma residuals or chroma residuals with ChromaArrayType equal to 3 of I_PCM macroblocks as specified in subclause G.8.5.3.1.1 is invoked with cO and sTCoeff as the inputs and the output is the 16x16 array mbRes of residual sample values.

– Otherwise, if cTrafo is equal to T_4x4, the construction process for residual 4x4 blocks as specified in subclause G.8.5.3.1.2 is invoked with bitDepth, cO, and sTCoeff as the inputs and the output is the 16x16 array mbRes of residual sample values.

– Otherwise, if cTrafo is equal to T_8x8, the construction process for residual 8x8 blocks as specified in subclause G.8.5.3.1.3 is invoked with bitDepth, cO, and sTCoeff as the inputs and the output is the 16x16 array mbRes of residual sample values.

– Otherwise (cTrafo is equal to T_16x16), the construction process for residuals of Intra_16x16 macroblocks as specified in subclause G.8.5.3.1.4 is invoked with bitDepth, cO, and sTCoeff as the inputs and the output is the 16x16 array mbRes of residual sample values.

G.8.5.3.1.1 Construction process for luma residuals or chroma residuals with ChromaArrayType equal to 3 of I_PCM macroblocks

Inputs to this process are

– a variable cO specifying the first coefficient index in the list of scaled transform coefficient values sTCoeff,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are residual sample values as a 16x16 array mbRes with elements mbRes[x, y].

The 16x16 array mbRes is derived by

$$mbRes[x, y] = sTCoeff[cO + y * 16 + x] \quad \text{with } x, y = 0..15 \tag{G-190}$$

G.8.5.3.1.2 Construction process for residual 4x4 blocks

Inputs to this process are

– a variable bitDepth specifying the bit depth,

– a variable cO specifying the first coefficient index in the list of scaled transform coefficient values sTCoeff,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are residual sample values as a 16x16 array mbRes with elements mbRes[x, y].

For each residual 4x4 block indexed by c4x4BlkIdx = 0..15, the following ordered steps are specified.

1. The 4x4 array d with elements d_{ij} is derived by

$$d_{ij} = sTCoeff[\ cO + 16 * c4x4BlkIdx + 4 * i + j\ ] \qquad \text{with } i, j = 0..3 \tag{G-191}$$

2. The transformation process for residual 4x4 blocks as specified in subclause 8.5.11.2 is invoked with bitDepth and the 4x4 array d as the inputs and the outputs are residual sample value as a 4x4 array r with elements r_{ij}.
3. The inverse 4x4 luma block scanning process as specified in subclause 6.4.3 is invoked with c4x4BlkIdx as the input and the output is assigned to (xP, yP).
4. The elements mbRes[x, y] of the 16x16 array mbRes with x = xP..(xP + 3) and y = yP..(yP + 3) are derived by

$$mbRes[\ xP + j, yP + i\ ] = r_{ij} \qquad \text{with } i, j = 0..3 \tag{G-192}$$

G.8.5.3.1.3 Construction process for residual 8x8 blocks

Inputs to this process are

– a variable bitDepth specifying the bit depth,

– a variable cO specifying the first coefficient index in the list of scaled transform coefficient values sTCoeff,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are residual sample values as a 16x16 array mbRes with elements mbRes[x, y].

For each residual 8x8 block indexed by c8x8BlkIdx = 0..3, the following ordered steps are specified.

1. The 8x8 array d with elements d_{ij} is derived by

$$d_{ij} = sTCoeff[\ cO + 64 * c8x8BlkIdx + 8 * i + j\ ] \qquad \text{with } i, j = 0..7 \tag{G-193}$$

2. The transformation process for residual 8x8 blocks as specified in subclause 8.5.12.2 is invoked with bitDepth and the 8x8 array d as the inputs and the outputs are residual sample values as an 8x8 array r with elements r_{ij}.
3. The inverse 8x8 luma block scanning process as specified in subclause 6.4.5 is invoked with c8x8BlkIdx as the input and the output is assigned to (xP, yP).
4. The elements mbRes[x, y] of the 16x16 array mbRes with x = xP..(xP + 7) and y = yP..(yP + 7) are derived by

$$mbRes[\ xP + j, yP + i\ ] = r_{ij} \qquad \text{with } i, j = 0..7 \tag{G-194}$$

G.8.5.3.1.4 Construction process for residuals of Intra_16x16 macroblocks

Inputs to this process are

– a variable bitDepth specifying the bit depth,

– a variable cO specifying the first coefficient index in the list of scaled transform coefficient values sTCoeff,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are residual sample values as a 16x16 array mbRes with elements mbRes[x, y].

For each residual 4x4 block indexed by c4x4BlkIdx = 0..15, the following ordered steps are specified.

1. The 4x4 array d with elements d_{ij} is derived by.

$$d_{ij} = sTCoeff[\ cO + 16 * c4x4BlkIdx + 4 * i + j\ ] \qquad \text{with } i, j = 0..3 \tag{G-195}$$

2. The transformation process for residual 4x4 blocks as specified in subclause 8.5.11.2 is invoked with bitDepth and the 4x4 array d as the inputs and the outputs are residual sample values as a 4x4 array r with elements r_{ij}.
3. The inverse 4x4 luma block scanning process as specified in subclause 6.4.3 is invoked with c4x4BlkIdx as the input and the output is assigned to (xP, yP).
4. The elements mbRes[x, y] of the 16x16 array mbRes with x = xP..(xP + 3) and y = yP..(yP + 3) are derived by

$$mbRes[\ xP + j, yP + i\ ] = r_{ij} \qquad \text{with } i, j = 0..3 \tag{G-196}$$

G.8.5.3.2 Construction process for chroma residuals

Inputs to this process are

– a variable cTrafo specifying the transform type,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements.

Outputs of this process are residual chroma sample values as two (MbWidthC)x(MbHeightC) arrays $mbRes_{Cb}$ and $mbRes_{Cr}$ with elements $mbRes_{Cb}$[x, y] and $mbRes_{Cr}$[x, y], respectively.

For both chroma components indexed by iCbCr = 0..1 and for CX being replaced by Cb for iCbCr equal to 0 and Cr for iCbCr equal to 1, the following applies.

– If ChromaArrayType is equal to 1 or 2, the following applies.

  – If cTrafo is equal to T_PCM, the construction process for chroma residuals of I_PCM macroblocks as specified in subclause G.8.5.3.2.1 is invoked with iCbCr and sTCoeff as the inputs and the output is the (MbWidthC)x(MbHeightC) array $mbRes_{CX}$ of residual chroma sample values.

  – Otherwise (cTrafo is not equal to T_PCM), the construction process for chroma residuals with ChromaArrayType equal to 1 or 2 as specified in subclause G.8.5.3.2.2 is invoked with iCbCr and sTCoeff as the inputs and the output is the (MbWidthC)x(MbHeightC) array $mbRes_{CX}$ of residual chroma sample values.

– Otherwise (ChromaArrayType is equal to 3), the construction process for luma residuals or chroma residuals with ChromaArrayType equal to 3 as specified in subclause G.8.5.3.1 is invoked with iYCbCr set equal to (1 + iCbCr), cTrafo, and sTCoeff as the inputs and the output is the (MbWidthC)x(MbHeightC) array $mbRes_{CX}$ of residual chroma sample values.

G.8.5.3.2.1 Construction process for chroma residuals of I_PCM macroblocks

Inputs to this process are

– a variable iCbCr specifying the chroma component,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements.

Output of this process are residual chroma sample values as a (MbWidthC)x(MbHeightC) array mbRes with elements mbRes[x, y].

The (MbWidthC)x(MbHeightC) array mbRes is derived by

$$mbRes[\ x, y\ ] = sTCoeff[\ 256 + iCbCr * MbWidth * MbHeight + y * MbWidthC + x\ ] \quad \text{with } x = 0..(MbWidthC - 1) \text{ and } y = 0..(MbHeightC - 1) \tag{G-197}$$

G.8.5.3.2.2 Construction process for chroma residuals with ChromaArrayType equal to 1 or 2

This process is only invoked when ChromaArrayType is equal to 1 or 2.

Inputs to this process are

– a variable iCbCr specifying the chroma component,

– a list of scaled transform coefficient values sTCoeff with (256 + 2 * MbWidthC * MbHeightC) elements.

Output of this process are residual chroma sample values as a (MbWidthC)x(MbHeightC) array mbRes with elements mbRes[x, y].

The variables nW, nH, numB, and cO are derived by

$$nW = MbWidthC / 4 \tag{G-198}$$
$$nH = MbHeightC / 4 \tag{G-199}$$
$$numB = nW * nH \tag{G-200}$$
$$cO = 256 + (iCbCr * MbWidthC * MbHeightC) \tag{G-201}$$

For the chroma DC transform coefficients of all residual 4x4 chroma blocks, the following ordered steps are specified.

1. The (nW)x(nH) array c with the elements c_{ij} is derived by

$$c_{ij} = sTCoeff[\ cO + 32 * i + 16 * j\ ] \quad \text{with } i = 0..(nH - 1),\ j = 0..(nW - 1) \tag{G-202}$$

2. The transformation process for chroma DC transform coefficients as specified in subclause 8.5.10.1 is invoked with $BitDepth_C$ and the (nW)x(nH) array c as the inputs and the outputs are DC values for all residual 4x4 chroma blocks as a (nW)x(nH) array f with elements f_{ij}.

3. Depending on ChromaArrayType, the (nW)x(nH) array dcC with elements dcC_{ij} is derived as follows.

   – If ChromaArrayType is equal to 1,

   $$dcC_{ij} = f_{ij} >> 5 \qquad \text{with } i = 0..(nH - 1),\ j = 0..(nW - 1) \tag{G-203}$$

   – Otherwise (ChromaArrayType is equal to 2),

   $$dcC_{ij} = (f_{ij} + (1 << 5)) >> 6 \qquad \text{with } i = 0..(nH - 1),\ j = 0..(nW - 1) \tag{G-204}$$

The bitstream shall not contain data that result in any element dcC_{ij} of dcC with $i = 0..(nH - 1)$ and $j = 0..(nW - 1)$ that exceeds the range of integer values from $-2^{(7 + BitDepth_C)}$ to $2^{(7 + BitDepth_C)}-1$, inclusive.

NOTE – For the layer representation with dependency_id equal to 0 and quality_id equal to 0, successive invocations of subclause G.8.5.1.2 (as part of an invocation of subclause G.8.5.1) and this subclause yield an array dcC that is identical to the array dcC that would be obtained by an invocation of subclause 8.5.10. However, the intermediate values c_{ij} and f_{ij} with $i = 0..(nH - 1)$ and $j = 0..(nW - 1)$ that are derived in this subclause can exceed the range of integer values from $-2^{(7 + BitDepth_C)}$ to $2^{(7 + BitDepth_C)}-1$, inclusive.

For each residual 4x4 chroma block indexed by c4x4BlkIdx = 0..(numB – 1), the following ordered steps are specified.

1. The 4x4 array d with elements d_{ij} is derived as follows.

   – The element d_{00} is derived by

   $$d_{00} = dcY_{kl} \quad \text{with } k = c4x4BlkIdx / 2 \text{ and } l = c4x4BlkIdx \% 2 \tag{G-205}$$

   – The elements d_{ij} with i, j = 0..3 and i + j > 0 are derived by

   $$d_{ij} = sTCoeff[cO + 16 * c4x4BlkIdx + 4 * i + j] \tag{G-206}$$

2. The transformation process for residual 4x4 blocks as specified in subclause 8.5.11.2 is invoked with $BitDepth_C$ and the 4x4 array d as the inputs and the outputs are residual chroma sample values as a 4x4 array r with elements r_{ij}.

3. The chroma location (xP, yP) is derived by

   $$xP = 4 * (c4x4BlkIdx \% 2) \tag{G-207}$$
   $$yP = 4 * (c4x4BlkIdx / 2) \tag{G-208}$$

4. The elements mbRes[x, y] of the (MbWidthC)x(MbHeightC) array mbRes with x = xP..(xP + 3) and y = yP..(yP + 3) are derived by

   $$mbRes[xP + j, yP + i] = r_{ij} \qquad \text{with } i, j = 0..3 \tag{G-209}$$

G.8.5.4 Sample array accumulation process

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a $(PicWidthInSamples_L)$x$(PicHeightInSamples_L)$ array $picRes_L$ containing residual luma sample values for the current layer representation,

– a $(PicWidthInSamples_L)$x$(PicHeightInSamples_L)$ array $picSamples_L$ containing constructed luma sample values for the current layer representation,

– when ChromaArrayType is not equal to 0, two $(PicWidthInSamples_C)$x$(PicHeightInSamples_C)$ arrays $picRes_{Cb}$ and $picRes_{Cr}$ containing residual chroma sample values for the current layer representation,

– when ChromaArrayType is not equal to 0, two $(PicWidthInSamples_C)$x$(PicHeightInSamples_C)$ arrays $picSamples_{Cb}$ and $picSamples_{Cr}$ containing constructed chroma sample values for the current layer representation.

Outputs of this process are

– a modified version of the array $picSamples_L$,

– when ChromaArrayType is not equal to 0, modified versions of the arrays $picSamples_{Cb}$ and $picSamples_{Cr}$.

The macroblock sample array extraction process as specified in subclause G.8.5.4.2 is invoked with fieldMbFlag, $picRes_L$, and, when ChromaArrayType is not equal to 0, $picRes_{Cb}$ and $picRes_{Cr}$ as the inputs and the outputs are assigned to $mbRes_L$ and, when ChromaArrayType is not equal to 0, $mbRes_{Cb}$ and $mbRes_{Cr}$.

The macroblock sample array extraction process as specified in subclause G.8.5.4.2 is invoked with fieldMbFlag, $picSamples_L$, and, when ChromaArrayType is not equal to 0, $picSamples_{Cb}$ and $picSamples_{Cr}$ as the inputs and the outputs are assigned to $mbPred_L$ and, when ChromaArrayType is not equal to 0, $mbPred_{Cb}$ and $mbPred_{Cr}$.

The 16x16 array $mbSamples_L$ is derived by

$$mbSamples_L[x, y] = Clip1_Y(mbPred_L[x, y] + mbRes_L[x, y]) \quad \text{with } x, y = 0..15 \quad \text{(G-210)}$$

When ChromaArrayType is not equal to 0, for CX being replaced by Cb and Cr, the (MbWidthC)x(MbHeightC) array $mbSamples_{CX}$ is derived by

$$mbSamples_{CX}[x, y] = Clip1_C(mbPred_{CX}[x, y] + mbRes_{CX}[x, y]) \quad \text{with } x = 0..(MbWidthC - 1) \text{ and } y = 0..(MbHeightC - 1) \quad \text{(G-211)}$$

The picture sample array construction process as specified in subclause G.8.5.4.1 is invoked with fieldMbFlag, $mbSamples_L$, $picSamples_L$, and, when ChromaArrayType is not equal to 0, $mbSamples_{Cb}$, $mbSamples_{Cr}$, $picSamples_{Cb}$, and $picSamples_{Cr}$ as inputs and the outputs are a modified version of $picSamples_L$ and, when ChromaArrayType is not equal to 0, modified versions of $picSamples_{Cb}$ and $picSamples_{Cr}$.

G.8.5.4.1 Picture sample array construction process

Inputs to this process are

- a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,
- a 16x16 array $mbArray_L$ containing luma sample values for the current macroblock,
- a ($PicWidthInSamples_L$)x($PicWidthInHeight_L$) array $picArray_L$ containing luma sample values for the current layer representation,
- when ChromaArrayType is not equal to 0, two (MbWidthC)x(MbHeightC) arrays $mbArray_{Cb}$ and $mbArray_{Cr}$ containing chroma sample values for the current macroblock,
- when ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays $picArray_{Cb}$ and $picArray_{Cr}$ containing chroma sample values for the current layer representation.

Outputs of this process are

- a modified version of the array $picArray_L$,
- when ChromaArrayType is not equal to 0, modified versions of the arrays $picArray_{Cb}$ and $picArray_{Cr}$.

The picture sample array construction process for a colour component as specified in subclause G.8.5.4.3 is invoked with fieldMbFlag, mbW set equal to 16, mbH set equal to 16, $mbArray_L$, and $picArray_L$ as the inputs and the output is a modified version of the array $picArray_L$.

When ChromaArrayType is not equal to 0, for CX being replaced with Cr and Cb, the picture sample array construction process for a colour component as specified in subclause G.8.5.4.3 is invoked with fieldMbFlag, mbW set equal to MbWidthC, mbH set equal to MbHeightC, $mbArray_{CX}$, and $picArray_{CX}$ as the inputs and the output is a modified version of the array $picArray_{CX}$.

G.8.5.4.2 Macroblock sample array extraction process

Inputs to this process are

- a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,
- a ($PicWidthInSamples_L$)x($PicWidthInHeight_L$) array $picArray_L$ containing luma sample values for the current layer representation
- when ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays $picArray_{Cb}$ and $picArray_{Cr}$ containing chroma sample values for the current layer representation.

Outputs of this process are

- a 16x16 array $mbArray_L$ containing luma sample values for the current macroblock,

– when ChromaArrayType is not equal to 0, two (MbWidthC)x(MbHeightC) arrays $mbArray_{Cb}$ and $mbArray_{Cr}$ containing chroma sample values for the current macroblock.

The macroblock sample array extraction process for a colour component as specified in subclause G.8.5.4.4 is invoked with fieldMbFlag, mbW set equal to 16, mbH set equal to 16, and $picArray_L$ as the inputs and the output is assigned to $mbArray_L$.

When ChromaArrayType is not equal to 0, for CX being replaced with Cr and Cb, the macroblock sample array extraction process for a colour component as specified in subclause G.8.5.4.4 is invoked with fieldMbFlag, mbW set equal to MbWidthC, mbH set equal to MbHeightC, and $picArray_{CX}$ as the inputs and the output is assigned to $mbArray_{CX}$.

G.8.5.4.3 Picture sample array construction process for a colour component

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable mbW specifying the width of a macroblock colour component in samples,

– a variable mbH specifying the height of a macroblock colour component in samples,

– an (mbW)x(mbH) array mbArray containing sample values for a colour component of the current macroblock,

– an (mbW * PicWidthInMbs)x(mbH * PicHeightInMbs) array picArray containing sample values for a colour component of the current layer representation.

Output of this process is a modified version of the array picArray.

The inverse macroblock scanning process as specified in subclause 6.4.1 is invoked with CurrMbAddr as the input and the output is assigned to (xO, yO). During the process in subclause 6.4.1, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1, and it is treated as frame macroblock when fieldMbFlag is equal to 0.

The sample location (xP, yP) is derived by

$$xP = (xO >> 4) * mbW \quad \text{(G-212)}$$
$$yP = ((yO >> 4) * mbH) + (yO \% 2) \quad \text{(G-213)}$$

Depending on the variables MbaffFrameFlag and fieldMbFlag, the array picArray is modified as follows.

– If MbaffFrameFlag is equal to 1 and fieldMbFlag is equal to 1,

$$picArray[xP + x, yP + 2 * y] = mbArray[x, y] \quad \text{with } x = 0..(mbW - 1),\ y = 0..(mbH - 1) \quad \text{(G-214)}$$

– Otherwise (MbaffFrameFlag is equal to 0 or fieldMbFlag is equal to 0),

$$picArray[xP + x, yP + y] = mbArray[x, y] \quad \text{with } x = 0..(mbW - 1),\ y = 0..(mbH - 1) \quad \text{(G-215)}$$

G.8.5.4.4 Macroblock sample array extraction process for a colour component

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable mbW specifying the width of a macroblock colour component in samples,

– a variable mbH specifying the height of a macroblock colour component in samples,

– an (mbW * PicWidthInMbs)x(mbH * PicHeightInMbs) array picArray containing sample values for a colour component of the current layer representation.

Output of this process is an (mbW)x(mbH) array mbArray containing sample values for a colour component of the current macroblock.

The inverse macroblock scanning process as specified in subclause 6.4.1 is invoked with CurrMbAddr as the input and the output is assigned to (xO, yO). During the process in subclause 6.4.1, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1, and it is treated as frame macroblock when fieldMbFlag is equal to 0.

The sample location (xP, yP) is derived by

$$xP = (xO >> 4) * mbW \quad \text{(G-216)}$$
$$yP = ((yO >> 4) * mbH) + (yO \% 2) \quad \text{(G-217)}$$

Depending on the variables MbaffFrameFlag and fieldMbFlag, the samples of the array mbArray are derived as follows.

– If MbaffFrameFlag is equal to 1 and fieldMbFlag is equal to 1,

$$mbArray[x, y] = picArray[xP + x, yP + 2 * y] \quad \text{with } x = 0..(mbW - 1),\ y = 0..(mbH - 1) \tag{G-218}$$

– Otherwise (MbaffFrameFlag is equal to 0 or fieldMbFlag is equal to 0),

$$mbArray[x, y] = picArray[xP + x, yP + y] \quad \text{with } x = 0..(mbW - 1),\ y = 0..(mbH - 1) \tag{G-219}$$

G.8.5.5 Sample array re-initialisation process

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$) array picSamples$_L$ containing luma sample values for the current layer representation,

– when ChromaArrayType is not equal to 0, two (PicWidthInSamples$_C$)x(PicHeightInSamples$_C$) arrays picSamples$_{Cb}$ and picSamples$_{Cr}$ containing chroma sample values for the current layer representation.

Outputs of this process are

– a modified version of the array picSamples$_L$,

– when ChromaArrayType is not equal to 0, modified versions of the arrays picSamples$_{Cb}$ and picSamples$_{Cr}$.

The 16x16 array mbSamples$_L$ is derived by

$$mbSamples_L[x, y] = 0 \quad \text{with } x, y = 0..15 \tag{G-220}$$

When ChromaArrayType is not equal to 0, for CX being replaced by Cb and Cr, the (MbWidthC)x(MbHeightC) array mbSamples$_{CX}$ is derived by

$$mbSamples_{CX}[x, y] = 0 \quad \text{with } x = 0..(MbWidthC - 1) \text{ and } y = 0..(MbHeightC - 1) \tag{G-221}$$

The picture sample array construction process as specified in subclause G.8.5.4.1 is invoked with fieldMbFlag, mbSamples$_L$, picSamples$_L$, and, when ChromaArrayType is not equal to 0, mbSamples$_{Cb}$, mbSamples$_{Cr}$, picSamples$_{Cb}$, and picSamples$_{Cr}$ as inputs and the outputs are a modified version of picSamples$_L$ and, when ChromaArrayType is not equal to 0, modified versions of picSamples$_{Cb}$ and picSamples$_{Cr}$.

G.8.6 Resampling processes for prediction data, intra samples, and residual samples

Subclause G.8.6.1 specifies the derivation process for inter-layer predictors for macroblock type, sub-macroblock type, references indices, and motion vectors.

Subclause G.8.6.2 specifies the resampling process for intra samples.

Subclause G.8.6.3 specifies the resampling process for residual samples.

G.8.6.1 Derivation process for inter-layer predictors for macroblock type, sub-macroblock type, reference indices, and motion vectors

This process is only invoked when base_mode_flag is equal to 1 or any motion_prediction_flag_lX[mbPartIdx] with X being replaced by 0 and 1 and mbPartIdx = 0..3 is equal to 1.

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying the macroblock types for the macroblocks of the reference layer representation,

– a (RefLayerPicSizeInMbs)x4 array refLayerSubMbType specifying the sub-macroblock types for the macroblocks of the reference layer representation,

– two (RefLayerPicSizeInMbs)x4 arrays refLayerPredFlagL0 and refLayerPredFlagL1 specifying prediction utilization flags for the macroblocks of the reference layer representation,

– two (RefLayerPicSizeInMbs)x4 arrays refLayerRefIdxL0 and refLayerRefIdxL1 specifying reference indices for the macroblocks of the reference layer representation,

– two (RefLayerPicSizeInMbs)x4x4x2 arrays refLayerMvL0 and refLayerMvL1 specifying motion vector components for the macroblocks of the reference layer representation,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2, the reference picture list refPicList0,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Outputs of this process are

– a variable mbTypeILPred specifying a predictor for the macroblock type of the current macroblock,

– a list subMbTypeILPred with 4 elements specifying predictors for sub-macroblock types of the current macroblock,

– two 2x2 arrays refIdxILPredL0 and refIdxILPredL1 specifying inter-layer predictors for the reference indices of the current macroblock,

– two 4x4x2 arrays mvILPredL0 and mvILPredL1 specifying inter-layer predictors for the motion vector components of the current macroblock.

The derivation process for reference layer partition identifications as specified in subclause G.8.6.1.1 is invoked with fieldMbFlag, refLayerFieldMbFlag, refLayerMbType, and refLayerSubMbType as the inputs and the outputs are a variable intraILPredFlag and, when intraILPredFlag is equal to 0, reference layer partition identifications as a 4x4 array refLayerPartIdc with elements refLayerPartIdc[x, y].

When slice_type is equal to EI, the bitstream shall not contain data that result in intraILPredFlag equal to 0.

Depending on intraILPredFlag, the 2x2 arrays refIdxILPredL0 and refIdxILPredL1 and the 4x4x2 array mvILPredL0 and mvILPredL1 are derived as follows.

– If intraILPredFlag is equal to 1, all elements of the 2x2 arrays refIdxILPredL0 and refIdxILPredL1 are set equal to –1 and all elements of the 4x4x2 arrays mvILPredL0 and mvILPredL1 are set equal to 0.

– Otherwise (intraILPredFlag is equal to 0), the derivation process for inter-layer predictors for reference indices and motion vectors as specified in subclause G.8.6.1.2 is invoked with fieldMbFlag, refLayerFieldMbFlag, refLayerPredFlagL0, refLayerPredFlagL1, refLayerRefIdxL0, refLayerRefIdxL1, refLayerMvL0, refLayerMvL1, refLayerPartIdc, refPicList0 (when available), and refPicList1 (when available) as the inputs and the outputs are the arrays refIdxILPredL0, refIdxILPredL1, mvILPredL0, and mvILPredL1.

Depending on intraILPredFlag, the variable mbTypeILPred and the list subMbTypeILPred are derived as follows.

– If intraILPredFlag is equal to 1, all elements subMbTypeILPred[mbPartIdx] of the list subMbTypeILPred with mbPartIdx = 0..3 are marked as unspecified, and the variable mbTypeILPred is derived as follows.

  – If tcoeff_level_prediction_flag is equal to 1, mbTypeILPred is set equal to refLayerMbType[CurrMbAddr].

  – Otherwise (tcoeff_level_prediction_flag is equal to 0), mbTypeILPred is set equal to I_BL.

– Otherwise (intraILPredFlag is equal to 0), the derivation process for inter-layer predictors for P and B macroblock and sub-macroblock types as specified in subclause G.8.6.1.3 is invoked with refIdxILPredL0, refIdxILPredL1, mvILPredL0, and mvILPredL1 as the inputs and the outputs are the variable mbTypeILPred and the list subMbTypeILPred.

G.8.6.1.1 Derivation process for reference layer partition identifications

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying the macroblock types for the macroblocks of the reference layer representation,

– a (RefLayerPicSizeInMbs)x4 array refLayerSubMbType specifying the sub-macroblock types for the macroblocks of the reference layer representation.

Outputs of this process are

– a variable intraILPredFlag specifying whether the current macroblock can be predicted by inter-layer intra prediction or, in the case of tcoeff_level_prediction_flag equal to 1, by a combination of intra-layer intra prediction and inter-layer prediction,

– when intraILPredFlag is equal to 0, reference layer partition identifications for the current macroblock as a 4x4 array refLayerPartIdc with elements refLayerPartIdc[x, y].

When the 4x4 array refLayerPartIdc is output of this process, each of its elements refLayerPartIdc[x, y] specifies the macroblock address, the macroblock partition index, and the sub-macroblock partition index of the partition in the reference layer representation that can be used for inter-layer motion prediction of the macroblock or sub-macroblock partition of the current macroblock that contains the 4x4 block with coordinates x and y.

For each 4x4 block with block coordinates x, y = 0..3, the element refLayerPartIdc[x, y] of the 4x4 array refLayerPartIdc is derived by applying the following ordered steps.

1. The derivation process for reference layer partitions as specified in subclause G.6.2 is invoked with the luma location (4 * x + 1, 4 * y + 1), fieldMbFlag, refLayerFieldMbFlag, refLayerMbType, and refLayerSubMbType as the inputs and the outputs are a macroblock address refMbAddr, a macroblock partition index refMbPartIdx, and a sub-macroblock partition index refSubMbPartIdx of a partition in the reference layer representation.

   The bitstream shall not contain data that result in refMbAddr, refMbPartIdx, or refSubMbPartIdx being marked as not available.

2. The element refLayerPartIdc[x, y] of the array refLayerPartIdc is derived as follows.

   – If refLayerMbType[refMbAddr] is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL, refLayerPartIdc[x, y] is set equal to –1.

   – Otherwise (refLayerMbType[refMbAddr] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL), refLayerPartIdc[x, y] is derived by

   $$refLayerPartIdc[x, y] = 16 * refMbAddr + 4 * refMbPartIdx + refSubMbPartIdx \quad (G\text{-}222)$$

The variable intraILPredFlag is derived as follows.

– If all elements refLayerPartIdc[x, y] with x, y = 0..3 are equal to –1, intraILPredFlag is set equal to 1.

– Otherwise (any element refLayerPartIdc[x, y] with x, y = 0..3 is not equal to –1, intraILPredFlag is set equal to 0.

When intraILPredFlag is equal to 0 and RestrictedSpatialResolutionChangeFlag is equal to 0, the 4x4 array refLayerPartIdc is modified by the following ordered steps.

NOTE – By the following process the elements refLayerPartIdc[x, y] that are equal to –1 are replaced by elements refLayerPartIdc[x, y] that are not equal to –1. This process can also be applied when RestrictedSpatialResolutionChangeFlag is equal to 1 or intraILPredFlag is equal to 1, but in this case, the 4x4 array refLayerPartIdc is not modified.

1. For each 8x8 block with block coordinates xP, yP = 0..1, the following ordered steps are specified.

   a. The variables xO and yO are set equal to (2 * xP) and (2 * yP), respectively.

   b. All elements procI4x4Blk[xS, yS] of the 2x2 array procI4x4Blk with xS, yS = 0..1 are set equal to 0.

   c. The 4x4 blocks of the current 8x8 block with block coordinates xS, yS = 0..1 are processed in increasing order of (2 * yS + xS), and when refLayerPartIdc[xO + xS, yO + yS] is equal to –1 for a 4x4 block, the element procI4x4Blk[xS, yS] of the array procI4x4Blk is set equal to 1 and the following applies.

      – If procI4x4Blk[1 – xS, yS] is equal to 0 and refLayerPartIdc[xO + 1 – xS, yO + yS] is not equal to –1, the element refLayerPartIdc[xO + xS, yO + yS] is modified by

      $$refLayerPartIdc[xO + xS, yO + yS] = refLayerPartIdc[xO + 1 – xS, yO + yS] \quad (G\text{-}223)$$

– Otherwise, if procI4x4Blk[xS, 1 – yS] is equal to 0 and refLayerPartIdc[xO + xS, yO + 1 – yS] is not equal to –1, the element refLayerPartIdc[xO + xS, yO + yS] is modified by

refLayerPartIdc[xO + xS, yO + yS] = refLayerPartIdc[xO + xS, yO + 1 – yS] (G-224)

– Otherwise, if procI4x4Blk[1 – xS, 1 – yS] is equal to 0 and refLayerPartIdc[xO + 1 - xS, yO + 1 - yS] is not equal to –1, the element refLayerPartIdc[xO + xS, yO + yS] is modified by

refLayerPartIdc[xO + xS, yO + yS] = refLayerPartIdc[xO + 1 – xS, yO + 1 – yS] (G-225)

– Otherwise, the element refLayerPartIdc[xO + xS, yO + yS] is not modified.

2. All elements procI8x8Blk[xP, yP] of the 2x2 array procI8x8Blk with xP, yP = 0..1 are set equal to 0.
3. The 8x8 blocks with block coordinates xP, yP = 0..1 are processed in increasing order of (2 * yP + xP), and when refLayerPartIdc[2 * xP, 2 * yP] is equal to –1 for an 8x8 block, the element procI8x8Blk[xP, yP] of the array procI8x8Blk is set equal to 1 and the following applies.

– If procI8x8Blk[1 – xP, yP] is equal to 0 and refLayerPartIdc[2 – xP, 2 * yP] is not equal to –1, the elements refLayerPartIdc[2 * xP + xS, 2 * yP + yS] with xS, yS = 0..1 are modified by

refLayerPartIdc[2 * xP + xS, 2 * yP + yS] = refLayerPartIdc[2 – xP, 2 * yP + yS] (G-226)

– Otherwise, if procI8x8Blk [xP, 1 – yP] is equal to 0 and refLayerPartIdc[2 * xP, 2 – yP] is not equal to –1, the elements refLayerPartIdc[2 * xP + xS, 2 * yP + yS] with xS, yS = 0..1 are modified by

refLayerPartIdc[2 * xP + xS, 2 * yP + yS] = refLayerPartIdc[2 * xP + xS, 2 – yP] (G-227)

– Otherwise, if procI8x8Blk[1 – xP, 1 – yP] is equal to 0 and refLayerPartIdc [2 – xP, 2 – yP] is not equal to –1, the elements refLayerPartIdc[2 * xP + xS, 2 * yP + yS] with xS, yS = 0..1 are modified by

refLayerPartIdc[2 * xP + xS, 2 * yP + yS] = refLayerPartIdc[2 – xP, 2 – yP] (G-228)

– Otherwise, the elements refLayerPartIdc[2 * xP + xS, 2 * yP + yS] with xS, yS = 0..1 are not modified.

G.8.6.1.2 Derivation process for inter-layer predictors for reference indices and motion vectors

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,
– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,
– two (RefLayerPicSizeInMbs)x4 arrays refLayerPredFlagL0 and refLayerPredFlagL1 specifying prediction utilization flags for the macroblocks of the reference layer representation,
– two (RefLayerPicSizeInMbs)x4 arrays refLayerRefIdxL0 and refLayerRefIdxL1 specifying reference indices for the macroblocks of the reference layer representation,
– two (RefLayerPicSizeInMbs)x4x4x2 arrays refLayerMvL0 and refLayerMvL1 specifying motion vector components for the macroblocks of the reference layer representation,
– a 4x4 array refLayerPartIdc specifying reference layer partition identifications for the 4x4 blocks of the current macroblock,
– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2, the reference picture list refPicList0,
– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Outputs of this process are

– two 2x2 arrays refIdxILPredL0 and refIdxILPredL0 specifying inter-layer predictors for the reference indices of the current macroblock,

– two 4x4x2 arrays mvILPredL0 and mvILPredL0 specifying inter-layer predictors for the motion vector components of the current macroblock.

Let tempRefIdxPredL0 and tempRefIdxPredL1 be two 4x4 arrays with elements tempRefIdxPredL0[x, y] and tempRefIdxPredL1[x, y], respectively, that specify auxiliary inter-layer predictors for reference indices.

For each 4x4 block indexed by x, y = 0..3 and for X being replaced by 0 and 1, the auxiliary reference index predictor tempRefIdxPredLX[x, y] and the motion vector predictor mvILPredLX[x, y] are derived as follows.

– If refLayerPredFlagLX[refLayerPartIdc[x, y] / 16][(refLayerPartIdc[x, y] % 16) / 4] is equal 0, the reference index predictor tempRefIdxPredLX[x, y] and the motion vector predictor mvILPredLX[x, y] are derived by

$$\text{tempRefIdxPredLX}[x, y] = -1 \quad \text{(G-229)}$$
$$\text{mvILPredLX}[x, y][0] = 0 \quad \text{(G-230)}$$
$$\text{mvILPredLX}[x, y][1] = 0 \quad \text{(G-231)}$$

– Otherwise (refLayerPredFlagLX[refLayerPartIdc[x, y] / 16][(refLayerPartIdc[x, y] % 16) / 4] is equal to 1), the following ordered steps are specified.

1. The variables refMbAddr, refMbPartIdx, and refSubMbPartIdx are derived by

$$\text{refMbAddr} = \text{refLayerPartIdc}[x, y] \,/\, 16 \quad \text{(G-232)}$$
$$\text{refMbPartIdx} = (\text{refLayerPartIdc}[x, y] \,\%\, 16) / 4 \quad \text{(G-233)}$$
$$\text{refSubMbPartIdx} = \text{refLayerPartIdc}[x, y] \,\%\, 4 \quad \text{(G-234)}$$

2. The auxiliary reference index predictor tempRefIdxPredLX[x, y] is derived by

$$\text{tempRefIdxPredLX}[x, y] = \text{refLayerRefIdxLX}[\text{refMbAddr}][\text{refMbPartIdx}] * (1 + \text{fieldMbFlag} - \text{field\_pic\_flag}) \,/\, (1 + \text{refLayerFieldMbFlag}[\text{refMbAddr}] - \text{RefLayerFieldPicFlag}) \quad \text{(G-235)}$$

3. The motion vector aMv is set equal to refLayerMvLX[refMbAddr][refMbPartIdx][refSubMbPartIdx], and afterwards its vertical component aMv[1] is modified by

$$\text{aMv}[1] = \text{aMv}[1] * (1 + \text{refLayerFieldMbFlag}[\text{refMbAddr}]) \quad \text{(G-236)}$$

4. The variables scaledW, scaledH, refLayerW, and refLayerH are derived by

$$\text{scaledW} = \text{ScaledRefLayerPicWidthInSamples}_L \quad \text{(G-237)}$$
$$\text{scaledH} = \text{ScaledRefLayerPicHeightInSamples}_L * (1 + \text{field\_pic\_flag}) \quad \text{(G-238)}$$
$$\text{refLayerW} = \text{RefLayerPicWidthInSamples}_L \quad \text{(G-239)}$$
$$\text{refLayerH} = \text{RefLayerPicHeightInSamples}_L * (1 + \text{RefLayerFieldPicFlag}) \quad \text{(G-240)}$$

5. The variables dOX, dOY, dSW, and dSH are derived as follows.

   – If CroppingChangeFlag is equal to 0 or the reference picture refPicListX[tempRefIdxPredLX[x, y]] is not available, dOX, dOY, dSW, and dSH are set equal to 0.

   – Otherwise (CroppingChangeFlag is equal to 1 and the reference picture refPicListX[tempRefIdxPredLX[x, y]] is available), the variables refPicScaledRefLayerLeftOffset, refPicScaledRefLayerRightOffset, refPicScaledRefLayerTopOffset, and refPicScaledRefLayerBottomOffset are set equal to the variables ScaledRefLayerLeftOffset, ScaledRefLayerRightOffset, ScaledRefLayerTopOffset, and ScaledRefLayerBottomOffset, respectively, that are associated with the layer representation of the reference picture refPicListX[tempRefIdxPredLX[x, y]] that has the same value of DQId as the current layer representation, and the variables dOX, dOY, dSW, and dSH are derived by

$$\text{dOX} = \text{ScaledRefLayerLeftOffset} - \text{refPicScaledRefLayerLeftOffset} \quad \text{(G-241)}$$
$$\text{dOY} = \text{ScaledRefLayerTopOffset} - \text{refPicScaledRefLayerTopOffset} \quad \text{(G-242)}$$
$$\text{dSW} = \text{ScaledRefLayerRightOffset} - \text{refPicScaledRefLayerRightOffset} + \text{dOX} \quad \text{(G-243)}$$
$$\text{dSH} = \text{ScaledRefLayerBottomOffset} - \text{refPicScaledRefLayerBottomOffset} + \text{dOY} \quad \text{(G-244)}$$

6. The variables scaleX and scaleY are derived by

$$scaleX = (((scaledW + dSW) << 16) + (refLayerW >> 1)) / refLayerW \quad \text{(G-245)}$$
$$scaleY = (((scaledH + dSH) << 16) + (refLayerH >> 1)) / refLayerH \quad \text{(G-246)}$$

7. The motion vector aMv is scaled by

$$aMv[0] = (aMv[0] * scaleX + 32768) >> 16 \quad \text{(G-247)}$$
$$aMv[1] = (aMv[1] * scaleY + 32768) >> 16 \quad \text{(G-248)}$$

8. When CroppingChangeFlag is equal to 1, the motion vector aMv is modified by applying the following ordered steps.

   a. The inverse macroblock scanning process as specified in subclause 6.4.1 is invoked with CurrMbAddr as the input and the output is a luma location (xMbPic, yMbPic). For this invocation of the process specified in subclause 6.4.1, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1, and it is treated as frame macroblock when fieldMbFlag is equal to 0.

   b. The luma location (xFrm, yFrm) is derived by

$$xFrm = (xMbPic + (4 * x + 1)) \quad \text{(G-249)}$$
$$yFrm = (yMbPic + (4 * y + 1) * (1 + fieldMbFlag – field_pic_flag)) * (1 + field_pic_flag) \quad \text{(G-250)}$$

   c. The variables scaleX and scaleY are modified by

$$scaleX = (((4 * dSW) << 16) + (scaledW >> 1)) / scaledW \quad \text{(G-251)}$$
$$scaleY = (((4 * dSH) << 16) + (scaledH >> 1)) / scaledH \quad \text{(G-252)}$$

   d. The motion vector aMv is modified by

$$aMv[0] += (((xFrm – ScaledRefLayerLeftOffset) * scaleX + 32768) >> 16) – 4 * dOX \quad \text{(G-253)}$$
$$aMv[1] += (((yFrm – ScaledRefLayerTopOffset) * scaleY + 32768) >> 16) – 4 * dOY \quad \text{(G-254)}$$

9. The motion vector predictor mvILPredLX[x, y] is derived by

$$mvILPredLX[x, y][0] = aMv[0] \quad \text{(G-255)}$$
$$mvILPredLX[x, y][1] = aMv[1] / (1 + fieldMbFlag) \quad \text{(G-256)}$$

For each 8x8 block indexed by xP, yP = 0..1 and for X being replaced by 0 or 1, the reference index predictor refIdxILPredLX[xP, yP] is set equal to tempRefIdxPredLX[2 * xP, 2 * yP], and when RestrictedSpatialResolutionChangeFlag is equal to 0, the following ordered steps are specified.

NOTE – The following process can also be applied when RestrictedSpatialResolutionChangeFlag is equal to 1, but in this case, the reference index predictor refIdxILPredLX[xP, yP] and the motion vector predictors mvILPredLX[2 * xP + xS, 2 * yP + yS] with xS, yS = 0..1 will not be modified.

1. The 4x4 blocks indexed by xS, yS = 0..1 of the current 8x8 block are processed in increasing order of (2 * yS + xS), and for each 4x4 block, the reference index predictor refIdxILPredLX[xP, yP] is modified by

$$refIdxILPredLX[xP, yP] = MinPositive(refIdxILPredLX[xP, yP], tempRefIdxPredLX[2 * xP + xS, 2 * yP + yS]) \quad \text{(G-257)}$$

   with

$$MinPositive(a, b) = \begin{cases} Min(a, b) & \text{if } a >= 0 \text{ and } b >= 0 \\ Max(a, b) & \text{otherwise} \end{cases} \quad \text{(G-258)}$$

2. The 4x4 blocks index by xS, yS = 0..1 of the current 8x8 block are processed in increasing order of (2 * yS + xS), and for each 4x4 block, when tempRefIdxPredLX[2 * xP + xS, 2 * yP + yS] is not equal to the reference index predictor refIdxILPredLX[xP, yP], the following applies.

– If tempRefIdxPredLX[2 * xP + 1 – xS, 2 * yP + yS] is equal to refIdxILPredLX[xP, yP], the motion vector predictor mvILPredLX[2 * xP + xS, 2 * yP + yS] is modified by

$$mvILPredLX[2 * xP + xS, 2 * yP + yS] = mvILPredLX[2 * xP + 1 – xS, 2 * yP + yS] \quad \text{(G-259)}$$

– Otherwise, if tempRefIdxPredLX[2 * xP + xS, 2 * yP + 1 – yS] is equal to refIdxILPredLX[xP, yP], the motion vector predictor mvILPredLX[2 * xP + xS, 2 * yP + yS] is modified by

$$mvILPredLX[2 * xP + xS, 2 * yP + yS] = mvILPredLX[2 * xP + xS, 2 * yP + 1 – yS] \quad \text{(G-260)}$$

– Otherwise (tempRefIdxPredLX[2 * xP + 1 – xS, 2 * yP + 1 – yS] is equal to refIdxILPredLX[xP, yP]), the motion vector predictor mvILPredLX[2 * xP + xS, 2 * yP + yS] is modified by

$$mvILPredLX[2 * xP + xS, 2 * yP + yS] = mvILPredLX[2 * xP + 1 – xS, 2 * yP + 1 – yS] \quad \text{(G-261)}$$

When RestrictedSpatialResolutionChangeFlag is equal to 0, for each 8x8 block indexed by xP, yP = 0..1, the motion vector predictor arrays mvILPredL0 and mvILPredL1 are modified by applying the following ordered steps.

NOTE – The following process shall not be applied when RestrictedSpatialResolutionChangeFlag is equal to 1.

1. The variable maxX is derived as follows.
   – If slice_type is equal to EB, maxX is set equal to 1.
   – Otherwise (slice_type is equal to EP), maxX is set equal to 0.
2. The variables xO and yO are set equal to (2 * xP) and (2 * yP), respectively.
3. The function mvDiff(mv_1, mv_2) of two motion vectors mv_1 and mv_2 is defined by

$$mvDiff(mv_1, mv_2) = Abs(mv_1[0] – mv_2[0]) + Abs(mv_1[1] – mv_2[1]) \quad \text{(G-262)}$$

4. The variable subPartSize is derived as follows.
   – If for X = 0..maxX, all of the following conditions are true, subPartSize is set equal to 8x8.
     – mvDiff(mvILPredLX[xO, yO], mvILPredLX[xO + 1, yO]) is less than or equal to 1
     – mvDiff(mvILPredLX[xO, yO], mvILPredLX[xO, yO + 1]) is less than or equal to 1
     – mvDiff(mvILPredLX[xO, yO], mvILPredLX[xO + 1, yO + 1]) is less than or equal to 1
   – Otherwise, if for X = 0..maxX, all of the following conditions are true, subPartSize is set equal to 8x4.
     – mvDiff(mvILPredLX[xO, yO], mvILPredLX[xO + 1, yO]) is less than or equal to 1
     – mvDiff(mvILPredLX[xO, yO + 1], mvILPredLX[xO + 1, yO + 1]) is less than or equal to 1
   – Otherwise, if for X = 0..maxX, all of the following conditions are true, subPartSize is set equal to 4x8.
     – mvDiff(mvILPredLX[xO, yO], mvILPredLX[xO, yO + 1]) is less than or equal to 1
     – mvDiff(mvILPredLX[xO + 1, yO], mvILPredLX[xO + 1, yO + 1]) is less than or equal to 1
   – Otherwise, subPartSize is set equal to 4x4.
5. When subPartSize is not equal to 4x4, for X = 0..maxX, the motion vectors tempMvALX and tempMvBLX (when subPartSize is equal to 8x4 or 4x8) are derived as follows
   – If subPartSize is equal to 8x8, tempMvALX is derived by

$$\begin{aligned} tempMvALX[c] = (& mvILPredLX[xO, yO][c] + \\ & mvILPredLX[xO + 1, yO][c] + \\ & mvILPredLX[xO, yO + 1][c] + \\ & mvILPredLX[xO + 1, yO + 1][c] + 2) >> 2 \quad \text{with } c = 0..1 \end{aligned} \quad \text{(G-263)}$$

   – Otherwise, if subPartSize is equal to 8x4, tempMvALX and tempMvBLX are derived by

tempMvALX[c] = (mvILPredLX[xO, yO][c] +
mvILPredLX[xO + 1, yO][c] + 1) >> 1 with c = 0..1 (G-264)

tempMvBLX[c] = (mvILPredLX[xO, yO + 1][c] +
mvILPredLX[xO + 1, yO + 1][c] + 1) >> 1 with c = 0..1 (G-265)

– Otherwise (subPartSize is equal to 4x8), tempMvALX and tempMvBLX are derived by

tempMvALX[c] = (mvILPredLX[xO, yO][c] +
mvILPredLX[xO, yO + 1][c] + 1) >> 1 with c = 0..1 (G-266)

tempMvBLX[c] = (mvILPredLX[xO + 1, yO][c] +
mvILPredLX[xO + 1, yO + 1][c] + 1) >> 1 with c = 0..1 (G-267)

6. When subPartSize is not equal to 4x4, for X = 0..maxX, the motion vector predictor array mvILPredLX is modified as follows.

– If subPartSize is equal to 8x8, the array mvILPredLX is modified by

mvILPredLX[xO + xS, yO + yS][c] = tempMvALX[c] with xS, yS = 0..1 and c = 0..1 (G-268)

– Otherwise, if subPartSize is equal to 8x4, the array mvILPredLX is modified by

mvILPredLX[xO + xS, yO][c] = tempMvALX[c] with xS = 0..1 and c = 0..1 (G-269)
mvILPredLX[xO + xS, yO + 1][c] = tempMvBLX[c] with xS = 0..1 and c = 0..1 (G-270)

– Otherwise (subPartSize is equal to 4x8), the array mvILPredLX is modified by

mvILPredLX[xO , yO + yS][c] = tempMvALX[c] with yS = 0..1 and c = 0..1 (G-271)
mvILPredLX[xO + 1, yO + yS][c] = tempMvBLX[c] with yS = 0..1 and c = 0..1 (G-272)

G.8.6.1.3 Derivation process for inter-layer predictors for P and B macroblock and sub-macroblock types

This process is only invoked when slice_type is equal to EP or EB.

Inputs to this process are

– two 2x2 arrays refIdxILPredL0 and refIdxILPredL0 specifying predictors for the reference indices of the current macroblock,

– two 4x4x2 arrays mvILPredL0 and mvILPredL0 specifying predictors for the motion vectors of the current macroblock.

Outputs of this process are

– a variable mbTypeILPred specifying a predictor for the macroblock type of the current macroblock,

– a list subMbTypeILPred with 4 elements specifying predictors for sub-macroblock types of the current macroblock.

The variable maxX is derived as follows.

– If slice_type is equal to EB, maxX is set equal to 1.

– Otherwise (slice_type is equal to EP), maxX is set equal to 0.

The macroblock type predictor mbTypeILPred is derived by applying the following ordered steps.

1. The variable partitionSize is derived as follows.

– If for X = 0..maxX, all of the following conditions are true, partitionSize is set equal to 16x16.

– all elements refIdxILPredLX[x, y] with x, y = 0..1 are the same

– all elements mvILPredLX[x, y] with x, y = 0..3 are the same

– Otherwise, if for X = 0..maxX, all of the following conditions are true, partitionSize is set equal to 16x8.

– refIdxILPredLX[0, 0] is equal to refIdxILPredLX[1, 0]

– refIdxILPredLX[0, 1] is equal to refIdxILPredLX[1, 1]

– all elements mvILPredLX[x, y] with x = 0..3 and y = 0..1 are the same

– all elements mvILPredLX[x, y] with x = 0..3 and y = 2..3 are the same

– Otherwise, if for X = 0..maxX, all of the following conditions are true, partitionSize is set equal to 8x16.

– refIdxILPredLX[0, 0] is equal to refIdxILPredLX[0, 1]

– refIdxILPredLX[1, 0] is equal to refIdxILPredLX[1, 1]

– all elements mvILPredLX[x, y] with x = 0..1 and y = 0..3 are the same

– all elements mvILPredLX[x, y] with x = 2..3 and y = 0..3 are the same

– Otherwise, partitionSize is set equal to 8x8.

2. When slice_type is equal to EB and partitionSize is not equal to 8x8, the variable partPredModeA is derived by

$$\begin{aligned} partPredModeA = &(refIdxILPredL1[0, 0] >= 0 \ ? \ 2 \ : \ 0) + \\ &(refIdxILPredL0[0, 0] >= 0 \ ? \ 1 \ : \ 0) \end{aligned} \quad \text{(G-273)}$$

3. When slice_type is equal to EB and partitionSize is equal to 16x8 or 8x16, the variable partPredModeB is derived by

$$\begin{aligned} partPredModeB = &(refIdxILPredL1[1, 1] >= 0 \ ? \ 2 \ : \ 0) + \\ &(refIdxILPredL0[1, 1] >= 0 \ ? \ 1 \ : \ 0) \end{aligned} \quad \text{(G-274)}$$

4. Depending on slice_type, partitionSize, partPredModeA (when applicable), and partPredModeB (when applicable), the macroblock type predictor mbTypeILPred is derived as specified in Table G-6.

All elements subMbTypeILPred[mbPartIdx] of the list subMbTypeILPred with mbPartIdx = 0..3 are marked as "unspecified".

When mbTypeILPred is equal to P_8x8 or B_8x8, each element subMbTypeILPred[mbPartIdx] with mbPartIdx = 0..3 is modified by applying the following ordered steps.

1. The coordinate offset (xO, yO) is set equal to (2 * (mbPartIdx % 2), 2 * (mbPartIdx / 2)).

2. The variable subPartitionSize is derived as follows.

– If for X = 0..maxX, all elements mvILPredLX[xO + xS, yO + yS] with xS, yS = 0..1 are the same, subPartitionSize is set equal to 8x8.

– Otherwise, if for X = 0..maxX, mvILPredLX[xO, yO] is equal to mvILPredLX[xO + 1, yO] and mvILPredLX[xO, yO + 1] is equal to mvILPredLX[xO + 1, yO + 1], subPartitionSize is set equal to 8x4.

– Otherwise, if for X = 0..maxX, mvILPredLX[xO, yO] is equal to mvILPredLX[xO, yO + 1] and mvILPredLX[xO + 1, yO] is equal to mvILPredLX[xO + 1, yO + 1], subPartitionSize is set equal to 4x8.

– Otherwise, subPartitionSize is set equal to 4x4.

3. When slice_type is equal to EB, the variable partPredMode is derived by

$$\begin{aligned} partPredMode = &(refIdxILPredL1[xO / 2, yO / 2] >= 0 \ ? \ 2 \ : \ 0) + \\ &(refIdxILPredL0[xO / 2, yO / 2] >= 0 \ ? \ 1 \ : \ 0) \end{aligned} \quad \text{(G-275)}$$

4. Depending on slice_type, subPartitionSize, and partPredMode (when applicable), the sub-macroblock type predictor subMbTypeILPred[mbPartIdx] is derived as specified in Table G-7.

Table G-6 – Macroblock type predictors mbTypeILPred

slice_type	partitionSize	partPredModeA	partPredModeB	mbTypeILPred	slice_type	partitionSize	partPredModeA	partPredModeB	mbTypeILPred
EB	16x16	1	na	B_L0_16x16	EB	16x8	2	3	B_L1_Bi_16x8
EB	16x16	2	na	B_L1_16x16	EB	8x16	2	3	B_L1_Bi_8x16
EB	16x16	3	na	B_Bi_16x16	EB	16x8	3	1	B_Bi_L0_16x8
EB	16x8	1	1	B_L0_L0_16x8	EB	8x16	3	1	B_Bi_L0_8x16
EB	8x16	1	1	B_L0_L0_8x16	EB	16x8	3	2	B_Bi_L1_16x8
EB	16x8	2	2	B_L1_L1_16x8	EB	8x16	3	2	B_Bi_L1_8x16
EB	8x16	2	2	B_L1_L1_8x16	EB	16x8	3	3	B_Bi_Bi_16x8
EB	16x8	1	2	B_L0_L1_16x8	EB	8x16	3	3	B_Bi_Bi_8x16
EB	8x16	1	2	B_L0_L1_8x16	EB	8x8	na	na	B_8x8
EB	16x8	2	1	B_L1_L0_16x8	EP	16x16	na	na	P_L0_16x16
EB	8x16	2	1	B_L1_L0_8x16	EP	16x8	na	na	P_L0_L0_16x8
EB	16x8	1	3	B_L0_Bi_16x8	EP	8x16	na	na	P_L0_L0_8x16
EB	8x16	1	3	B_L0_Bi_8x16	EP	8x8	na	na	P_8x8

Table G-7 – Sub-macroblock type predictors subMbTypeILPred[mbPartIdx]

slice_type	subPartitionSize	partPredMode	subMbTypeILPred [mbPartIdx]	slice_type	subPartitionSize	partPredMode	subMbTypeILPred [mbPartIdx]
EB	8x8	1	B_L0_8x8	EB	4x8	3	B_Bi_4x8
EB	8x8	2	B_L1_8x8	EB	4x4	1	B_L0_4x4
EB	8x8	3	B_Bi_8x8	EB	4x4	2	B_L1_4x4
EB	8x4	1	B_L0_8x4	EB	4x4	3	B_Bi_4x4
EB	8x4	2	B_L1_8x4	EP	8x8	na	P_L0_8x8
EB	8x4	3	B_Bi_8x4	EP	8x4	na	P_L0_8x4
EB	4x8	1	B_L0_4x8	EP	4x8	na	P_L0_4x8
EB	4x8	2	B_L1_4x8	EP	4x4	na	P_L0_4x4

G.8.6.2 Resampling process for intra samples

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a one-dimensional array refLayerSliceIdc with RefLayerPicSizeInMbs elements specifying slice identifications for the macroblocks of the reference layer representation,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation,

– a (RefLayerPicWidthInSamples$_L$)x(RefLayerPicHeightInSamples$_L$) array refLayerPicSamples$_L$ of luma samples for the reference layer representation,

– a (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$) array picSamples$_L$ of luma samples,

– when ChromaArrayType is not equal to 0, two (RefLayerPicWidthInSamples$_C$)x(RefLayerPicHeightInSamples$_C$) arrays refLayerPicSamples$_{Cb}$ and refLayerPicSamples$_{Cr}$ of chroma samples for the reference layer representation,

– when ChromaArrayType is not equal to 0, two (PicWidthInSamples$_C$)x(PicHeightInSamples$_C$) arrays picSamples$_{Cb}$ and picSamples$_{Cr}$ of chroma samples.

Outputs of this process are

– a modified version of the array picSamples$_L$ of luma samples,

– when ChromaArrayType is not equal to 0, modified versions of the arrays picSamples$_{Cb}$ and picSamples$_{Cr}$ of chroma samples.

The resampling process for intra samples of a macroblock colour component as specified in subclause G.8.6.2.1 is invoked with chromaFlag equal to 0, mbW equal to 16, mbH equal to 16, fieldMbFlag, refLayerPicSamples$_L$, refLayerSliceIdc, refLayerFieldMbFlag, and refLayerMbType as the inputs and the output is the 16x16 array mbPred$_L$ of Intra_Base prediction samples for the luma component of the current macroblock.

When ChromaArrayType is not equal to 0, for CX being replaced by Cb and Cr, the resampling process for intra samples of a macroblock colour component as specified in subclause G.8.6.2.1 is invoked with chromaFlag equal to 1, mbW equal to MbWidthC, mbH equal to MbHeightC, fieldMbFlag, refLayerPicSamples$_{CX}$, refLayerSliceIdc, refLayerFieldMbFlag, and refLayerMbType as the inputs and the output is the (MbWidthC)x(MbHeightC) array mbPred$_{CX}$ of Intra_Base prediction samples for the CX component of the current macroblock.

The picture sample array construction process as specified in subclause G.8.5.4.1 is invoked with fieldMbFlag, mbPred$_L$, picSamples$_L$ and, when ChromaArrayType is not equal to 0, mbPred$_{Cb}$, mbPred$_{Cr}$, picSamples$_{Cb}$, and picSamples$_{Cr}$ as the inputs and the outputs are a modified version of picSamples$_L$ and, when ChromaArrayType is not equal to 0, modified versions of picSamples$_{Cb}$, and picSamples$_{Cr}$.

G.8.6.2.1 Resampling process for intra samples of a macroblock colour component

Inputs to this process are

– a variable chromaFlag specifying whether the luma or a chroma component is subject to the resampling process,

– two variables mbW and mbH specifying the width and height, respectively, of a macroblock for the considered colour component,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– an array refLayerPicSamples, which is a (RefLayerPicWidthInSamples$_L$)x(RefLayerPicHeightInSamples$_L$) array containing constructed intra luma sample values for the reference layer representation when chromaFlag is equal to 0 or a (RefLayerPicWidthInSamples$_C$)x(RefLayerPicHeightInSamples$_C$) array containing constructed intra chroma sample values for the reference layer representation when chromaFlag is equal to 1,

– a one-dimensional array refLayerSliceIdc with RefLayerPicSizeInMbs elements specifying slice identifications for the macroblocks of the reference layer representation,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation.

Output of this process is an (mbW)x(mbH) array mbPred of Intra_Base prediction samples.

The variable botFieldFlag is derived as follows.

– If RefLayerFrameMbsOnlyFlag is equal to 0, botFieldFlag is set equal to 0.

– Otherwise, if field_pic_flag is equal to 1, botFieldFlag is set equal to bottom_field_flag.

– Otherwise, if RefLayerFieldPicFlag is equal to 1, botFieldFlag is set equal to RefLayerBottomFieldFlag.

– Otherwise, if fieldMbFlag is equal to 1, botFieldFlag is set equal to (CurrMbAddr % 2).

– Otherwise, botFieldFlag is set equal to 0.

The variable frameBasedResamplingFlag is derived as follows.

– If all of the following conditions are true, frameBasedResamplingFlag is set equal to 1.
  – RefLayerFrameMbsOnlyFlag is equal to 1
  – frame_mbs_only_flag is equal to 1

– Otherwise, frameBasedResamplingFlag is set equal to 0.

The variable topAndBotResamplingFlag is derived as follows.

– If all of the following conditions are true, topAndBotResamplingFlag is set equal to 1.
  – RefLayerFrameMbsOnlyFlag is equal to 0
  – RefLayerFieldPicFlag is equal to 0
  – frame_mbs_only_flag is equal to 0
  – fieldMbFlag is equal to 0

– Otherwise, topAndBotResamplingFlag is set equal to 0.

The variable filteringModeFlag is derived as follows.

– If chromaFlag is equal to 0 or ChromaArrayType is equal to 3, filteringModeFlag is set equal to 0.

– Otherwise (chromaFlag is equal to 1 and ChromaArrayType is not equal to 3), filteringModeFlag is set equal to 1.

The array predArray is derived as specified in the following.

– If frameBasedResamplingFlag is equal to 1 or fieldMbFlag is equal to 1, the following ordered steps are specified.

  1. The reference layer sample array construction process prior to intra resampling as specified in subclause G.8.6.2.2 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag, refLayerPicSamples, refLayerSliceIdc, refLayerFieldMbFlag, and refLayerMbType as the inputs and the outputs are the variables refArrayW, refArrayH, the array refSampleArray of reference layer sample values, and the variables xOffset and yOffset.

  2. The interpolation process for Intra_Base prediction as specified in subclause G.8.6.2.3 is invoked with filteringModeFlag, chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag, fldPrdInFrmMbFlag equal to 0, yBorder equal to 0, refArrayW, refArrayH, refSampleArray, xOffset, and yOffset as the inputs and the output is the (mbW)x(mbH) array mbPred of Intra_Base prediction samples.

– Otherwise, if topAndBotResamplingFlag is equal to 0, the following ordered steps are specified.

  1. The reference layer sample array construction process prior to intra resampling as specified in subclause G.8.6.2.2 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag, refLayerPicSamples, refLayerSliceIdc, refLayerFieldMbFlag, and refLayerMbType as the inputs and the outputs are the variables refArrayW, refArrayH, the array refSampleArray of reference layer sample values, and the variables xOffset and yOffset.

  2. The variable yBorder is set equal to (2 – chromaFlag).

  3. The interpolation process for Intra_Base prediction as specified in subclause G.8.6.2.3 is invoked with filteringModeFlag, chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag, fldPrdInFrmMbFlag equal to 1,

yBorder, refArrayW, refArrayH, refSampleArray, xOffset, and yOffset as the inputs and the output is the (mbW)x(mbH / 2 + 2* yBorder) array fieldPredArray of field prediction samples.

4. The vertical interpolation process for Intra_Base prediction as specified in subclause G.8.6.2.4 is invoked with filteringModeFlag, chromaFlag, mbW, mbH, botFieldFlag, yBorder, and fieldPredArray as the inputs and the output is the (mbW)x(mbH) array mbPred of Intra_Base prediction samples.

– Otherwise (topAndBotResamplingFlag is equal to 1), the following ordered steps are specified.

1. The reference layer sample array construction process prior to intra resampling as specified in subclause G.8.6.2.2 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag equal to 0, refLayerPicSamples, refLayerSliceIdc, refLayerFieldMbFlag, and refLayerMbType as the inputs and the outputs are the variables refArrayTopW, refArrayTopH, the array refSampleArrayTop of top field reference layer sample values, and the variables xOffsetTop and yOffsetTop.

2. The interpolation process for Intra_Base prediction as specified in subclause G.8.6.2.3 is invoked with filteringModeFlag, chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag equal to 0, fldPrdInFrmMbFlag equal to 1, yBorder equal to 0, refArrayTopW, refArrayTopH, refSampleArrayTop, xOffsetTop, and yOffsetTop as the inputs and the output is the (mbW)x(mbH / 2) array topFieldPredArray of top field prediction samples.

3. The reference layer sample array construction process prior to intra resampling as specified in subclause G.8.6.2.2 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag equal to 1, refLayerPicSamples, refLayerSliceIdc, refLayerFieldMbFlag, and refLayerMbType as the inputs and the outputs are the variables refArrayBotW, refArrayBotH, the array refSampleArrayBot of bottom field reference layer sample values, and the variables xOffsetBot and yOffsetBot.

4. The interpolation process for Intra_Base prediction as specified in subclause G.8.6.2.3 is invoked with filteringModeFlag, chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag equal to 1, fldPrdInFrmMbFlag equal to 1, yBorder equal to 0, refArrayBotW, refArrayBotH, refSampleArrayBot, xOffsetBot, and yOffsetBot as the inputs and the output is the (mbW)x(mbH / 2) array botFieldPredArray of bottom field prediction samples.

5. Each sample predArray[x, y] with x = 0..(mbW – 1) and y = 0..(mbH – 1) of the array mbPred of Intra_Base prediction samples is derived by

$$\begin{aligned} mbPred[\,x, y\,] = (\,(\,y \,\%\, 2\,) == 0\ ?\ & topFieldPredArray[\,x, y >> 1\,] \\ :\ & botFieldPredArray[\,x, y >> 1\,]\,) \end{aligned} \tag{G-276}$$

G.8.6.2.2 Reference layer sample array construction process prior to intra resampling

Inputs to this process are

– a variable chromaFlag specifying whether the luma or a chroma component is subject to the resampling process,

– two variables mbW and mbH specifying the width and height, respectively, of a macroblock for the considered colour component,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable botFieldFlag specifying whether a top or a bottom field is subject to the resampling process (when RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0),

– an array refLayerPicSamples, which is a ($RefLayerPicWidthInSamples_L$)x($RefLayerPicHeightInSamples_L$) array containing constructed intra luma sample values for the reference layer representation when chromaFlag is equal to 0 or a ($RefLayerPicWidthInSamples_C$)x($RefLayerPicHeightInSamples_C$) array containing constructed intra chroma sample values for the reference layer representation when chromaFlag is equal to 1,

– a one-dimensional array refLayerSliceIdc with RefLayerPicSizeInMbs elements specifying slice identifications for the macroblocks of the reference layer representation,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation.

Outputs of this process are

– two variables refArrayW and refArrayH specifying the width and height, respectively, of the constructed array of reference layer sample values,

– a (refArrayW)x(refArrayH) array refSampleArray of reference layer sample values,

– two variables xOffset and yOffset specifying the x and y coordinate, respectively, of the reference layer sample location that corresponds to the sample refSampleArray[0, 0] of the array refSampleArray.

The variables refW, refH, refMbW, refMbH, xOffset, yOffset, refArrayW, refArrayH, xMin, yMin, xMax, yMax, yRefScale, and yRefAdd are derived as specified in the following ordered steps.

1. The derivation process for reference layer sample locations in resampling as specified in subclause G.6.3 is invoked with chromaFlag, the sample location (0, 0), fieldMbFlag, and botFieldFlag as the inputs and the output is the sample location (xRefMin16, yRefMin16) in units of 1/16-th sample.

2. The derivation process for reference layer sample locations in resampling as specified in subclause G.6.3 is invoked with chromaFlag, the sample location (mbW – 1, mbH – 1), fieldMbFlag, and botFieldFlag as the inputs and the output is the sample location (xRefMax16, yRefMax16) in units of 1/16-th sample.

3. With Z being replaced by L for chromaFlag equal to 0 and C for chromaFlag equal to 1, the variables refW, refH, refMbW, and refMbH are derived by

$$refW = RefLayerPicWidthInSamples_Z \quad \text{(G-277)}$$
$$refH = RefLayerPicHeightInSamples_Z \quad \text{(G-278)}$$
$$refMbW = ((chromaFlag == 0) ? 16 : RefLayerMbWidthC) \quad \text{(G-279)}$$
$$refMbH = ((chromaFlag == 0) ? 16 : RefLayerMbHeightC) \quad \text{(G-280)}$$

4. The variables xOffset, yOffset, refArrayW, and refArrayH are derived by

$$xOffset = ((xRefMin16 >> 8) << 4) – (refMbW >> 1) \quad \text{(G-281)}$$
$$yOffset = ((yRefMin16 >> 8) << 4) – (refMbH >> 1) \quad \text{(G-282)}$$
$$refArrayW = (((xRefMax16 + 15) >> 8) << 4) + (refMbW >> 1) – xOffset + 16 \quad \text{(G-283)}$$
$$refArrayH = (((yRefMax16 + 15) >> 8) << 4) + (refMbH >> 1) – yOffset + 16 \quad \text{(G-284)}$$

NOTE 1 – The derived array size might be larger than the array size that is required by the interpolation process for Intra_Base prediction specified in subclause G.8.6.2.3.

5. The variables xMin, yMin, xMax, and yMax are derived by

$$xMin = (xRefMin16 >> 4) – xOffset \quad \text{(G-285)}$$
$$yMin = (yRefMin16 >> 4) – yOffset \quad \text{(G-286)}$$
$$xMax = ((xRefMax16 + 15) >> 4) – xOffset \quad \text{(G-287)}$$
$$yMax = ((yRefMax16 + 15) >> 4) – yOffset \quad \text{(G-288)}$$

6. The variables yRefScale and yRefAdd are derived as follows.

   – If RefLayerFrameMbsOnlyFlag is equal to 1 or RefLayerFieldMbFlag is equal to 1, yRefScale is set equal to 1 and yRefAdd is set equal to 0.

   – Otherwise (RefLayerFrameMbsOnlyFlag is equal to 0 and RefLayerFieldMbFlag is equal to 0), yRefScale is set equal to 2 and yRefAdd is set equal to botFieldFlag.

The variable refSliceIdcMb is marked as "not available".

Each sample refSampleArray[x, y] with x = 0..(refArrayW – 1) and y = 0..(refArrayH – 1) is derived as specified in the following ordered steps.

1. A reference layer sample location (xRef, yRef) is derived by

$$xRef = max(0, min(refW – 1, x + xOffset)) \quad \text{(G-289)}$$
$$yRef = yRefScale * max(0, min(refH / yRefScale – 1, y + yOffset)) + yRefAdd \quad \text{(G-290)}$$

2. The derivation process for reference layer slice and intra macroblock identifications as specified in subclause G.8.6.2.2.1 is invoked with the reference layer sample location (xRef, yRef), refMbW, refMbH, refLayerSliceIdc, refLayerFieldMbFlag, and refLayerMbType as the inputs and the outputs are the reference layer slice identification refSliceIdc and the variable refIntraMbFlag.

3. When constrained_intra_resampling_flag is equal to 1, refIntraMbFlag is equal to 1, x is greater than or equal to xMin, x is less than or equal to xMax, y is greater than or equal to yMin, and y is less than or equal to yMax, the following applies.

   – If the variable refSliceIdcMb is marked as "not available", refSliceIdcMb is marked as "available" and its value is set equal to refSliceIdc.

– Otherwise (refSliceIdcMb is marked as "available"), the bitstream shall not contain data that result in a reference layer slice identification refSliceIdc that is not equal to refSliceIdcMb.

NOTE 2 – This constraint specifies that a macroblock cannot be coded with base_mode_flag equal to 1 when it covers intra-coded macroblocks of more than one slice in the reference layer representation and constrained_intra_resampling_flag is equal to 1.

4. Depending on refIntraMbFlag, constrained_intra_resampling_flag, and refSliceIdc, the following applies.

   – If any of the following conditions is true, the sample refSampleArray[x, y] is marked as "not available for Intra_Base prediction" and its value is set equal to 0.

     – refIntraMbFlag is equal to 0

     – constrained_intra_resampling_flag is equal to 1 and refSliceIdc is not equal to refSliceIdcMb

   – Otherwise, the sample refSampleArray[x, y] is marked as "available for Intra_Base prediction" and its value is derived by

$$refSampleArray[x, y] = refLayerPicSamples[xRef, yRef] \quad \text{(G-291)}$$

The construction process for not available sample values prior to intra resampling as specified in subclause G.8.6.2.2.2 is invoked with refMbW, refMbH, refArrayW, refArrayH, refSampleArray, xOffset, and yOffset as the inputs and the output is a modified version of the sample array refSampleArray.

G.8.6.2.2.1 Derivation process for reference layer slice and intra macroblock identifications

Inputs to this process are

– a reference layer sample location (xRef, yRef) relative to the upper-left sample of the considered colour component of the reference layer picture,

– two variables refMbW and refMbH specifying the width and height, respectively, of a reference layer macroblock for the considered colour component,

– a one-dimensional array refLayerSliceIdc with RefLayerPicSizeInMbs elements specifying slice identifications for the macroblocks of the reference layer representation,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation.

Outputs of this process are

– a reference layer slice identification refSliceIdc for the slice that covers the input reference layer sample location,

– a variable refIntraMbFlag specifying whether the reference layer macroblock that covers the input reference layer sample location is intra coded.

The reference layer macroblock address refMbAddr is derived as follows.

– If RefLayerMbaffFrameFlag is equal to 0, the variable refMbAddr is derived by

$$refMbAddr = (yRef / refMbH) * RefLayerPicWidthInMbs + (xRef / refMbW) \quad \text{(G-292)}$$

– Otherwise (RefLayerMbaffFrameFlag is equal to 1), the variable refMbAddr is derived as specified in the following ordered steps.

1. A variable refMbAddrTop is derived by

$$refMbAddrTop = 2 * ((yRef / (2 * refMbH)) * RefLayerPicWidthInMbs + (xRef / refMbW)) \quad \text{(G-293)}$$

2. Depending on refLayerFieldMbFlag[refMbAddrTop], the variable refMbAddr is derived as follows.

   – If refLayerFieldMbFlag[refMbAddrTop] is equal to 0, the variable refMbAddr is derived by

$$refMbAddr = refMbAddrTop + (yRef \% (2 * refMbH)) / refMbH \quad \text{(G-294)}$$

– Otherwise (refLayerFieldMbFlag[refMbAddrTop] is equal to 1), the variable refMbAddr is derived by

refMbAddr = refMbAddrTop + (yRef % 2) (G-295)

The reference layer slice identification refSliceIdc is set equal to refLayerSliceIdc[refMbAddr].

Depending on refLayerMbType[refMbAddr], the variable refIntraMbFlag is derived as follows.

– If refLayerMbType[refMbAddr] is equal to I_4x4, I_8x8, I_16x16, I_PCM, or I_BL, refIntraMbFlag is set equal to 1.

– Otherwise (refLayerMbType[refMbAddr] is not equal to I_4x4, I_8x8, I_16x16, I_PCM, or I_BL), refIntraMbFlag is set equal to 0.

G.8.6.2.2.2 Construction process for not available sample values prior to intra resampling

Inputs to this process are

– two variables refMbW and refMbH specifying the width and height, respectively, of a reference layer macroblock for the considered colour component,

– two variables refArrayW and refArrayH specifying the width and height, respectively, of the array of reference layer sample values,

– a (refArrayW)x(refArrayH) array refSampleArray of reference layer sample values,

– two variables xOffset and yOffset specifying the x and y coordinates, respectively, of the reference layer sample location that corresponds to the sample refSampleArray[0, 0] of the array refSampleArray.

Output of this process is a modified version of the array refSampleArray.

For each sample refSampleArray[x, y] with x = (refMbW / 2)..(refArrayW – refMbW / 2 – 1) and y = (refMbH / 2)..(refArrayH – refMbH / 2 – 1) that is marked as "not available for Intra_Base prediction", the following ordered steps are specified.

1. The sample location difference (xD, yD) and the variable yA are derived by

xR = (x + xOffset) % refMbW (G-296)
yR = (y + yOffset) % refMbH (G-297)

xD = ((xR >= refMbW / 2) ? (xR – refMbW) : (xR + 1)) (G-298)
yD = ((yR >= refMbH / 2) ? (yR – refMbH) : (yR + 1)) (G-299)

yA = yD – 9 * Sign(yD) (G-300)

2. When any of the following conditions is true, yD is set equal to yA.

   – the sample refSampleArray[x, y – yD] is marked as "not available for Intra_Base prediction" and the sample refSampleArray[x, y - yA] is marked as "available for Intra_Base prediction"

   – all of the samples refSampleArray[x – xD, y], refSampleArray[x, y – yD], and refSampleArray[x - xD, y – yD] are marked as "not available for Intra_Base prediction"

3. The sample value refSampleArray[x, y] is derived as follows.

   – If the sample refSampleArray[x – xD, y] and the sample refSampleArray[x, y – yD] are marked as "available for Intra_Base prediction", the following ordered steps are specified.

      a. A variable cornerSampleAvailableFlag is derived as follows.

         – If the sample refSampleArray[x – xD, y – yD] is marked as "available for Intra_Base prediction", the variable cornerSampleAvailableFlag is set equal to 1.

         – Otherwise (the sample refSampleArray[x – xD, y – yD] is marked as "not available for Intra_Base prediction"), the variable cornerSampleAvailable is set equal to 0.

      b. The diagonal construction process for not available sample values as specified in subclause G.8.6.2.2.2.1 is invoked with refArrayW, refArrayH, refSampleArray, the sample location difference (xD, yD), the sample location (x, y), and the variable cornerSampleAvailableFlag as the inputs and the output is the sample array refSampleArray with a modified sample value at sample location (x, y).

– Otherwise (the sample refSampleArray[x – xD, y] or the sample refSampleArray[x, y – yD] is marked as "not available for Intra_Base prediction"), the following applies.

  – If the sample refSampleArray[x – xD, y] is marked as "available for Intra_Base prediction", the sample value refSampleArray[x, y] is set equal to refSampleArray[x – xD, y].

  – Otherwise, if the sample refSampleArray[x, y – yD] is marked as "available for Intra_Base prediction", the sample value refSampleArray[x, y] is set equal to refSampleArray[x, y – yD].

  – Otherwise (the sample refSampleArray[x – xD, y] and the sample refSampleArray[x, y – yD] are marked as "not available for Intra_Base prediction"), the sample value refSampleArray[x, y] is set equal to refSampleArray[x – xD, y – yD].

All samples refSampleArray[x, y] with x = 0..(refArrayW – 1) and y = 0..(refArrayH – 1) are marked as "available for Intra_Base prediction".

G.8.6.2.2.2.1 Diagonal construction process for not available sample values

Inputs to this process are

– two variables refArrayW and refArrayH specifying the width and height, respectively, of the array of reference layer sample values,

– a (refArrayW)x(refArrayH) array p of reference layer sample values,

– a sample location difference (xD, yD),

– a sample location (x, y) inside the reference layer sample array refSampleArray,

– a variable cornerSampleAvailableFlag.

Output of this process is the sample array p with a modified sample value at sample location (x, y).

The variables diffHorVer and sgnXY are derived by

diffHorVer = Abs(xD) – Abs(yD) (G-301)
sgnXY = Sign(xD * yD) (G-302)

When cornerSampleAvailableFlag is equal to 1, the following applies.

1. The variable cornerSample is set equal to p[x – xD, y – yD].
2. The sample value p[x – xD, y – yD] is modified by

$$p[x - xD, y - yD] = (p[x - xD, y] + p[x, y - yD] + 1) >> 1 \quad \text{(G-324a)}$$

The sample value p[x, y] is derived as follows.

– If diffHorVer is greater then 0, the sample location (xC, yC) is set equal to (x – sgnXY * yD, y – yD) and the sample value p[x, y] is derived by

$$p[x, y] = (p[xC - 1, yC] + 2 * p[xC, yC] + p[xC + 1, yC] + 2) >> 2 \quad \text{(G-303)}$$

– Otherwise, if diffHorVer is less then 0, the sample location (xC, yC) is set equal to (x – xD, y – sgnXY * xD) and the sample value p[x, y] is derived by

$$p[x, y] = (p[xC, yC - 1] + 2 * p[xC, yC] + p[xC, yC + 1] + 2) >> 2 \quad \text{(G-304)}$$

– Otherwise (diffVerHor is equal to 0), the sample value p[x, y] is derived by

$$p[x, y] = (p[x, y - yD] + 2 * p[x - xD, y - yD] + p[x - xD, y] + 2) >> 2 \quad \text{(G-305)}$$

When cornerSampleAvailableFlag is equal to 1, the sample value p[x – xD, y – yD] is set equal to cornerSample.

G.8.6.2.3 Interpolation process for Intra_Base prediction

Inputs to this process are

– a variable filteringModeFlag specifying the interpolation method,

– a variable chromaFlag specifying whether the luma or a chroma component is subject to the resampling process,

– two variables mbW and mbH specifying the width and height, respectively, of a macroblock for the considered colour component,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable botFieldFlag specifying whether a top or a bottom field is subject to the resampling process (when RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0),

– a variable fldPrdInFrmMbFlag specifying whether field prediction for a frame macroblock is applied,

– a variable yBorder specifying the vertical border for the output sample array predSamples,

– two variables refArrayW and refArrayH specifying the width and height, respectively, of the array of reference layer sample values,

– a (refArrayW)x(refArrayH) array refSampleArray of reference layer sample values,

– two variables xOffset and yOffset specifying the x and y coordinate, respectively, of the reference layer sample location that corresponds to the sample refSampleArray[0, 0] of the array refSampleArray.

Output of this process is an (mbW)x(mbH / (1 + fldPrdInFrmMbFlag) + 2 * yBorder) array predArray of interpolated sample values.

Table G-8 specifies the filter coefficients eF[p, x] with p = 0..15 and x = 0..3 of the luma interpolation filter eF for resampling in Intra_Base prediction.

Table G-8 – 16-phase luma interpolation filter for resampling in Intra_Base prediction

Phase p	Interpolation filter coefficients			
	eF[p, 0]	eF[p, 1]	eF[p, 2]	eF[p, 3]
0	0	32	0	0
1	-1	32	2	-1
2	-2	31	4	-1
3	-3	30	6	-1
4	-3	28	8	-1
5	-4	26	11	-1
6	-4	24	14	-2
7	-3	22	16	-3
8	-3	19	19	-3
9	-3	16	22	-3
10	-2	14	24	-4
11	-1	11	26	-4
12	-1	8	28	-3
13	-1	6	30	-3
14	-1	4	31	-2
15	-1	2	32	-1

Let tempArray be a (refArrayW)x(mbH / (1 + fldPrdInFrmMbFlag) + 2 * yBorder) array of samples. Each sample tempArray[x, y] with x = 0..(refArrayW – 1) and y = 0..(mbH / (1 + fldPrdInFrmMbFlag) + 2 * yBorder – 1) is derived as specified in the following ordered steps.

1. The variable yP is derived by

$$yP = y * (1 + fldPrdInFrmMbFlag) – yBorder + botFieldFlag \quad (G\text{-}306)$$

2. The derivation process for reference layer sample locations in resampling as specified in subclause G.6.3 is invoked with chromaFlag, the sample location (0, yP), fieldMbFlag, and botFieldFlag as the inputs and the output is the sample location (xRef16, yRef16) in units of 1/16-th sample.

   NOTE 1 – In this invocation of the process in subclause G.6.3, only the vertical component yRef16 of the sample location needs to be derived.

3. The variables yRef and yPhase are derived by

$$yRef = (yRef16 >> 4) – yOffset \quad (G\text{-}307)$$
$$yPhase = (yRef16 + 16) \% 16 \quad (G\text{-}308)$$

4. Depending on filteringModeFlag, the sample value tempArray[x, y] is derived as follows.

   – If filteringModeFlag is equal to 0, the sample value tempArray[x, y] is derived by

$$\begin{aligned} \text{tempArray}[\,x, y\,] = {} & \text{eF}[\,\text{yPhase}, 0\,] * \text{refSampleArray}[\,x, \text{yRef} - 1\,] + \\ & \text{eF}[\,\text{yPhase}, 1\,] * \text{refSampleArray}[\,x, \text{yRef}\,] + \\ & \text{eF}[\,\text{yPhase}, 2\,] * \text{refSampleArray}[\,x, \text{yRef} + 1\,] + \\ & \text{eF}[\,\text{yPhase}, 3\,] * \text{refSampleArray}[\,x, \text{yRef} + 2\,] \end{aligned} \tag{G-309}$$

   – Otherwise (filteringModeFlag is equal to 1), the sample value tempArray[x, y] is derived by

$$\begin{aligned} \text{tempArray}[\,x, y\,] = {} & (\,16 - \text{yPhase}\,) * \text{refSampleArray}[\,x, \text{yRef}\,] + \\ & \text{yPhase} * \text{refSampleArray}[\,x, \text{yRef} + 1\,] \end{aligned} \tag{G-310}$$

Each sample predArray[x, y] with x = 0..(mbW – 1) and y = 0..(mbH / (1 + fldPrdInFrmMbFlag) + 2 * yBorder – 1) is derived as specified in the following ordered steps.

1. The derivation process for reference layer sample locations in resampling as specified in subclause G.6.3 is invoked with chromaFlag, the sample location (x, 0), fieldMbFlag, and botFieldFlag as the inputs and the output is the sample location (xRef16, yRef16) in units of 1/16-th sample.

   NOTE 2 – In this invocation of the process in subclause G.6.3, only the horizontal component xRef16 of the sample location needs to be derived.

2. The variables xRef and xPhase are derived by

$$\text{xRef} = (\,\text{xRef16} >> 4\,) - \text{xOffset} \tag{G-311}$$

$$\text{xPhase} = (\,\text{xRef16} + 16\,) \,\%\, 16 \tag{G-312}$$

3. Depending on filteringModeFlag, and with Clip1 being replaced by Clip1_Y for chromaFlag equal to 0 and Clip1_C for chromaFlag equal to 1, the sample value predArray[x, y] is derived as follows.

   – If filteringModeFlag is equal to 0, the sample value tempArray[x, y] is derived by

$$\begin{aligned} \text{predArray}[\,x, y\,] = \text{Clip1}({} & (\,\text{eF}[\,\text{xPhase}, 0\,] * \text{tempArray}[\,\text{xRef} - 1, y\,] + \\ & \text{eF}[\,\text{xPhase}, 1\,] * \text{tempArray}[\,\text{xRef} , y] + \\ & \text{eF}[\,\text{xPhase}, 2\,] * \text{tempArray}[\,\text{xRef} + 1, y\,] + \\ & \text{eF}[\,\text{xPhase}, 3\,] * \text{tempArray}[\,\text{xRef} + 2, y\,] + 512\,) >> 10\,) \end{aligned} \tag{G-313}$$

   – Otherwise (filteringModeFlag is equal to 1), the sample value tempArray[x, y] is derived by

$$\begin{aligned} \text{predArray}[\,x, y\,] = {} & (\,(\,16 - \text{xPhase}\,) * \text{tempArray}[\,\text{xRef}, y\,] + \\ & \text{xPhase} * \text{tempArray}[\,\text{xRef} + 1, y\,] + 128\,) >> 8 \end{aligned} \tag{G-314}$$

G.8.6.2.4 Vertical interpolation process for Intra_Base prediction

Inputs to this process are

– a variable filteringModeFlag specifying the interpolation method,

– a variable chromaFlag specifying whether the luma or a chroma component is subject to the resampling process,

– two variables mbW and mbH specifying the width and height, respectively, of a macroblock for the considered colour component,

– a variable botFieldFlag specifying whether the sample array fieldPredArray contains interpolated samples for the top or bottom field,

– a variable yBorder specifying the vertical border for the sample array fieldPredArray,

– an (mbW)x(mbH / 2 + 2 * yBorder) array fieldPredArray of sample values.

Output of this process is an (mbW)x(mbH) array predArray of interpolated sample values.

Each sample predArray[x, y] with x = 0..(mbW – 1) and y = 0..(mbH – 1) is derived as follows.

– If (y % 2) is equal to botFieldFlag, the sample value predArray[x, y] is derived by

$$\text{predArray}[\,x, y\,] = \text{fieldPredArray}[\,x, (\,y >> 1\,) + \text{yBorder}\,] \tag{G-315}$$

– Otherwise ((y % 2) is not equal to botFieldFlag), the following ordered steps are specified.

1. The variable yFld is derived by

$$yFld = (y >> 1) + yBorder - botFieldFlag \quad \text{(G-316)}$$

2. Depending on filteringModeFlag, and with Clip1 being replaced by $Clip1_Y$ for chromaFlag equal to 0 and $Clip1_C$ for chromaFlag equal to 1, the sample value predArray[x, y] is derived as follows.

   – If filteringModeFlag is equal to 0, the sample value predArray[x, y] is derived by

$$\begin{aligned} predArray[x, y] = Clip1((19 * (& fieldPredArray[x, yFld] + \\ & fieldPredArray[x, yFld + 1]) - \\ 3 * (& fieldPredArray[x, yFld - 1] + \\ & fieldPredArray[x, yFld + 2]) + 16) >> 5) \end{aligned} \quad \text{(G-317)}$$

   – Otherwise (filteringModeFlag is equal to 1), the sample value predArray[x, y] is derived by

$$\begin{aligned} predArray[x, y] = (& fieldPredArray[x, yFld] + \\ & fieldPredArray[x, yFld + 1] + 1) >> 1 \end{aligned} \quad \text{(G-318)}$$

G.8.6.3 Resampling process for residual samples

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerCTrafo with RefLayerPicSizeInMbs elements specifying the luma transform types for the macroblocks of the reference layer representation,

– a ($RefLayerPicWidthInSamples_C$)x($RefLayerPicHeightInSamples_C$) array $refLayerPicSamples_L$ of luma samples for the reference layer representation,

– a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array $picSamples_L$ of luma samples,

– when ChromaArrayType is not equal to 0, two ($RefLayerPicWidthInSamples_C$)x($RefLayerPicHeightInSamples_C$) arrays $refLayerPicSamples_{Cb}$ and $refLayerPicSamples_{Cr}$ of chroma samples for the reference layer representation,

– when ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays $picSamples_{Cb}$ and $picSamples_{Cr}$ of chroma samples.

Outputs of this process are

– a modified version of the array $picSamples_L$ of luma samples,

– when ChromaArrayType is not equal to 0, modified versions of the arrays $picSamples_{Cb}$ and $picSamples_{Cr}$ of chroma samples.

The resampling process for residual samples of a macroblock colour component as specified in subclause G.8.6.3.1 is invoked with chromaFlag equal to 0, mbW equal to 16, mbH equal to 16, fieldMbFlag, $refLayerPicSamples_L$, refLayerFieldMbFlag, and refLayerCTrafo as the inputs and the output is the 16x16 array $mbPred_L$ of residual prediction samples for the luma component of the current macroblock.

When ChromaArrayType is not equal to 0, for CX being replaced by Cb and Cr, the resampling process for residual samples of a macroblock colour component as specified in subclause G.8.6.3.1 is invoked with chromaFlag equal to 1, mbW equal to MbWidthC, mbH equal to MbHeightC, fieldMbFlag, $refLayerPicSamples_{CX}$, refLayerFieldMbFlag, and refLayerCTrafo as the inputs and the output is the (MbWidthC)x(MbHeightC) array $mbPred_{CX}$ of residual prediction samples for the CX component of the current macroblock.

The picture sample array construction process as specified in subclause G.8.5.4.1 is invoked with fieldMbFlag, $mbPred_L$, $picSamples_L$ and, when ChromaArrayType is not equal to 0, $mbPred_{Cb}$, $mbPred_{Cr}$, $picSamples_{Cb}$, and $picSamples_{Cr}$ as the inputs and the outputs are a modified version of $picSamples_L$ and, when ChromaArrayType is not equal to 0, modified versions of $picSamples_{Cb}$, and $picSamples_{Cr}$.

G.8.6.3.1 Resampling process for residual samples of a macroblock colour component

Inputs to this process are

– a variable chromaFlag specifying whether the luma or a chroma component is subject to the resampling process,

– two variables mbW and mbH specifying the width and height, respectively, of a macroblock for the considered colour component,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– an array refLayerPicSamples, which is a (RefLayerPicWidthInSamples$_L$)x(RefLayerPicHeightInSamples$_L$) array containing constructed residual luma sample values for the reference layer representation when chromaFlag is equal to 0 or a (RefLayerPicWidthInSamples$_C$)x(RefLayerPicHeightInSamples$_C$) array containing constructed residual chroma sample values for the reference layer representation when chromaFlag is equal to 1,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerCTrafo with RefLayerPicSizeInMbs elements specifying the luma transform types for the macroblocks of the reference layer representation.

Output of this process is an (mbW)x(mbH) array mbPred of residual prediction samples.

The variable botFieldFlag is derived as follows.

– If RefLayerFrameMbsOnlyFlag is equal to 0, botFieldFlag is set equal to 0.

– Otherwise, if field_pic_flag is equal to 1, botFieldFlag is set equal to bottom_field_flag.

– Otherwise, if RefLayerFieldPicFlag is equal to 1, botFieldFlag is set equal to RefLayerBottomFieldFlag.

– Otherwise, if fieldMbFlag is equal to 1, botFieldFlag is set equal to (CurrMbAddr % 2).

– Otherwise, botFieldFlag is set equal to 0.

The variable frameBasedResamplingFlag is derived as follows.

– If all of the following conditions are true, frameBasedResamplingFlag is set equal to 1.
  – RefLayerFrameMbsOnlyFlag is equal to 1
  – frame_mbs_only_flag is equal to 1

– Otherwise, frameBasedResamplingFlag is set equal to 0.

The variable topAndBotResamplingFlag is derived as follows.

– If all of the following conditions are true, topAndBotResamplingFlag is set equal to 1.
  – RefLayerFrameMbsOnlyFlag is equal to 0
  – RefLayerFieldPicFlag is equal to 0
  – frame_mbs_only_flag is equal to 0
  – fieldMbFlag is equal to 0

– Otherwise, topAndBotResamplingFlag is set equal to 0.

The array predArray is derived as specified in the following.

– If frameBasedResamplingFlag is equal to 1 or fieldMbFlag is equal to 1, the following ordered steps are specified.

  1. The reference layer sample array construction process prior to residual resampling as specified in subclause G.8.6.3.2 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag, yBorder equal to 0, refLayerPicSamples, refLayerFieldMbFlag, and refLayerCTrafo as the inputs and the outputs are the variables refArrayW, refArrayH, the array refSampleArray of reference layer sample values, the array refTransBlkIdc of reference layer transform block identifications, and the variables xOffset and yOffset.

  2. The interpolation process for residual prediction as specified in subclause G.8.6.3.3 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag, fldPrdInFrmMbFlag equal to 0, yBorder equal to 0, refArrayW, refArrayH, refSampleArray, refTransBlkIdc, xOffset, and yOffset as the inputs and the output is the (mbW)x(mbH) array mbPred of residual prediction samples.

– Otherwise, if topAndBotResamplingFlag is equal to 0, the following ordered steps are specified.

1. The reference layer sample array construction process prior to residual resampling as specified in subclause G.8.6.3.2 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag, yBorder equal to 1, refLayerPicSamples, refLayerFieldMbFlag, and refLayerCTrafo as the inputs and the outputs are the variables refArrayW, refArrayH, the array refSampleArray of reference layer sample values, the array refTransBlkIdc of reference layer transform block identifications, and the variables xOffset and yOffset.
2. The interpolation process for residual prediction as specified in subclause G.8.6.3.3 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag, fldPrdInFrmMbFlag equal to 1, yBorder equal to 1, refArrayW, refArrayH, refSampleArray, refTransBlkIdc, xOffset, and yOffset as the inputs and the output is the (mbW)x(mbH / 2 + 2) array fieldPredArray of field prediction samples.
3. The vertical interpolation process for residual prediction as specified in subclause G.8.6.3.4 is invoked with mbW, mbH, botFieldFlag, yBorder, and fieldPredArray as the inputs and the output is the (mbW)x(mbH) array mbPred of residual prediction samples.

– Otherwise (topAndBotResamplingFlag is equal to 1), the following ordered steps are specified.

1. The reference layer sample array construction process prior to residual resampling as specified in subclause G.8.6.3.2 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag equal to 0, yBorder equal to 0, refLayerPicSamples, refLayerFieldMbFlag, and refLayerCTrafo as the inputs and the outputs are the variables refArrayTopW, refArrayTopH, the array refSampleArrayTop of reference layer sample values, the array refTransBlkIdcTop of reference layer transform block identifications, and the variables xOffsetTop and yOffsetTop.
2. The interpolation process for residual prediction as specified in subclause G.8.6.3.3 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag equal to 0, fldPrdInFrmMbFlag equal to 1, yBorder equal to 0, refArrayTopW, refArrayTopH, refSampleArrayTop, refTransBlkIdcTop, xOffsetTop, and yOffsetTop as the inputs and the output is the (mbW)x(mbH / 2) array topFieldPredArray of top field prediction samples.
3. The reference layer sample array construction process prior to residual resampling as specified in subclause G.8.6.3.2 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag equal to 1, yBorder equal to 0, refLayerPicSamples, refLayerFieldMbFlag, and refLayerCTrafo as the inputs and the outputs are the variables refArrayBotW, refArrayBotH, the array refSampleArrayBot of reference layer sample values, the array refTransBlkIdcBot of reference layer transform block identifications, and the variables xOffsetBot and yOffsetBot.
4. The interpolation process for residual prediction as specified in subclause G.8.6.3.3 is invoked with chromaFlag, mbW, mbH, fieldMbFlag, botFieldFlag equal to 1, fldPrdInFrmMbFlag equal to 1, yBorder equal to 0, refArrayBotW, refArrayBotH, refSampleArrayBot, refTransBlkIdcBot, xOffsetBot, and yOffsetBot as the inputs and the output is the (mbW)x(mbH / 2) array botFieldPredArray of bottom field prediction samples.
5. Each sample predArray[x, y] with x = 0..(mbW – 1) and y = 0..(mbH – 1) of the array mbPred of residual prediction samples is derived by

$$\begin{aligned} mbPred[\, x, y \,] = (\, (\, y \,\%\, 2 \,) == 0 \;?\; & topFieldPredArray[\, x, y >> 1 \,] \\ & :\; botFieldPredArray[\, x, y >> 1 \,] \,) \end{aligned} \tag{G-319}$$

G.8.6.3.2 Reference layer sample array construction process prior to residual resampling

Inputs to this process are

– a variable chromaFlag specifying whether the luma or a chroma component is subject to the resampling process,

– two variables mbW and mbH specifying the width and height, respectively, of a macroblock for the considered colour component,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable botFieldFlag specifying whether a top or a bottom field is subject to the resampling process (when RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0),

– a variable yBorder specifying the vertical border for determining the vertical size of the output arrays,

– an array refLayerPicSamples, which is a (RefLayerPicWidthInSamples$_L$)x(RefLayerPicHeightInSamples$_L$) array containing constructed residual luma sample values for the reference layer representation when chromaFlag is equal to 0 or a (RefLayerPicWidthInSamples$_C$)x(RefLayerPicHeightInSamples$_C$) array containing constructed residual chroma sample values for the reference layer representation when chromaFlag is equal to 1,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerCTrafo with RefLayerPicSizeInMbs elements specifying the luma transform types for the macroblocks of the reference layer representation.

Outputs of this process are

– two variables refArrayW and refArrayH specifying the width and height, respectively, of the constructed arrays of reference layer sample values and reference layer transform block identification,

– a (refArrayW)x(refArrayH) array refSampleArray of reference layer sample values,

– a (refArrayW)x(refArrayH) array refTransBlkIdc of reference layer transform block identifications,

– two variables xOffset and yOffset specifying the x and y coordinate, respectively, of the reference layer sample location that corresponds to the sample refSampleArray[0, 0] of the array refSampleArray and the transform block identification refTransBlkIdc[0, 0] of the array refTransBlkIdc.

The variables refW, refH, refMbW, refMbH, xOffset, yOffset, refArrayW, refArrayH, yRefScale, and yRefAdd are derived as specified in the following ordered steps.

1. The derivation process for reference layer sample locations in resampling as specified in subclause G.6.3 is invoked with chromaFlag, the sample location (0, –yBorder), fieldMbFlag, and botFieldFlag as the inputs and the output is the sample location (xRefMin16, yRefMin16) in units of 1/16-th sample.

2. The derivation process for reference layer sample locations in resampling as specified in subclause G.6.3 is invoked with chromaFlag, the sample location (mbW – 1, mbH – 1 + yBorder), fieldMbFlag, and botFieldFlag as the inputs and the output is the sample location (xRefMax16, yRefMax16) in units of 1/16-th sample.

3. With Z being replaced by L for chromaFlag equal to 0 and C for chromaFlag equal to 1, the variables refW, refH, refMbW, and refMbH are derived by

$$refW = RefLayerPicWidthInSamples_Z \quad \text{(G-320)}$$
$$refH = RefLayerPicHeightInSamples_Z \quad \text{(G-321)}$$
$$refMbW = ((chromaFlag == 0) ? 16 : RefLayerMbWidthC) \quad \text{(G-322)}$$
$$refMbH = ((chromaFlag == 0) ? 16 : RefLayerMbHeightC) \quad \text{(G-323)}$$

4. The variables xOffset, yOffset, refArrayW, and refArrayH are derived by

$$xOffset = (xRefMin16 >> 4) \quad \text{(G-324)}$$
$$yOffset = (yRefMin16 >> 4) \quad \text{(G-325)}$$
$$refArrayW = ((xRefMax16 + 15) >> 4) - xOffset + 1 \quad \text{(G-326)}$$
$$refArrayH = ((yRefMax16 + 15) >> 4) - yOffset + 1 \quad \text{(G-327)}$$

5. The variables yRefScale and yRefAdd are derived as follows.

   – If RefLayerFrameMbsOnlyFlag is equal to 1 or RefLayerFieldMbFlag is equal to 1, yRefScale is set equal to 1 and yRefAdd is set equal to 0.

   – Otherwise (RefLayerFrameMbsOnlyFlag is equal to 0 and RefLayerFieldMbFlag is equal to 0), yRefScale is set equal to 2 and yRefAdd is set equal to botFieldFlag.

Each sample refSampleArray[x, y] and each transform block identification refTransBlkIdc[x, y] with x = 0..(refArrayW – 1) and y = 0..(refArrayH – 1) are derived as specified in the following ordered steps.

1. A reference layer sample location (xRef, yRef) is derived by

$$xRef = max(0, min(refW - 1, x + xOffset)) \quad \text{(G-328)}$$
$$yRef = yRefScale * max(0, min(refH / yRefScale - 1, y + yOffset)) + yRefAdd \quad \text{(G-329)}$$

2. The sample refSampleArray[x, y] is derived by

$$refSampleArray[x, y] = refLayerPicSamples[xRef, yRef] \quad \text{(G-330)}$$

3. The transform block identification refTransBlkIdc[x, y] is derived by invoking the derivation process for reference layer transform block identifications as specified in subclause G.8.6.3.2.1 with the reference layer

sample location (xRef, yRef), chromaFlag, refMbW, refMbH, refLayerFieldMbFlag, and refLayerCTrafo as the inputs and assigning the output to refTransBlkIdc[x, y].

G.8.6.3.2.1 Derivation process for reference layer transform block identifications

Inputs to this process are

– a reference layer sample location (xRef, yRef) relative to the upper-left sample of the considered colour component of the reference layer picture,

– a variable chromaFlag specifying whether the luma or a chroma component is subject to the resampling process,

– two variables refMbW and refMbH specifying the width and height, respectively, of a reference layer macroblock for the considered colour component,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerCTrafo with RefLayerPicSizeInMbs elements specifying the luma transform types for the macroblocks of the reference layer representation.

Output of this process is a variable refTransBlkIdc specifying an identification for the reference layer transform block that contains the sample at location (xRef, yRef).

The reference layer macroblock address refMbAddr and the reference layer sample location (xM, yM) inside the reference layer macroblock are derived as follows.

– If RefLayerMbaffFrameFlag is equal to 0, the variable refMbAddr and the sample location (xM, yM) are derived by

$$refMbAddr = (yRef / refMbH) * RefLayerPicWidthInMbs + (xRef / refMbW) \quad (G\text{-}331)$$
$$xM = xRef \% refMbW \quad (G\text{-}332)$$
$$yM = yRef \% refMbH \quad (G\text{-}333)$$

– Otherwise (RefLayerMbaffFrameFlag is equal to 1), the variable refMbAddr is derived as specified in the following ordered steps.

1. A variable refMbAddrTop and the horizontal sample location xM are derived by

$$refMbAddrTop = 2 * ((yRef / (2 * refMbH)) * RefLayerPicWidthInMbs + (xRef / refMbW)) \quad (G\text{-}334)$$
$$xM = xRef \% refMbW \quad (G\text{-}335)$$

2. Depending on refLayerFieldMbFlag[refMbAddrTop], the variable refMbAddr and the vertical sample location yM are derived as follows.

   – If refLayerFieldMbFlag[refMbAddrTop] is equal to 0, the variables refMbAddr and yM are derived by

$$refMbAddr = refMbAddrTop + (yRef \% (2 * refMbH)) / refMbH \quad (G\text{-}336)$$
$$yM = yRef \% refMbH \quad (G\text{-}337)$$

   – Otherwise (refLayerFieldMbFlag[refMbAddrTop] is equal to 1), the variables refMbAddr and yM are derived by

$$refMbAddr = refMbAddrTop + (yRef \% 2) \quad (G\text{-}338)$$
$$yM = (yRef \% (2 * refMbH)) >> 1 \quad (G\text{-}339)$$

Depending on chromaFlag, RefLayerChromaArrayType, and refLayerCTrafo[refMbAddr], the following applies.

– If (chromaFlag is equal to 0 or RefLayerChromaArrayType is equal to 3) and refLayerCTrafo[refMbAddr] is equal to T_8x8, the variable refTransBlkIdc is derived by

$$refTransBlkIdc = 1 + 2 * (4 * refMbAddr + 2 * (yM / 8) + (xM / 8)) \quad (G\text{-}340)$$

– Otherwise ((chromaFlag is equal to 1 and RefLayerChromaArrayType is not equal to 3) or refLayerCTrafo[refMbAddr] is not equal to T_8x8), the variable refTransBlkIdc is derived by

$$refTransBlkIdc = 2 * (16 * refMbAddr + 4 * (yM / 4) + (xM / 4)) \quad (G\text{-}341)$$

G.8.6.3.3 Interpolation process for residual prediction

Inputs to this process are

- a variable chromaFlag specifying whether the luma or a chroma component is subject to the resampling process,
- two variables mbW and mbH specifying the width and height, respectively, of a macroblock for the considered colour component,
- a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,
- a variable botFieldFlag specifying whether a top or a bottom field is subject to the resampling process (when RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0),
- a variable fldPrdInFrmMbFlag specifying whether field prediction for a frame macroblock is applied,
- a variable yBorder specifying the vertical border for the output sample array predSamples,
- two variables refArrayW and refArrayH specifying the width and height, respectively, of the array of reference layer sample values and the array of transform block identifications,
- a (refArrayW)x(refArrayH) array refSampleArray of reference layer sample values,
- a (refArrayW)x(refArrayH) array refTransBlkIdc of transform block identifications,
- two variables xOffset and yOffset specifying the x and y coordinate, respectively, of the reference layer sample location that corresponds to the sample refSampleArray[0, 0] of the array refSampleArray and the transform block identification refTransBlkIdc[0, 0] of the array refTransBlkIdc.

Output of this process is an (mbW)x(mbH / (1 + fldPrdInFrmMbFlag) + 2 * yBorder) array predArray of interpolated sample values.

Each sample predArray[x, y] with x = 0..(mbW – 1) and y = 0..(mbH / (1 + fldPrdInFrmMbFlag) + 2 *yBorder – 1) is derived as specified in the following ordered steps.

1. The variable yP is derived by

$$yP = y * (1 + fldPrdInFrmMbFlag) – yBorder + botFieldFlag \quad \text{(G-342)}$$

2. The derivation process for reference layer sample locations in resampling as specified in subclause G.6.3 is invoked with chromaFlag, the sample location (x, yP), fieldMbFlag, and botFieldFlag as the inputs and the output is the sample location (xRef16, yRef16) in units of 1/16-th sample.

3. The variables xRef, yRef, xPhase, and yPhase are derived by

$$xRef = (xRef16 >> 4) – xOffset \quad \text{(G-343)}$$
$$yRef = (yRef16 >> 4) – yOffset \quad \text{(G-344)}$$
$$xPhase = (xRef16 + 16) \% 16 \quad \text{(G-345)}$$
$$yPhase = (yRef16 + 16) \% 16 \quad \text{(G-346)}$$

4. Let tempPred by a one-dimensional array with 2 elements. Each sample value tempPred[dY] with dY = 0..1 is derived as follows.

   – If refTransBlkIdc[xRef, yRef + dY] is equal to refTransBlkIdc[xRef + 1, yRef + dY], the sample value tempPred[dY] is derived by

$$tempPred[dY] = (16 – xPhase) * refSampleArray[xRef, yRef + dY] + xPhase * refSampleArray[xRef + 1, yRef + dY] \quad \text{(G-347)}$$

   – Otherwise (refTransBlkIdc[xRef, yRef + dY] is not equal to refTransBlkIdc[xRef + 1, yRef + dY]), the sample value tempPred[dY] is derived by

$$tempPred[dY] = ((xPhase < 8) \ ? \ refSampleArray[xRef, yRef + dY] \ : \ refSampleArray[xRef + 1, yRef + dY]) \quad \text{(G-348)}$$

5. The sample value predArray[x, y] is derived as follows.

   – If refTransBlkIdc[xRef, yRef] is equal to refTransBlkIdc[xRef, yRef + 1], the sample value predArray[x, y] is derived by

$$predArray[x, y] = ((16 – yPhase) * tempPred[0] + yPhase * tempPred[1] + 128) >> 8 \quad \text{(G-349)}$$

– Otherwise (refTransBlkIdc[xRef, yRef] is not equal to refTransBlkIdc[xRef, yRef + 1]), the sample value predArray[x, y] is derived by

$$predArray[dY] = (((yPhase < 8) \ ? \ tempPred[0] \ : \ tempPred[1]) + 8) >> 4 \quad \text{(G-350)}$$

G.8.6.3.4 Vertical interpolation process for residual prediction

Inputs to this process are

– two variables mbW and mbH specifying the width and height, respectively, of a macroblock for the considered colour component,

– a variable botFieldFlag specifying whether the sample array fieldPredArray contains interpolated samples for the top or bottom field,

– a variable yBorder specifying the vertical border for the sample array fieldPredArray,

– an (mbW)x(mbH / 2 + 2 * yBorder) array fieldPredArray of sample values.

Output of this process is an (mbW)x(mbH) array predArray of interpolated sample values.

Each sample predArray[x, y] with x = 0..(mbW – 1) and y = 0..(mbH – 1) is derived as follows.

– If (y % 2) is equal to botFieldFlag, the sample value predArray[x, y] is derived by

$$predArray[x, y] = fieldPredArray[x, (y >> 1) + yBorder] \quad \text{(G-351)}$$

– Otherwise ((y % 2) is not equal to botFieldFlag), the sample value predArray[x, y] is derived by

$$predArray[x, y] = (fieldPredArray[x, (y >> 1) + yBorder – botFieldFlag] + fieldPredArray[x, (y >> 1) + yBorder – botFieldFlag + 1] + 1) >> 1 \quad \text{(G-352)}$$

G.8.7 SVC deblocking filter processes

Subclause G.8.7.1 specifies the deblocking filter process for Intra_Base prediction

Subclause G.8.7.2 specifies the deblocking filter process for target slices

G.8.7.1 Deblocking filter process for Intra_Base prediction

Inputs to the process are

– the variable dependencyIdRefLayer

– the collective term currentVars

Output of this process is a modified version of currentVars.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the layer representation with DQId equal to (dependencyIdRefLayer << 4).

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

The derivation process for quantisation parameters used in the deblocking filter process as specified in subclause G.8.7.3 is invoked with mbType, tQP_Y, and tCoeffLevel as the inputs and the outputs are a list $qpDB_Y$ specifying luma quantisation parameter that are used in the deblocking filter process and, when ChromaArrayType is not equal to 0, two lists $qpDB_{Cb}$ and $qpDB_{Cr}$ specifying chroma quantisation parameters that are used in the deblocking filter process.

Let disableDeblockingFilterIdc, filterOffsetA, and filterOffsetB be equal to the value of disable_inter_layer_deblocking_filter_idc, InterlayerFilterOffsetA, and InterlayerFilterOffsetB, respectively, for the layer representation with DQId equal to (dependency_id << 4).

For the current macroblock address CurrMbAddr proceeding over values 0..(PicSizeInMbs – 1), the following applies.

– The macroblock deblocking filter process as specified in subclause G.8.7.4 is invoked with interLayerDeblockingFlag = 1, disableDeblockingFilterIdc, filterOffsetA, filterOffsetB, sliceBoundariesOnlyFlag = 0, currentVars, $qpDB_Y$ and, when ChromaArrayType is not equal to 0, $qpDB_{Cb}$ and $qpDB_{Cr}$ as the inputs and the output is a modified version of currentVars.

When disable_deblocking_filter_idc is equal to 3 or 6, for the current macroblock address CurrMbAddr proceeding over values 0..(PicSizeInMbs – 1), the following applies.

– The macroblock deblocking filter process as specified in subclause G.8.7.4 is invoked with interLayerDeblockingFlag = 1, disableDeblockingFilterIdc, filterOffsetA, filterOffsetB, sliceBoundariesOnlyFlag = 1, currentVars, $qpDB_Y$ and, when ChromaArrayType is not equal to 0, $qpDB_{Cb}$ and $qpDB_{Cr}$ as the inputs and the output is a modified version of currentVars.

G.8.7.2 Deblocking filter process for target representations

Input to the process is the collective term currentVars

Output of this process are decoded samples represented by the sample arrays S_L, and, when ChromaArrayType is not equal to 0, S_{Cb} and S_{Cr}.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the layer representation with DQId equal to (dependencyId << 4).

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

The derivation process for quantisation parameters used in the deblocking filter process as specified in subclause G.8.7.3 is invoked with mbType, tQP_Y, and tCoeffLevel as the inputs and the outputs are a list $qpDB_Y$ specifying luma quantisation parameter that are used in the deblocking filter process and, when ChromaArrayType is not equal to 0, two lists $qpDB_{Cb}$ and $qpDB_{Cr}$ specifying chroma quantisation parameters that are used in the deblocking filter process.

For the current macroblock address CurrMbAddr proceeding over values 0..(PicSizeInMbs – 1), the following applies.

– Let disableDeblockingFilterIdc, filterOffsetA, and filterOffsetB be equal to the value of disable_deblocking_filter_idc, FilterOffsetA, and FilterOffsetB, respectively, for the slice with DQId equal to (sliceIdc[CurrMbAddr] & 127) and first_mb_in_slice equal to (sliceIdc[CurrMbAddr] >> 7).

– The macroblock deblocking filter process as specified in subclause G.8.7.4 is invoked with interLayerDeblockingFlag = 0, disableDeblockingFilterIdc, filterOffsetA, filterOffsetB, sliceBoundariesOnlyFlag = 0, currentVars, $qpDB_Y$ and, when ChromaArrayType is not equal to 0, $qpDB_{Cb}$ and $qpDB_{Cr}$ as the inputs and the output is a modified version of currentVars.

When disable_deblocking_filter_idc is equal to 3 or 6, for the current macroblock address CurrMbAddr proceeding over values 0..(PicSizeInMbs – 1), the following applies.

– Let disableDeblockingFilterIdc, filterOffsetA, and filterOffsetB be equal to the value of disable_deblocking_filter_idc, FilterOffsetA, and FilterOffsetB, respectively, for the slice with DQId equal to (sliceIdc[CurrMbAddr] & 127) and first_mb_in_slice equal to (sliceIdc[CurrMbAddr] >> 7).

– The macroblock deblocking filter process as specified in subclause G.8.7.4 is invoked with interLayerDeblockingFlag = 0, disableDeblockingFilterIdc, filterOffsetA, filterOffsetB, sliceBoundariesOnlyFlag = 1, currentVars, $qpDB_Y$ and, when ChromaArrayType is not equal to 0, $qpDB_{Cb}$ and $qpDB_{Cr}$ as inputs and the output is a modified version of currentVars.

G.8.7.3 Derivation process for quantisation parameters used in the deblocking filter process

Inputs to this process are

– a one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current decoded or partly decoded dependency representation,

– a one-dimensional array tQP_Y with PicSizeInMbs elements specifying luma quantisation parameters for the macroblocks of the current decoded or partly decoded dependency representation,

– a (PicSizeInMbs)x(256 + 2 * MbWidthC * MbHeightC) array tCoeffLevel specifying transform coefficient level values for the macroblocks of the current decoded or partly decoded dependency representation.

Outputs of this process are

– a one-dimensional array $qpDB_Y$ with PicSizeInMbs elements specifying luma quantisation parameters used in the deblocking filter process for the macroblocks of the current decoded or partly decoded dependency representation,

– when ChromaArrayType is not equal to 0, two one-dimensional arrays $qpDB_{Cb}$ and $qpDB_{Cr}$ with PicSizeInMbs elements specifying chroma quantisation parameters used in the deblocking filter process for the macroblocks of the current decoded or partly decoded dependency representation.

The macroblock address mbAddr proceeds over the values 0..(PicSizeInMbs – 1), and for each value of mbAddr, the following ordered steps are specified.

1. The variable $qpDB_Y$[mbAddr] is derived as follows.
   - If mbType[mbAddr] is equal to I_PCM, $qpDB_Y$[mbAddr] is set equal to 0.
   - Otherwise, if tcoeff_level_prediction_flag is equal to 1, mbAddr is greater than 0, mbType[mbAddr] is not equal to I_16x16, and all elements tCoeffLevel[mbAddr][i] with i = 0..(255 + 2 * MbWidthC * MbHeightC) are equal to 0, $qpDB_Y$[mbAddr] is set equal to $qpDB_Y$[mbAddr – 1].
   - Otherwise, $qpDB_Y$[mbAddr] is set equal to tQP_Y[mbAddr].
2. When ChromaArrayType is not equal to 0, for C being replaced by Cb and Cr, the variable $qpDB_C$[mbAddr] is set equal to the value of QP_C that corresponds to a value of $qpDB_Y$[mbAddr] for QP_Y as specified in subclause 8.5.8. During this invocation of the process in subclause 8.5.8, the syntax elements chroma_qp_index_offset and second_chroma_qp_index_offset of the layer representation with DQId equal to DQIdMax are used.

G.8.7.4 Macroblock deblocking filter process

Inputs to this process are

- the variables interLayerDeblockingFlag, disableDeblockingFilterIdc, filterOffsetA, filterOffsetB, and sliceBoundariesOnlyFlag,
- the collective term currentVars,
- a one-dimensional array $qpDB_Y$ with PicSizeInMbs elements specifying luma quantisation parameters used in the deblocking filter process for the macroblocks of the current decoded or partly decoded dependency representation,
- when ChromaArrayType is not equal to 0, two one-dimensional arrays $qpDB_{Cb}$ and $qpDB_{Cr}$ with PicSizeInMbs elements specifying chroma quantisation parameters used in the deblocking filter process for the macroblocks of the current decoded or partly decoded dependency representation.

Output of this process is a modified version of currentVars

In the following of this subclause, the variables sliceIdc, fieldMbFlag, baseModeFlag, mbType, lumaTrafo, subMbType, ipred4x4, ipred8x8, ipred16x16, ipredChroma, refIdxL0, refIdxL1, predFlagL0, predFlagL1. mvL0, mvL1, mvCnt, sTCoeff, tCoeffLevel, tQP_Y, tQP_{Cb}, tQP_{Cr}, rS_L, rS_{Cb}, rS_{Cr}, cS_L, cS_{Cb}, and cS_{Cr} of the collective term currentVars are referred to as sliceIdc, fieldMbFlag, baseModeFlag, mbType, lumaTrafo, subMbType, ipred4x4, ipred8x8, ipred16x16, ipredChroma, refIdxL0, refIdxL1, predFlagL0, predFlagL1, mvL0, mvL1, mvCnt, sTCoeff, tCoeffLevel, tQP_Y, tQP_{Cb}, tQP_{Cr}, rS_L, rS_{Cb}, rS_{Cr}, cS_L, cS_{Cb}, and cS_{Cr}, respectively.

The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB. For this invocation of the process in subclause 6.4.10.1, the current macroblock is treated as field macroblock when fieldMbFlag[CurrMbAddr] is equal to 1, and it is treated as frame macroblock when fieldMbFlag[CurrMbAddr] is equal to 0.

NOTE – The availability status of the macroblocks mbAddrA and mbAddrB is not used inside this subclause. Slice boundaries are detected using the array sliceIdc.

The variable filterLeftLumaMbEdgeFlag is derived as follows.

- If any of the following conditions is true, the variable filterLeftLumaMbEdgeFlag is set equal to 0.
  - MbaffFrameFlag is equal to 0 and CurrMbAddr % PicWidthInMbs is equal to 0
  - MbaffFrameFlag is equal to 1 and (CurrMbAddr >> 1) % PicWidthInMbs is equal to 0
  - disableDeblockingFilterIdc is equal to 1
  - disableDeblockingFilterIdc is equal to 2 or 5 and sliceIdc[mbAddrA] is different than sliceIdc[CurrMbAddr]
  - disableDeblockingFilterIdc is equal to 3 or 6, sliceBoundariesOnlyFlag is equal to 0, and sliceIdc[mbAddrA] is different than sliceIdc[CurrMbAddr]
  - disableDeblockingFilterIdc is equal to 3 or 6, sliceBoundariesOnlyFlag is equal to 1, and sliceIdc[mbAddrA] is equal to sliceIdc[CurrMbAddr]

  - interLayerDeblockingFlag is equal to 1 and mbType[CurrMbAddr] specifies an Inter macroblock prediction mode
  - interLayerDeblockingFlag is equal to 1 and mbType[mbAddrA] specifies an Inter macroblock prediction mode
- Otherwise, the variable filterLeftLumaMbEdgeFlag is set equal to 1.

The variable filterTopLumaMbEdgeFlag is derived as follows.

- If any of the following conditions is true, the variable filterTopLumaMbEdgeFlag is set equal to 0.
  - MbaffFrameFlag is equal to 0 and CurrMbAddr is less than PicWidthInMbs
  - MbaffFrameFlag is equal to 1, (CurrMbAddr >> 1) is less than PicWidthInMbs, and fieldMbFlag[CurrMbAddr] is equal to 1
  - MbaffFrameFlag is equal to 1, (CurrMbAddr >> 1) is less than PicWidthInMbs, fieldMbFlag[CurrMbAddr] is equal to 0, and CurrMbAddr % 2 is equal to 0
  - disableDeblockingFilterIdc is equal to 1
  - disableDeblockingFilterIdc is equal to 2 or 5 and sliceIdc[mbAddrB] is different than sliceIdc[CurrMbAddr]
  - disableDeblockingFilterIdc is equal to 3 or 6, sliceBoundariesOnlyFlag is equal to 0, and sliceIdc[mbAddrB] is different than sliceIdc[CurrMbAddr]
  - disableDeblockingFilterIdc is equal to 3 or 6, sliceBoundariesOnlyFlag is equal to 1, and sliceIdc[mbAddrB] is equal to sliceIdc[CurrMbAddr]
  - interLayerDeblockingFlag is equal to 1 and mbType[CurrMbAddr] specifies an Inter macroblock prediction mode
  - interLayerDeblockingFlag is equal to 1 and mbType[mbAddrB] specifies an Inter macroblock prediction mode
- Otherwise, the variable filterTopLumaMbEdgeFlag is set equal to 1.

The variable filterInternalLumaEdgesFlag is derived as follows.

- If any of the following conditions is true, the variable filterInternalLumaEdgesFlag is set equal to 0.
  - disableDeblockingFilterIdc is equal to 1
  - disableDeblockingFilterIdc is equal to 3 or 6 and sliceBoundariesOnlyFlag is equal to 1
  - interLayerDeblockingFlag is equal to 1 mbType[CurrMbAddr] specifies an Inter macroblock prediction mode
- Otherwise the variable filterInternalLumaEdgesFlag is set equal to 1.

The variables filterLeftChromaMbEdgeFlag, filterTopChromaMbEdgeFlag, and filterInternalChromaEdgesFlag are derived as follows.

- If disableDeblockingFilterIdc is greater than 3, filterLeftChromaMbEdgeFlag, filterTopChromaMbEdgeFlag, and filterInternalChromaEdgesFlag are set equal to 0.
- Otherwise (disableDeblockingFilterIdc is less than 4), filterLeftChromaMbEdgeFlag, filterTopChromaMbEdgeFlag, and filterInternalChromaEdgesFlag are set equal to filterLeftLumaMbEdgeFlag, filterTopLumaMbEdgeFlag, and filterInternalLumaEdgesFlag, respectively.

The variable fieldModeMbFlag is derived as follows.

- If any of the following conditions is true, fieldModeMbFlag is set equal to 1.
  - field_pic_flag is equal to 1
  - MbaffFrameFlag is equal to 1 and fieldMbFlag[CurrMbAddr] is equal to 1
- Otherwise, fieldModeMbFlag is set equal to 0.

When filterLeftLumaMbEdgeFlag is equal to 1, the filtering of the left vertical luma edge is specified as follows.

– The process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 0, verticalEdgeFlag set equal to 1, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_Y$[mbAddrA], qP_q set equal to $qpDB_Y$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (0, k) with k = 0..15, and cS_L as inputs and cS_L as output.

When filterInternalLumaEdgesFlag is equal to 1, the filtering of the internal vertical luma edges is specified as follows.

– When lumaTrafo[CurrMbAddr] is not equal to T_8x8, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 0, verticalEdgeFlag set equal to 1, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_Y$[CurrMbAddr], qP_q set equal to $qpDB_Y$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (4, k) with k = 0..15, and cS_L as inputs and cS_L as output.

– The process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 0, verticalEdgeFlag set equal to 1, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_Y$[CurrMbAddr], qP_q set equal to $qpDB_Y$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (8, k) with k = 0..15, and cS_L as inputs and cS_L as output.

– When lumaTrafo[CurrMbAddr] is not equal to T_8x8, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 0, verticalEdgeFlag set equal to 1, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_Y$[CurrMbAddr], qP_q set equal to $qpDB_Y$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (12, k) with k = 0..15, and cS_L as inputs and cS_L as output.

When filterTopLumaMbEdgeFlag is equal to 1, the filtering of the top horizontal luma edge is specified as follows.

– If MbaffFrameFlag is equal to 1, (CurrMbAddr % 2) is equal to 0, CurrMbAddr is greater than or equal to (2 * PicWidthInMbs), fieldMbFlag[CurrMbAddr] is equal to 0, and fieldMbFlag[CurrMbAddr - 2 * PicWidthInMbs + 1] is equal to 1, the following applies.

  – The process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 0, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to 1, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_Y$[CurrMbAddr - 2 * PicWidthInMbs], qP_q set equal to $qpDB_Y$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 0) with k = 0..15, and cS_L as inputs and cS_L as output.

  – The process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 0, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to 1, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_Y$[CurrMbAddr - 2 * PicWidthInMbs + 1], qP_q set equal to $qpDB_Y$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 1) with k = 0..15, and cS_L as inputs and cS_L as output.

– Otherwise, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 0, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_Y$[mbAddrB], qP_q set equal to $qpDB_Y$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 0) with k = 0..15, and cS_L as inputs and cS_L as output.

When filterInternalLumaEdgesFlag is equal to 1, the filtering of the internal horizontal luma edges is specified as follows.

– When lumaTrafo[CurrMbAddr] is not equal to T_8x8, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 0, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_Y$[CurrMbAddr], qP_q set equal to $qpDB_Y$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 4) with k = 0..15, and cS_L as inputs and cS_L as output.

– The process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 0, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_Y$[CurrMbAddr], qP_q set equal to $qpDB_Y$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 8) with k = 0..15, and cS_L as inputs and cS_L as output.

– When lumaTrafo[CurrMbAddr] is not equal to T_8x8, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 0, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_Y$[CurrMbAddr], qP_q set equal to $qpDB_Y$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 12) with k = 0..15, and cS_L as inputs and cS_L as output.

When ChromaArrayType is not equal to 0, for the filtering of both chroma components with C being replaced by Cb and Cr in $qpDB_C$ and cS_C, the following applies.

– When filterLeftChromaMbEdgeFlag is equal to 1, the filtering of the left vertical chroma edge is specified as follows.

  – The process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 1, verticalEdgeFlag set equal to 1, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_C$[mbAddrA], qP_q set equal to $qpDB_C$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (0, k) with k = 0..(MbHeightC – 1), and cS_C as inputs and cS_C as output.

– When filterInternalChromaEdgesFlag is equal to 1, the filtering of the internal vertical chroma edge is specified as follows.

  – When ChromaArrayType is not equal to 3 or transform_size_8x8_flag is equal to 0, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 1, verticalEdgeFlag set equal to 1, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_C$[CurrMbAddr], qP_q set equal to $qpDB_C$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (4, k) with k = 0..(MbHeightC – 1), and cS_C as inputs and cS_C as output.

  – When ChromaArrayType is equal to 3, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 1, verticalEdgeFlag set equal to 1, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_C$[CurrMbAddr], qP_q set equal to $qpDB_C$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (8, k) with k = 0..(MbHeightC – 1), and cS_C as inputs and cS_C as output.

  – When ChromaArrayType is equal to 3, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 1, verticalEdgeFlag set equal to 1, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_C$[CurrMbAddr], qP_q set equal to $qpDB_C$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (12, k) with k = 0..(MbHeightC – 1), and cS_C as inputs and cS_C as output.

– When filterTopChromaMbEdgeFlag is equal to 1, the filtering of the top horizontal chroma edge is specified as follows.

  – If MbaffFrameFlag is equal to 1, (CurrMbAddr % 2) is equal to 0, CurrMbAddr is greater than or equal to (2 * PicWidthInMbs), fieldMbFlag[CurrMbAddr] is equal to 0, fieldMbFlag[CurrMbAddr - 2 * PicWidthInMbs + 1] is equal to 1, the following applies.

    – The process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 1, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to 1, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_C$[CurrMbAddr – 2 * PicWidthInMbs], qP_q set equal to $qpDB_C$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 0) with k = 0..(MbWidthC – 1), and cS_C as inputs and cS_C as output.

    – The process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 1, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to 1, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_C$[CurrMbAddr – 2 * PicWidthInMbs + 1], qP_q set equal to $qpDB_C$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 1) with k = 0..(MbWidthC – 1), and cS_C as inputs and cS_C as output.

  – Otherwise, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 1, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_C$[mbAddrB], qP_q set equal to $qpDB_C$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 0) with k = 0..(MbWidthC – 1), and cS_C as inputs and cS_C as output.

– When filterInternalChromaEdgesFlag is equal to 1, the filtering of the internal horizontal chroma edge is specified as follows.

  – When ChromaArrayType is not equal to 3 or transform_size_8x8_flag is equal to 0, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 1, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_C$[CurrMbAddr], qP_q set equal to $qpDB_C$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 4) with k = 0..(MbWidthC – 1), and cS_C as inputs and cS_C as output.

  – When ChromaArrayType is not equal to 1, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 1, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_C$[CurrMbAddr], qP_q set equal to

$qpDB_C$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 8) with k = 0..(MbWidthC – 1), and cS_C as inputs and cS_C as output.

– When ChromaArrayType is equal to 2, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 1, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_C$[CurrMbAddr], qP_q set equal to $qpDB_C$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 12) with k = 0..(MbWidthC – 1), and cS_C as inputs and cS_C as output.

– When ChromaArrayType is equal to 3 or transform_size_8x8_flag is equal to 0, the process specified in subclause G.8.7.4.1 is invoked with chromaEdgeFlag set equal to 1, verticalEdgeFlag set equal to 0, fieldModeFilteringFlag set equal to fieldModeMbFlag, filterOffsetA, filterOffsetB, qP_p set equal to $qpDB_C$[CurrMbAddr], qP_q set equal to $qpDB_C$[CurrMbAddr], currentVars, (xE_k, yE_k) set equal to (k, 12) with k = 0..(MbWidthC – 1), and cS_C as inputs and cS_C as output.

NOTE 1 – When field mode filtering (fieldModeFilteringFlag is equal to 1) is applied across the top horizontal edges of a frame macroblock, this vertical filtering across the top or bottom macroblock boundary may involve some samples that extend across an internal block edge that is also filtered internally in frame mode.

NOTE 2 – For example, in 4:2:0 chroma format when transform_size_8x8_flag is equal to 0, the following applies. 3 horizontal luma edges, 1 horizontal chroma edge for Cb, and 1 horizontal chroma edge for Cr are filtered that are internal to a macroblock. When field mode filtering (fieldModeFilteringFlag is equal to 1) is applied to the top edges of a frame macroblock, 2 horizontal luma, 2 horizontal chroma edges for Cb, and 2 horizontal chroma edges for Cr between the frame macroblock and the above macroblock pair are filtered using field mode filtering, for a total of up to 5 horizontal luma edges, 3 horizontal chroma edges for Cb, and 3 horizontal chroma edges for Cr filtered that are considered to be controlled by the frame macroblock. In all other cases, at most 4 horizontal luma, 2 horizontal chroma edges for Cb, and 2 horizontal chroma edges for Cr are filtered that are considered to be controlled by a particular macroblock.

G.8.7.4.1 SVC filtering process for block edges

Inputs to this process are

– the variable chromaEdgeFlag,

– the variable verticalEdgeFlag,

– the variable fieldModeFilteringFlag,

– the variables filterOffsetA and filterOffsetB,

– the variables qP_p and qP_q,

– the collective term currentVars,

– a set of nE sample locations (xE_k, yE_k), with k = 0..(nE – 1), expressed relative to the upper left corner of the macroblock CurrMbAddr. The set of sample locations (xE_k, yE_k) represent the sample locations immediately to the right of a vertical edge (when verticalEdgeFlag is equal to 1) or immediately below a horizontal edge (when verticalEdgeFlag is equal to 0),

– an array of samples s'.

Output of this process is a modified version of the array s'.

The variable nE is derived as follows

– If chromaEdgeFlag is equal to 0, nE is set equal to 16.

– Otherwise (chromaEdgeFlag is equal to 1), nE is set equal to ((verticalEdgeFlag = = 1) ? MbHeightC : MbWidthC).

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

The variable dy is derived as follows.

– If fieldModeFilteringFlag is equal to 1 and MbaffFrameFlag is equal to 1, dy is set equal to 2.

– Otherwise (fieldModeFilteringFlag is equal to 0 or MbaffFrameFlag is equal to 0), dy is set equal to 1.

The position of the upper-left luma sample of the macroblock CurrMbAddr is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddr = CurrMbAddr as input and the output being assigned to (xI, yI). During the process in subclause 6.4.1, the current macroblock is treated as field macroblock when

fieldMbFlag[CurrMbAddr] is equal to 1, and it is treated as frame macroblock when fieldMbFlag[CurrMbAddr] is equal to 0.

The variables xP and yP are derived as follows.

– If chromaEdgeFlag is equal to 0, xP is set equal to xI and yP is set equal to yI.

– Otherwise (chromaEdgeFlag is equal to 1), xP is set equal to (xI / SubWidthC) and yP is set equal to ((yI + SubHeightC – 1) / SubHeightC).

For each sample location (xE_k, yE_k), k = 0..(nE – 1), the following applies.

– The filtering process is applied to a set of eight samples across a 4x4 block horizontal or vertical edge denoted as p_i and q_i with i = 0..3 as shown in Figure 8-11 with the edge lying between p_0 and q_0. p_i and q_i with i = 0..3 are specified as follows.

  – If verticalEdgeFlag is equal to 1,

$$q_i = s'[\ xP + xE_k + i,\ yP + dy * yE_k\ ] \quad \text{(G-353)}$$
$$p_i = s'[\ xP + xE_k – i – 1,\ yP + dy * yE_k\ ] \quad \text{(G-354)}$$

  – Otherwise (verticalEdgeFlag is equal to 0),

$$q_i = s'[\ xP + xE_k,\ yP + dy * (yE_k + i) – (yE_k \% 2)\ ] \quad \text{(G-355)}$$
$$p_i = s'[\ xP + xE_k,\ yP + dy * (yE_k – i – 1) – (yE_k \% 2)\ ] \quad \text{(G-356)}$$

– The process specified in subclause G.8.7.4.2 is invoked with the sample values p_i and q_i (i = 0..3), chromaEdgeFlag, verticalEdgeFlag, fieldModeFilteringFlag, filterOffsetA, filterOffsetB, qP_p, qP_q, sliceIdc, fieldMbFlag, mbType, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, sTCoeff, and rS_L as inputs, and the output is assigned to the filtered result sample values p'_i and q'_i with i = 0..2.

– The input sample values p_i and q_i with i = 0..2 are replaced by the corresponding filtered result sample values p'_i and q'_i with i = 0..2 inside the sample array s' as follows.

  – If verticalEdgeFlag is equal to 1,

$$s'[\ xP + xE_k + i,\ yP + dy * yE_k\ ] = q'_i \quad \text{(G-357)}$$
$$s'[\ xP + xE_k – i – 1,\ yP + dy * yE_k\ ] = p'_i \quad \text{(G-358)}$$

  – Otherwise (verticalEdgeFlag is equal to 0),

$$s'[\ xP + xE_k,\ yP + dy * (yE_k + i) – (yE_k \% 2)\ ] = q'_i \quad \text{(G-359)}$$
$$s'[\ xP + xE_k,\ yP + dy * (yE_k – i – 1) – (yE_k \% 2)\ ] = p'_i \quad \text{(G-360)}$$

G.8.7.4.2 SVC filtering process for a set of samples across a horizontal or vertical block edge

Inputs to this process are

– the input sample values p_i and q_i with i = 0..3 of a single set of samples across an edge that is to be filtered,

– the variable chromaEdgeFlag,

– the variable verticalEdgeFlag,

– the variable fieldModeFilteringFlag,

– the variables filterOffsetA and filterOffsetB,

– the variables qP_p and qP_q,

– the arrays sliceIdc, fieldMbFlag, mbType, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, and sTCoeff,

– an array rS_L containing residual sample values.

Outputs of this process are the filtered result sample values p'_i and q'_i with i in the range of 0..2.

The content dependent boundary filtering strength variable bS is derived as follows.

– If chromaEdgeFlag is equal to 0, the SVC derivation process for the luma content dependent boundary filtering strength specified in subclause G.8.7.4.3 is invoked with p_0, q_0, verticalEdgeFlag, sliceIdc, fieldMbFlag, mbType, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, sTCoeff, and rS_L as inputs, and the output is assigned to bS.

– Otherwise (chromaEdgeFlag is equal to 1), the bS used for filtering a set of samples of a horizontal or vertical chroma edge is set equal to the value of bS for filtering the set of samples of a horizontal or vertical luma edge, respectively, that contains the luma sample at location (SubWidthC * x, SubHeightC * y) inside the luma array of the same field, where (x, y) is the location of the chroma sample q_0 inside the chroma array for that field.

The process specified in subclause 8.7.2.2 is invoked with p_0, q_0, p_1, q_1, chromaEdgeFlag, bS, filterOffsetA, filterOffsetB, qP_p, and qP_q as inputs, and the output is assigned to filterSamplesFlag, indexA, α, and β.

Depending on the variable filterSamplesFlag, the following applies.

– If filterSamplesFlag is equal to 1, the following applies.

  – If bS is less than 4, the process specified in subclause 8.7.2.3 is invoked with p_i and q_i (i = 0..2), chromaEdgeFlag, bS, β, and indexA given as input, and the output is assigned to p'_i and q'_i (i = 0..2).

  – Otherwise (bS is equal to 4), the process specified in subclause 8.7.2.4 is invoked with p_i and q_i (i = 0..3), chromaEdgeFlag, α, and β given as input, and the output is assigned to p'_i and q'_i (i = 0..2).

– Otherwise (filterSamplesFlag is equal to 0), the filtered result samples p'_i and q'_i (i = 0..2) are replaced by the corresponding input samples p_i and q_i:

$$\text{for } i = 0..2, \quad p'_i = p_i \tag{G-361}$$
$$\text{for } i = 0..2, \quad q'_i = q_i \tag{G-362}$$

G.8.7.4.3 SVC derivation process for the luma content dependent boundary filtering strength

Inputs to this process are

– the input sample values p_0 and q_0 of a single set of samples across an edge that is to be filtered,

– the variable verticalEdgeFlag,

– the arrays sliceIdc, fieldMbFlag, mbType, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, and sTCoeff,

– the array rS_L containing residual sample values.

Output of this process is the variable bS.

The following variables are derived as specified in the following:

– mbAddrP and mbAddrQ specify the macroblocks containing the samples p_0 and q_0, respectively.

– mbPartIdxP and mbPartIdxQ specify the macroblock partitions containing the samples p_0 and q_0, respectively.

– subMbPartIdxP and subMbPartIdxQ specify the sub-macroblock partitions containing the samples p_0 and q_0, respectively.

– pFLXP and pFLXQ with X being replaced by 0 and 1 are equal to predFlagLX[mbAddrP][mbPartIdxP] and predFlagLX[mbAddrQ][mbPartIdxQ], respectively.

– refLXP and refFLXQ with X being replaced by 0 and 1 are equal to refIdxLX[mbAddrP][mbPartIdxP] and refIdxLX[mbAddrQ][mbPartIdxQ], respectively.

– mvLXP and mvFLXQ with X being replaced by 0 and 1 are equal to mvLX[mbAddrP][mbPartIdxP][subMbPartP] and mvLX[mbAddrQ][mbPartIdxQ][subMbPartQ], respectively.

– numMvP and numMvQ are equal to (pFL0P + pFL1P) and (pFL0Q + pFL1Q), respectively.

– When numMvP and numMvQ are both equal to 1, the variables refX and mvX with X being replaced by P and Q are derived as follows.

  – If pFL0X is equal to 1, refX is set equal to refL0X and mvX is set equal to mvL0X.

  - Otherwise (pFL1X is equal to 1), refX is set equal to refL1X and mvX is set equal to mvL1X.

- sliceX with X being replaced by P and Q is the slice with DQId equal to (sliceIdc[mbAddrP] & 127) and first_mb_in_slice equal to (sliceIdc[mbAddrP] >> 7)

Let the variable mixedModeEdgeFlag be derived as follows.

- If MbaffFrameFlag is equal to 1 and fieldMbFlag[mbAddrP] is not equal to fieldMbFlag[mbAddrQ], mixedModeEdgeFlag is set equal to 1
- Otherwise, mixedModeEdgeFlag is set equal to 0.

The variable bS is derived as follows.

- If SpatialResolutionChangeFlag is equal to 1 and either or both mbType[mbAddrP] or mbType[mbAddrQ] is equal to I_BL, the following applies.
  - If either mbType[mbAddrP] or mbType[mbAddrQ] specifies an Intra macroblock prediction mode other than I_BL, bS is set equal to 4.
  - Otherwise, if mbType[mbAddrP] is equal to I_BL and mbType[mbAddrQ] is equal to I_BL, the following applies.
    - If the luma transform block of sliceP containing sample p_0 or the luma transform block of sliceQ containing sample q_0 contains non-zero transform coefficient levels, bS is set equal to 1.

      NOTE 1 – A luma transform block of a layer representation with dependency_id and quality_id is considered to contain non-zero transform coefficient levels, if and only if non-zero transform coefficients are transmitted in the macroblock layer for dependency_id and quality_id for the considered luma transform block. Transform coefficient levels that are transmitted in layers employed by inter-layer prediction are not taken into account.

    - Otherwise, bS is set equal to 0
  - Otherwise (either mbType[mbAddrP] or mbType[mbAddrQ] specifies an Inter macroblock prediction mode), the following applies.
    - If mbType[mbAddrP] specifies an Inter macroblock prediction type and the array rS_L contains any non-zero sample for the luma block containing sample p_0, bS is set equal to 2.
    - Otherwise, if mbType[mbAddrQ] specifies an Inter macroblock prediction type and the array rS_L contains any non-zero sample for the luma block containing sample q_0, bS is set equal to 2.

      NOTE 2 – The array rS_L contains samples for the accumulated residual signal. Transform coefficient values of layer representations that are employed for inter-layer prediction are taken into account.

    - Otherwise, bS is set equal to 1.
- Otherwise, if the block edge is also a macroblock edge and any of the following conditions is true, bS is set equal to 4.
  - fieldMbFlag[mbAddrP] is equal to 0 and fieldMbFlag[mbAddrQ] is equal to 0 and either or both mbType[mbAddrP] or mbType[mbAddrQ] specify an Intra macroblock prediction mode.
  - MbaffFrameFlag is equal to 1 or field_pic_flag is equal to 1, and verticalEdgeFlag is equal to 1, and either or both mbType[mbAddrP] or mbType[mbAddrQ] specify an Intra macroblock prediction mode.
- Otherwise, if any of the following conditions is true, bS is set equal to 3.
  - mixedModeEdgeFlag is equal to 0 and either or both mbType[mbAddrP] or mbType[mbAddrQ] specify an Intra macroblock prediction mode.
  - mixedModeEdgeFlag is equal to 1, verticalEdgeFlag is equal to 0, and either or both mbType[mbAddrP] or mbType[mbAddrQ] specify an Intra macroblock prediction mode.
- Otherwise, if any of the following conditions is true, bS is set equal to 2.
  - The array rS_L contains any non-zero sample for the luma block containing sample p_0 or the array sTCoeff[mbAddrP] contains any non-zero scaled transform coefficient value for the luma block containing sample p_0.
  - The array rS_L contains any non-zero sample for the luma block containing sample q_0 or the array sTCoeff[mbAddrQ] contains any non-zero scaled transform coefficient value for the luma block containing sample q_0.

    NOTE 3 – The array rS_L contains samples for the accumulated residual signal. Transform coefficient values of layer representations that are employed for inter-layer prediction are taken into account.

- Otherwise, if any of the following conditions is true, bS is set equal to 1.
  - mixedModeEdgeFlag is equal to 1
  - mixedModeEdgeFlag is equal to 0 and any of the following conditions is true
    - numMvP is not equal to numMvQ
    - numMvP and numMvQ are both equal to 1 and any of the following conditions is true
      - refP and refQ specify different reference pictures
      - the absolute difference between the horizontal or vertical component of the motion vectors mvP and mvQ is greater than or equal to 4 in units of quarter luma frame samples
    - numRefP and numRefQ are both equal to 2 and any of the following conditions is true
      - refL0P and refL1P specify different reference pictures and any of the following conditions is true
        - both of the following conditions are true
          - refL0P and refL0Q specify different reference pictures or refL1P and refL1Q specify different reference pictures
          - refL0P and refL1Q specify different reference pictures or refL1P and refL0Q specify different reference pictures
        - refL0P and refL0Q specifies the same reference picture, refL1P and refL1Q specify the same reference picture, and any of the following conditions is true
          - the absolute difference between the horizontal or vertical component of the motion vectors mvL0P and mvL0Q is greater than or equal to 4 in units of quarter luma frame samples
          - the absolute difference between the horizontal or vertical component of the motion vectors mvL1P and mvL1Q is greater than or equal to 4 in units of quarter luma frame samples
        - refL0P and refL1Q specifies the same reference picture, refL1P and refL0Q specify the same reference picture, and any of the following conditions is true
          - the absolute difference between the horizontal or vertical component of the motion vectors mvL0P and mvL1Q is greater than or equal to 4 in units of quarter luma frame samples
          - the absolute difference between the horizontal or vertical component of the motion vectors mvL1P and mvL0Q is greater than or equal to 4 in units of quarter luma frame samples
      - refL0P and refL1P specify the same reference picture and any of the following conditions is true
        - refL0Q or refL1Q specify a different reference picture than refL0P (or refL1P)
        - refL0Q and refL1Q specify the same reference picture as refL0P (and refL1P) and any of the following conditions is true
          - the absolute difference between the horizontal or vertical component of the motion vectors mvL0P and mvL0Q is greater than or equal to 4 in units of quarter luma frame samples
          - the absolute difference between the horizontal or vertical component of the motion vectors mvL1P and mvL1Q is greater than or equal to 4 in units of quarter luma frame samples
          - the absolute difference between the horizontal or vertical component of the motion vectors mvL0P and mvL1Q is greater than or equal to 4 in units of quarter luma frame samples
          - the absolute difference between the horizontal or vertical component of the motion vectors mvL1P and mvL0Q is greater than or equal to 4 in units of quarter luma frame samples

    NOTE 4 – The determination of whether the reference pictures used for the two macroblock/sub-macroblock partitions are the same or different is based only on which pictures are referenced, without regard to whether a prediction is formed using an index into reference picture list 0 or an index into reference picture list 1, and also without regard to whether the index position within a reference picture list is different.

    NOTE 5 – A vertical difference of 4 in units of quarter luma frame samples is a difference of 2 in units of quarter luma field samples

- Otherwise, bS is set equal to 0.

G.8.8 Specification of bitstream subsets

Subclause G.8.8.1 specifies the sub-bitstream extraction process.

Subclause G.8.8.2 specifies the base layer bitstream.

G.8.8.1 Sub-bitstream extraction process

Inputs to this process are

– a variable pIdTarget (when present),

– a variable tIdTarget (when present),

– a variable dIdTarget (when present),

– a variable qIdTarget (when present).

Output of this process is a sub-bitstream.

When pIdTarget is not present as input to this subclause, pIdTarget is inferred to be equal to 63.

When tIdTarget is not present as input to this subclause, tIdTarget is inferred to be equal to 7.

When dIdTarget is not present as input to this subclause, dIdTarget is inferred to be equal to 7.

When qIdTarget is not present as input to this subclause, qIdTarget is inferred to be equal to 15.

The sub-bitstream is derived by applying the following operations in sequential order.

1. Mark all VCL, filler prefix, and filler data NAL units for which any of the following conditions is true as "to be removed from the bit-stream".
   – priority_id is greater than pIdTarget
   – temporal_id is greater than tIdTarget
   – dependency_id is greater than dIdTarget
   – dependency_id is equal to dIdTarget and quality_id is greater than qIdTarget
2. Remove all access units for which all VCL NAL units are marked as "to be removed from the bit-stream".
3. Remove all VCL, filler prefix, and filler data NAL units that are marked as "to be removed from the bit-stream".
4. When dIdTarget is equal to 0 and qIdTarget is equal to 0, remove the following NAL units.
   – all NAL units with nal_unit_type equal to 14 or 15
   – all NAL units with nal_unit_type equal to 6 in which the first SEI message has payloadType in the range of 24 to 35, inclusive
5. Remove all NAL units with nal_unit_type equal to 6 that only contain SEI messages that are part of a scalable nesting SEI message with any of the following properties
   – sei_temporal_id is greater than tIdTarget
   – the minimum value of (sei_dependency_id[i] << 4) + sei_quality_id[i] for all i in the range of 0 to num_layer_representations_minus1, inclusive, is greater than (dIdTarget << 4) + qIdTarget

G.8.8.2 Specification of the base layer bitstream

Each scalable bitstream that conforms to this specification shall contain a base layer bitstream that conforms to one or more of the profiles specified in Annex A. This base layer bitstream is derived by invoking the sub-bitstream extraction process as specified in subclause G.8.8.1 with dIdTarget being equal to 0 and qIdTarget being equal to 0 and the base layer bitstream being the output.

G.9 Parsing process

Inputs to this process are bits from the RBSP, a request for a value of a syntax element, and values of prior parsed syntax elements (if applicable).

Output of this process is the value of the syntax element.

This process is invoked for all syntax elements in the syntax tables in subclause G.7.3 with descriptors equal to u(v), ue(v), me(v), se(v), te(v), ce(v), and ae(v).

When parsing coded slice NAL units with nal_unit_type equal to 20, the syntax elements scan_idx_start and scan_idx_end, which are not present in these NAL units, are inferred to be equal to 0 and 15, respectively.

When the parsing process is invoked for the first request for a value of a syntax element in the slice data and entropy_coding_mode_flag is equal to 1, the following ordered steps apply.

1. The initialisation process as specified in subclause 9.3.1 is invoked, where a slice_type equal to EI is interpreted as I, a slice_type equal to EP is interpreted as P, and a slice_type equal to EB is interpreted as B.
2. The initialisation process as specified in subclause G.9.3.1 is invoked.

Depending on entropy_coding_mode_flag and the descriptor, the value of a syntax element is derived as follows.

– If entropy_coding_mode_flag is equal to 0, the following applies.
  – The parsing process for syntax elements coded as coded as ue(v), se(v), or te(v) is specified in subclause 9.1.
  – The parsing process for the syntax element coded_block_pattern is specified in subclause G.9.1.
  – The parsing process for syntax elements of the residual_block_cavlc( ) syntax structure is specified in subclause G.9.2.
– Otherwise (entropy_coding_mode_flag is equal to 1), the value of the syntax element is derived as follows.
  – If the syntax element is equal to base_mode_flag, motion_prediction_flag_l0, motion_prediction_flag_l1, or residual_prediction_flag, the following applies.
    1. The binarization process as specified in subclause G.9.3.2 is invoked.
    2. The decoding process flow as specified in G.9.3.3 is invoked.
  – Otherwise (the syntax element is not equal to base_mode_flag, motion_prediction_flag_l0, motion_prediction_flag_l1, or residual_prediction_flag), the following applies.
    1. The binarization process as specified in subclause 9.3.2 is invoked, where a slice_type equal to EI is interpreted as I, a slice_type equal to EP is interpreted as P, and a slice_type equal to EB is interpreted as B.
    2. The decoding process flow as specified in subclause 9.3.3 is invoked.
    3. When the syntax element is equal to mb_type and the decoded value of mb_type is equal to I_PCM, the arithmetic decoding engine is initialised after decoding of any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data as specified in subclause 9.3.1.2.

G.9.1 Alternative parsing process for coded block pattern

This process is invoked for the parsing syntax elements with descriptor equal to me(v) when entropy_coding_mode_flag is equal to 0.

Inputs to this process are bits from the RBSP.

Outputs of this process is a value of the syntax element coded_block_pattern.

The parsing process for the syntax elements begins with reading the bits starting at the current location in the bitstream up to and including the first non-zero bit. By counting the number of leading bits that are equal to 0 and assigning this value to the variable leadingZeroBits, the variable codeNum is then derived as follows:

$$codeNum = 2^{leadingZeroBits} - 1 + read\_bits(leadingZeroBits)$$

where the value returned from read_bits(leadingZeroBits) is interpreted as a binary representation of an unsigned integer with most significant bit written first.

When ref_layer_dq_id is greater than or equal to 0 and (scan_idx_end – scan_idx_start) is less than 15, codeNum is set equal to (codeNum – 1).

Depending on codeNum, the following applies.

– If codeNum is equal to –1, the following ordered steps are specified.
  1. The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

2. When mbAddrN is available, the variable codedBlockPatternN is set equal to (16 * cbpChromaN + cbpLumaN) with cbpChromaN and cbpLumaN representing the values of CodedBlockPatternLuma and CodedBlockPatternChroma for the macroblock mbAddrN (with N being either A or B).

3. Depending on mbAddrA and mbAddrB, the following applies.

   – If mbAddrA is available, coded_block_pattern is set equal to codedBlockPatternA.

   – Otherwise, if mbAddrB is available, coded_block_pattern is set equal to codedBlockPatternB.

   – Otherwise (mbAddrA and mbAddrB are not available), coded_block_pattern is set equal to 0.

– Otherwise (codeNum is greater than or equal to 0), the mapping process for coded block pattern as specified in subclause 9.1.2 is invoked with codeNum as input and the output is assigned to the syntax element coded_block_pattern.

G.9.2 Alternative CAVLC parsing process for transform coefficient levels

This process is invoked for the parsing syntax elements with descriptor equal to ce(v) when entropy_coding_mode_flag is equal to 0.

Inputs to this process are a request for a value of a syntax element, bits from slice data, a maximum number of non-zero transform coefficient levels maxNumCoeff, the luma block index luma4x4BlkIdx or the chroma block index chroma4x4BlkIdx, cb4x4BlkIdx or cr4x4BlkIdx of the current block of transform coefficient levels.

Output of this process is the list coeffLevel containing transform coefficient levels of the luma block with block index luma4x4BlkIdx or the chroma block with block index chroma4x4BlkIdx, cb4x4BlkIdx or cr4x4BlkIdx.

The process is specified in the following ordered steps:

1. All transform coefficient levels, with indices from 0 to maxNumCoeff – 1, in the list coeffLevel are set equal to 0.

2. The total number of non-zero transform coefficient levels TotalCoeff(coeff_token) and the number of trailing one transform coefficient levels TrailingOnes(coeff_token) are derived by parsing coeff_token as follows.

   a. The parsing process of coeff_token as specified in subclause 9.2.1 is invoked and the outputs are TotalCoeff(coeff_token), TrailingOnes(coeff_token), and nC.

   b. When the CAVLC parsing process not invoked for ChromaDCLevel and (scan_idx_end - scan_idx_start) is less than 15, nC modified by setting it equal to Min(7, nC), and the additional parsing process for total number of transform coefficient levels and trailing ones as specified in subclause G.9.2.1 is invoked with nC, totalCoeffStart set equal to TotalCoeff(coeff_token), and trailingOnesStart set equal to TrailingOnes(coeff_token) as the inputs and the outputs are assigned to TotalCoeff(coeff_token) and TrailingOnes(coeff_token).

3. When TotalCoeff(coeff_token) is greater than 0, the following applies.

   a. The non-zero transform coefficient levels are derived by parsing trailing_ones_sign_flag, level_prefix, and level_suffix as specified in subclause 9.2.2.

   b. The runs of zero transform coefficient levels before each non-zero transform coefficient level are derived by parsing total_zeros and run_before as specified in subclause G.9.2.2.

   c. The level and run information are combined into the list coeffLevel as specified in subclause 9.2.4.

G.9.2.1 Additional parsing process for total number of transform coefficient levels and trailing ones

Inputs to this process are variables nC, totalCoeffStart, and trailingOnesStart.

Outputs of this process are variables totalCoeff and trailingOnes.

The value of totalCoeffStart resulting from decoding coeff_token as specified in subclause 9.2.1 shall be in the range of 0 to (scan_idx_end – scan_idx_start + 1), inclusive.

Let invTotalCoeff(coeffTokenIdx) and invTrailingOnes(coeffTokenIdx) be functions that map the variable coeffTokenIdx to the variables nX and nY, respectively, as specified by Table G-9 given the variable nC.

A variable targetCoeffTokenIdx is derived as specified by Table G-9 given the variables nC, nX = totalCoeffStart, and nY = trailingOnesStart.

A variable coeffTokenIdx is derived as specified by the following pseudo code.

```
for( coeffTokenIdx = 0, i = 0; i <= targetCoeffTokenIdx; coeffTokenIdx++ )
{
  if( invTotalCoeff  ( coeffTokenIdx ) < min(  4, scan_idx_end – scan_idx_start + 2 ) &&
      invTrailingOnes( coeffTokenIdx ) < min( 17, scan_idx_end – scan_idx_start + 2 ) )
    i++;
}
```

The variable totalCoeff is set equal to invTotalCoeff(coeffTokenIdx – 1) and the variable trailingOnes is set equal to invTrailingOnes(coeffTokenIdx – 1).

Table G-9 – Mapping of (nX, nY) to coeffTokenIdx and vice versa

nY	nX	0 <= nC < 2	2 <= nC < 4	4 <= nC < 8
0	0	0	0	0
0	1	4	7	16
1	1	1	1	1
0	2	9	11	20
1	2	5	5	8
2	2	2	2	2
0	3	13	15	23
1	3	10	8	11
2	3	7	9	9
3	3	3	3	3
0	4	17	19	24
1	4	14	12	13
2	4	11	13	12
3	4	6	4	4
0	5	21	22	28
1	5	18	16	15
2	5	15	17	14
3	5	8	6	5
0	6	25	23	30
1	6	22	20	17
2	6	19	21	18
3	6	12	10	6
0	7	29	27	31
1	7	26	24	21
2	7	23	25	22
3	7	16	14	7
0	8	32	31	32
1	8	30	28	25
2	8	27	29	26
3	8	20	18	10
0	9	33	35	36

Table G-9 – Mapping of (nX, nY) to coeffTokenIdx and vice versa

nY	nX	0 <= nC < 2	2 <= nC < 4	4 <= nC < 8
1	9	34	32	33
2	9	31	33	29
3	9	24	26	19
0	10	37	39	40
1	10	38	36	37
2	10	35	37	34
3	10	28	30	27
0	11	41	42	44
1	11	42	40	41
2	11	39	41	38
3	11	36	34	35
0	12	45	43	47
1	12	46	44	45
2	12	43	45	42
3	12	40	38	39
0	13	50	47	49
1	13	49	48	48
2	13	47	49	46
3	13	44	46	43
0	14	54	51	53
1	14	51	54	50
2	14	52	52	51
3	14	48	50	52
0	15	58	55	57
1	15	55	56	54
2	15	56	57	55
3	15	53	53	56
0	16	61	59	61
1	16	59	60	58
2	16	60	61	59
3	16	57	58	60

G.9.2.2 Alternative parsing process for run information

Inputs to this process are bits from slice data and the number of non-zero transform coefficient levels TotalCoeff(coeff_token).

Output of this process is a list of runs of zero transform coefficient levels preceding non-zero transform coefficient levels called run.

Let maxCoeff be a variable that is set equal to (scan_idx_end – scan_idx_start + 1).

Initially, an index i is set equal to 0.

The variable zerosLeft is derived as follows.

– If the number of non-zero transform coefficient levels TotalCoeff(coeff_token) is equal to the maximum number of non-zero transform coefficient levels maxCoeff, a variable zerosLeft is set equal to 0.

– Otherwise (the number of non-zero transform coefficient levels TotalCoeff(coeff_token) is less than the maximum number of non-zero transform coefficient levels maxCoeff), total_zeros is decoded and zerosLeft is set equal to its value.

The VLC used to decode total_zeros is derived as follows:

– If maxCoeff is less than or equal to 4, one of the VLCs specified in Table 9-9(a) is used with tzVlcIndex being derived by

$$tzVlcIndex = \min(3, TotalCoeff(coeff\_token) + 4 - maxCoeff) \quad \text{(G-363)}$$

– Otherwise, if maxCoeff is greater than 4 and less than or equal to 8, one of the VLCs specified in Table 9-9(b) is used with tzVlcIndex being derived by

$$tzVlcIndex = \min(7, TotalCoeff(coeff\_token) + 8 - maxCoeff) \quad \text{(G-364)}$$

– Otherwise, if maxCoeff is greater than 8 and less than 15, VLCs from Table 9-7 and Table 9-8 are used with tzVlcIndex being derived by

$$tzVlcIndex = \min(15, TotalCoeff(coeff\_token) + 16 - maxCoeff) \quad \text{(G-365)}$$

– Otherwise (maxCoeff is greater than or equal to 15), VLCs from Table 9-7 and Table 9-8 are used with tzVlcIndex equal to TotalCoeff(coeff_token).

The following procedure is then applied iteratively (TotalCoeff(coeff_token) – 1) times.

1. The variable run[i] is derived as follows.
   – If zerosLeft is greater than zero, a value run_before is decoded based on Table 9-10 and zerosLeft. run[i] is set equal to run_before.
   – Otherwise (zerosLeft is equal to 0), run[i] is set equal to 0.
2. The value of run[i] is subtracted from zerosLeft and the result assigned to zerosLeft. The result of the subtraction shall be greater than or equal to 0.
3. The index i is incremented by 1.

Finally the value of zerosLeft is assigned to run[i].

G.9.3 Alternative CABAC parsing process for slice data in scalable extension

Subclause G.9.3.1 specifies the initialisation process for the alternative CABAC parsing process for slice data in scalable extension.

Subclause G.9.3.2 specifies the binarization process for the alternative CABAC parsing process for slice data in scalable extension.

Subclause G.9.3.3 specifies the decoding process flow for the alternative CABAC parsing process for slice data in scalable extension.

G.9.3.1 Initialisation process

Outputs of this process are the initialised CABAC context variables indexed by ctxIdx.

Table G-11 and Table G-12 contain the values of the variables n and m used in the initialisation of context variables that are assigned to syntax element base_mode_flag, motion_prediction_flag_l0, motion_prediction_flag_l1, and residual_prediction_flag in subclause G.7.3.4.1 and G.7.3.6. For all other syntax elements in subclauses G.7.3.4.1 and G.7.3.6 the initialisation process of context variables as specified in subclause 9.3.1 applies.

For each context variable, the two variables pStateIdx and valMPS are initialised. The two values assigned to pStateIdx and valMPS for the initialisation are derived from $SliceQP_Y$, which is derived in Equation 7-28. Given the two table entries (m, n), the following applies

1. preCtxState = Clip3(1, 126, ((m * Clip3(0, 51, $SliceQP_Y$)) >> 4) + n)
2. if(preCtxState <= 63) {

        pStateIdx = 63 - preCtxState

        valMPS = 0

    } else {

        pStateIdx = preCtxState - 64

        valMPS = 1

    }

In Table G-10, the ctxIdx for which initialisation is needed for each of the slice types EI, EP, and EB are listed. Also listed is the table number that includes the values of m and n needed for the initialisation. For EP and EB slices, the initialisation depends also on the value of the cabac_init_idc syntax element. Note that the syntax element names do not affect the initialisation process.

Table G-10 - Association of ctxIdx and syntax elements for each slice type in the initialisation process

	Syntax element	Table	Slice type		
			EI	EP	EB
macroblock_layer_in_scalable_extension( )	base_mode_flag	Table G-11	1024-1026	1024-1026	1024-1026
mb_pred_in_scalable_extension( ) and sub_mb_pred_in_scalable_extension( )	motion_prediction_flag_l0	Table G-12		1027	1027
	motion_prediction_flag_l1	Table G-12		1027	1027
residual_in_scalable_extension( )	residual_prediction_flag	Table G-12		1028-1029	1028-1029

Table G-11 - Values of variables m and n for ctxIdx from 1024 to 1026

ctxIdx	EI slices		Value of cabac_init_idc (EP, EB slices)					
			0		1		2	
	m	n	m	n	m	n	m	n
1024	-14	138	0	75	0	75	0	75
1025	-22	140	2	65	2	65	2	65
1026	-11	99	2	59	2	59	2	59

Table G-12 - Values of variables m and n for ctxIdx from 1027 to 1029

ctxIdx	Value of cabac_init_idc					
	0		1		2	
	m	n	m	n	m	n
1027	-6	67	-6	67	-6	67
1028	-23	104	-23	104	-23	104
1029	-35	106	-35	106	-35	106

G.9.3.2 Binarization process

Input to this process is a request for a syntax element.

Output of this process is the binarization of the syntax element, maxBinIdxCtx, ctxIdxOffset, and bypassFlag.

Associated with each binarization or binarization part of a syntax element is a specific value of the context index offset (ctxIdxOffset) variable and a specific value of the maxBinIdxCtx variable as given in Table G-13.

The variable bypassFlag is set equal to 0.

The possible values of the context index ctxIdx are in the range 1024 to 1029, inclusive. The value assigned to ctxIdxOffset specifies the lower value of the range of ctxIdx assigned to the corresponding binarization or binarization part of a syntax element.

Table G-13 - Syntax elements and associated types of binarization, maxBinIdxCtx, and ctxIdxOffset

Syntax element	Type of binarization	maxBinIdxCtx	ctxIdxOffset
base_mode_flag	FL, cMax=1	0	1024
motion_prediction_flag_l0, motion_prediction_flag_l1	FL, cMax=1	0	1027
residual_prediction_flag	FL, cMax=1	0	1028

G.9.3.3 Decoding process flow

Input to this process is a binarization of the requested syntax element, maxBinIdxCtx, bypassFlag and ctxIdxOffset as specified in subclause G.9.3.2.

Output of this process is the value of the syntax element.

This process specifies how each bit of a bit string is parsed for each syntax element.

After parsing each bit, the resulting bit string is compared to all bin strings of the binarization of the syntax element and the following applies.

– If the bit string is equal to one of the bin strings, the corresponding value of the syntax element is the output.

– Otherwise (the bit string is not equal to one of the bin strings), the next bit is parsed.

While parsing each bin, the variable binIdx is incremented by 1 starting with binIdx being set equal to 0 for the first bin.

The parsing of each bin is specified by the following two ordered steps:

1. Given binIdx, maxBinIdxCtx and ctxIdxOffset, ctxIdx is derived as specified in subclause G.9.3.3.1.
2. Given ctxIdx, the value of the bin from the bitstream as specified in subclause 9.3.3.2 is decoded.

G.9.3.3.1 Derivation process for ctxIdx

Inputs to this process are binIdx, maxBinIdxCtx and ctxIdxOffset.

Output of this process is ctxIdx.

Table G-14 shows the assignment of ctxIdx increments (ctxIdxInc) to binIdx for all ctxIdxOffset values for the syntax elements base_mode_flag, motion_prediction_flag_l0, motion_prediction_flag_l1, and residual_prediction_flag.

The ctxIdx to be used with a specific binIdx is the sum of ctxIdxOffset and ctxIdxInc, which is found in Table G-14. When more than one value is listed in Table G-14 or Table 9-39 for a binIdx, the assignment process for ctxIdxInc for that binIdx is further specified in the subclauses given in parenthesis of the corresponding table entry.

All entries in Table G-14 labelled with "na" correspond to values of binIdx that do not occur for the corresponding ctxIdxOffset.

Table G-14 - Assignment of ctxIdxInc to binIdx for the ctxIdxOffset values related to the syntax elements base_mode_flag and residual_prediction_flag

ctxIdxOffset	binIdx						
	0	**1**	**2**	**3**	**4**	**5**	**>= 6**
1024	0,1,2 (subclause G.9.3.3.2.1)	na	na	na	na	na	na
1027	0	na	na	na	na	na	na
1028	0,1 (subclause G.9.3.3.2.2)	na	na	na	na	na	na

G.9.3.3.2 Assignment process of ctxIdxInc using neighbouring syntax elements

Subclause G.9.3.3.2.1 specifies the derivation process of ctxIdxInc for the syntax element base_mode_flag.

Subclause G.9.3.3.2.2 specifies the derivation process of ctxIdxInc for the syntax element residual_prediction_flag.

G.9.3.3.2.1 Derivation process of ctxIdxInc for the syntax element base_mode_flag

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If mbAddrN is available and base_mode_flag for the macroblock mbAddrN is equal to 1, condTermFlagN is set equal to 0.

– Otherwise (mbAddrN is not available or base_mode_flag for the macroblock mbAddrN is equal to 0), condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad \text{(G-366)}$$

G.9.3.3.2.2 Derivation process of ctxIdxInc for the syntax element residual_prediction_flag

Output of this process is ctxIdxInc.

Depending on base_mode_flag, the following applies.

– If base_mode_flag is equal to 1, ctxIdxInc is set equal to 0.

– Otherwise (base_mode_flag is equal to 0), ctxIdxInc is set equal to 1.

G.10 Profiles and levels

G.10.1 Profiles

G.10.1.1 Scalable Baseline profile

Bitstreams conforming to the Scalable Baseline profile shall obey the following constraints:

a) The base layer bitstream as specified in subclause G.8.8.2 shall obey the following constraints.

NOTE – In addition to the base layer constraints specified below in items i) through vi), the value of the syntax element constrained_intra_pred_flag for picture parameter sets of the base layer stream is constrained as specified below in item k).

i) All constraints of the Baseline profile specified in subclause A.2.1 shall be obeyed.

ii) Sequence parameter sets should have profile_idc equal to 66. Sequence parameter sets may have profile_idc equal to 77 or 88. Sequence parameter sets shall not have profile_idc equal to a value other than 66, 77, or 88.

iii) Sequence parameter sets shall have constraint_set0_flag, constraint_set1_flag, and constraint_set2_flag equal to 1.

iv) Picture parameter sets shall have num_slice_groups_minus1 equal to 0.

v) Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0.

vi) Arbitrary slice order is not allowed.

b) Only I, P, EI, EP, and EB slices shall be present.

c) SVC sequence parameter sets shall have chroma_format_idc equal to 1.

d) SVC sequence parameter sets shall have bit_depth_luma_minus8 equal to 0.

e) SVC sequence parameter sets shall have bit_depth_chroma_minus8 equal to 0.

f) SVC sequence parameter sets shall have separate_colour_plane_flag equal to 0.

g) SVC sequence parameter sets shall have qpprime_y_zero_transform_bypass_flag equal to 0.

h) SVC sequence parameter sets shall have frame_mbs_only_flag equal to 1.

i) Picture parameter sets shall have num_slice_groups_minus1 in the range of 0 to 7, inclusive.

j) When present, picture parameter sets shall have slice_group_map_type equal to 2.

k) A list of integer values specifying layer representation identifiers is derived by invoking the process specified in G.8.1.1 with the output being the list dqIdList. The variable numDQEntries is set equal to the number of elements in the list dqIdList. When numDQEntries is greater than 1, for any element dqIdList[i] with i = 0..(numDQEntries – 2), when tcoeff_level_prediction_flag is equal to 0 for any layer representation with DQId in the set specified by dqIdList[k] with k = i..(numDQEntries – 1), the picture parameter set that is referenced by the coded slice NAL units of the layer representation with DQId equal to dqIdList[i] shall have constrained_intra_pred_flag equal to 1.

l) Arbitrary slice order is not allowed.

m) For each present value of dependency_id greater than 0, one of the following constraints shall be obeyed.

– $ScaledRefLayerPicWidthInSamples_L$ is equal to $RefLayerPicWidthInSamples_L$ and $ScaledRefLayerPicHeightInSamples_L$ is equal to $RefLayerPicHeightInSamples_L$

– $ScaledRefLayerPicWidthInSamples_L$ is equal to (1.5 * $RefLayerPicWidthInSamples_L$) and $ScaledRefLayerPicHeightInSamples_L$ is equal to (1.5 * $RefLayerPicHeightInSamples_L$)

– $ScaledRefLayerPicWidthInSamples_L$ is equal to (2 * $RefLayerPicWidthInSamples_L$) and $ScaledRefLayerPicHeightInSamples_L$ is equal to (2 * $RefLayerPicHeightInSamples_L$)

n) For each present value of dependency_id greater than 0, all of the following constraints shall be obeyed.

– (ScaledRefLayerLeftOffset % 16) is equal to 0

– (ScaledRefLayerTopOffset % 16) is equal to 0

o) The level constraints specified in subclause G.10.2 shall be fulfilled.

Conformance of a bitstream to Scalable Baseline profile is specified by profile_idc equal to 83.

Decoders conforming to the Scalable Baseline profile at a specific level shall be capable of decoding all bitstreams in which all active SVC sequence parameter sets have profile_idc equal to 83 or (profile_idc equal to 86 and constraint_set0_flag equal to 1) or (profile_idc equal to 66, 77, or 88 and constraint_set0_flag equal to 1 and constraint_set1_flag equal to 1 and constraint_set2_flag equal to 1) and in which level_idc or (level_idc and constraint_set3_flag) for all active SVC sequence parameter sets represent a level less than or equal to the specified level.

G.10.1.2 Scalable High profile

Bitstreams conforming to the Scalable High profile shall obey the following constraints:

a) The base layer bit-stream as specified in subclause G.8.8.2 shall obey the following constraints.

NOTE – In addition to the base layer constraints specified below in items i) through iii), the value of the syntax element constrained_intra_pred_flag for picture parameter sets of the base layer stream is constrained as specified below in item j).

i) All constraints of the High profile specified in subclause A.2.4 shall be obeyed.

ii) Sequence parameter sets should have profile_idc equal to 100. Sequence parameter sets may have profile_idc equal to 66, 77, or 88 and constraint_set1_flag equal to 1. Sequence parameter sets shall not have profile_idc equal to a value other than 66, 77, 88, or 100.

iii) The syntax element direct_spatial_mv_pred_flag shall be equal to 1.

b) Only I, P, B, EI, EP, and EB slices shall be present.

c) SVC sequence parameter sets shall have chroma_format_idc equal to 1.

d) SVC sequence parameter sets shall have bit_depth_luma_minus8 equal to 0.

e) SVC sequence parameter sets shall have bit_depth_chroma_minus8 equal to 0.

f) SVC sequence parameter sets shall have separate_colour_plane_flag equal to 0.

g) SVC sequence parameter sets shall have qpprime_y_zero_transform_bypass_flag equal to 0.

h) Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0.

i) Picture parameter sets shall have num_slice_groups_minus1 equal to 0.

j) A list of integer values specifying layer representation identifiers is derived by invoking the process specified in G.8.1.1 with the output being the list dqIdList. The variable numDQEntries is set equal to the number of elements in the list dqIdList. When numDQEntries is greater than 1, for any element dqIdList[i] with i = 0..(numDQEntries – 2), when tcoeff_level_prediction_flag is equal to 0 for any layer representation with DQId in the set specified by dqIdList[k] with k = i..(numDQEntries – 1), the picture parameter set that is referenced by the coded slice NAL units of the layer representation with DQId equal to dqIdList[i] shall have constrained_intra_pred_flag equal to 1.

k) Arbitrary slice order is not allowed.

l) The level constraints specified in subclause G.10.2 shall be fulfilled.

Conformance of a bitstream to Scalable High profile is specified by profile_idc equal to 86.

Decoders conforming to the Scalable High profile at a specific level shall be capable of decoding all bitstreams in which all active SVC sequence parameter sets have profile_idc equal to 86 or (profile_idc equal to 83 and constraint_set1_flag equal to 1) or profile_idc equal to 77 or profile_idc equal to 100 or (profile_idc not equal to 83 or 86 and constraint_set1_flag equal to 1) and in which level_idc or (level_idc and constraint_set3_flag) for all active SVC sequence parameter sets represent a level less than or equal to the specified level.

G.10.1.3 Scalable High Intra profile

Bitstreams conforming to the Scalable High Intra profile shall obey the following constraints:

a) The base layer bit-stream as specified in subclause G.8.8.2 shall obey the following constraints:

i) All constraints of the High profile specified in subclause A.2.4 shall be obeyed.

ii) Sequence parameter sets should have profile_idc equal to 100 and constraint_set3_flag equal to 1. Sequence parameter sets may have profile_idc equal to 66, 77, or 88 and constraint_set1_flag equal to 1. Sequence parameter sets shall not have profile_idc equal to a value other than 66, 77, 88, or 100.

b) All constraints of the Scalable High profile specified in subclause G.10.1.2 shall be obeyed.

c) All pictures shall be IDR pictures.

d) SVC sequence parameter sets shall have num_ref_frames equal to 0.

e) When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, SVC sequence parameter sets shall have num_reorder_frames equal to 0.

f) When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, SVC sequence parameter sets shall have max_dec_frame_buffering equal to 0.

g) Picture timing SEI messages, whether present in the bitstream (by non-VCL NAL units) or conveyed equivalently by other means not specified in this Recommendation | International Standard, shall have dpb_output_delay equal to 0.

h) The level constraints specified in subclause G.10.2 shall be fulfilled.

Conformance of a bitstream to Scalable High Intra profile is specified by constraint_set3_flag being equal to 1 with profile_idc equal to 86.

Decoders conforming to the Scalable High Intra profile at a specific level shall be capable of decoding all bitstreams in which all active SVC sequence parameter sets have profile_idc equal to 86 or 100 and constraint_set3_flag equal to 1 and in which level_idc for all active SVC sequence parameter sets represents a level less than or equal to the specified level.

G.10.2 Levels

The following is specified for expressing the constraints in this subclause.

– Let access unit n be the n-th access unit in decoding order with the first access unit being access unit 0.

– Let picture n be the primary coded picture or the corresponding decoded picture of access unit n.

G.10.2.1 Level limits common to Scalable Baseline, Scalable High, and Scalable High Intra profiles

The variable fR is derived as follows.

– If picture n is a frame, fR is set equal to (1 ÷ 172).

– Otherwise (picture n is a field), fR is set equal to (1 ÷ (172 * 2)).

The variable dqIdMax is set equal to the maximum value of DQId for the layer representation of the access unit.

The variable refLayerDQId is set equal to the maximum value of ref_layer_dq_id for the layer representation with DQId equal to dqIdMax.

A list of integer values specifying layer representation identifiers for the access unit is derived by invoking the process specified in subclause G.8.1.1 with the output being the list dqIdList. The variable numDQEntries is set equal to the number of elements in the list dqIdList.

A variable dependentDId is derived by the following pseudo-code.

```
dependentDId = 0
for( i = 0; i < numDQEntries; i++ )
    if( ( dqIdList[ i ] % 16 ) = = 0 )                    (G-367)
        dependentDId++
```

The variable svcPicSizeInMbs is derived as follows.

– If numDQEntries is less than 3, svcPicSizeInMbs is set equal to PicSizeInMbs for the layer representation with DQId equal to dqIdMax.

– Otherwise (numDQEntries is greater than 2), svcPicSizeInMbs is derived by applying the following ordered steps.

1. svcPicSizeInMbs is set equal to PicSizeInMbs for the layer representation with DQId equal to dqIdMax.
2. The variable refLayerMbs is set equal to 0.
3. For each element dqIdList[i] with i = 2..(numDQEntries – 1), with refLayerPicSizeInMbs being the variable PicSizeInMbs for the layer representation, the variable refLayerMbs is modified by

   refLayerMbs += refLayerPicSizeInMbs (G-368)

4. svcPicSizeInMbs is modified by

   svcPicSizeInMbs += (refLayerMbs + 1) >> 1 (G-369)

Bitstreams conforming to the Scalable Baseline, Scalable High, or Scalable High Intra profiles at a specific level shall obey the following constraints:

a) The nominal removal time of access unit n (with n > 0) from the CPB as specified in subclause C.1.2, satisfies the constraint that $t_{r,n}(n) - t_r(n - 1)$ is greater than or equal to Max(svcPicSizeInMbs ÷ MaxMBPS, fR), where MaxMBPS is the value specified in Table A-1 that applies to picture n – 1 and svcPicSizeInMbs is derived for picture n – 1.

b) The difference between consecutive output times of pictures from the DPB as specified in subclause C.2.2, satisfies the constraint that $\Delta t_{o,dpb}(n) >= Max(svcPicSizeInMbs \div MaxMBPS, fR)$, where MaxMBPS is the value specified in Table A-1 for picture n, and svcPicSizeInMbs is derived for picture n, provided that picture n is a picture that is output and is not the last picture of the bitstream that is output.

c) PicWidthInMbs * FrameHeightInMbs <= MaxFS, where MaxFS is specified in Table A-1. PicWidthInMbs and FrameHeightInMbs are the derived variables for the layer representation with DQId equal to dqIdmax.

d) PicWidthInMbs <= Sqrt(MaxFS * 8), where MaxFS is specified in Table A-1. PicWidthInMbs and FrameHeightInMbs are the derived variables for the layer representation with DQId equal to dqIdmax.

e) PicHeightInMbs <= Sqrt(MaxFS * 8), where MaxFS is specified in Table A-1. PicWidthInMbs and FrameHeightInMbs are the derived variables for the layer representation with DQId equal to dqIdmax.

f) max_dec_frame_buffering <= MaxDpbSize, where MaxDpbSize is equal to Min(1024 * MaxDPB / (PicWidthInMbs * FrameHeightInMbs * 384), 16) and MaxDPB is specified in Table A-1. PicWidthInMbs and FrameHeightInMbs are the derived variables for the layer representation with DQId equal to dqIdmax.

g) Vertical motion vector component range does not exceed MaxVmvR in units of luma frame samples, where MaxVmvR is specified in Table A-1.

h) Horizontal motion vector range does not exceed the range of -2048 to 2047.75, inclusive, in units of luma samples.

i) Number of motion vectors per two consecutive macroblocks in decoding order (also applying to the total from the last macroblock of a slice and the first macroblock of the next slice in decoding order) does not exceed MaxMvsPer2Mb, where MaxMvsPer2Mb is specified in Table A-1. The number of motion vectors for each macroblock is value of the variable MvCnt after the completion of the target macroblock decoding process specified in subclause G.8.1.5.6.

j) Number of bits of macroblock_layer( ) and macroblock_layer_in_scalable_extension( ) data for any macroblock is not greater than 128 + RawMbBits. Depending on entropy_coding_mode_flag, the bits of macroblock_layer( ) data are counted as follows.

   – If entropy_coding_mode_flag is equal to 0, the number of bits of macroblock_layer( ) data is given by the number of bits in the macroblock_layer( ) syntax structure for a macroblock.

   – Otherwise (entropy_coding_mode_flag is equal to 1), the number of bits of macroblock_layer( ) data for a macroblock is given by the number of times read_bits(1) is called in subclauses 9.3.3.2.2 and 9.3.3.2.3 when parsing the macroblock_layer( ) associated with the macroblock.

k) The variable dependentDId specified at the beginning of this subclause shall not exceed 3.

l) When refLayerDQId is greater than or equal to 0, with PicSizeInMbs being the variable PicSizeInMbs for the layer representation with DQId equal to dqIdMax, with refLayerPicSizeInMbs being the variable PicSizeInMbs for the layer representation with DQId equal to refLayerDQId, with mbType specifying the array mbType of the collective term currentVars after completion of the SVC decoding process specified in subclause G.8, with refLayerMbType specifying the array mbType of the collective term currentVars after completion of the base decoding process for layer representations specified in subclauses G.8.1.3.1 and G.8.1.3.2 for the layer representation with DQId equal to refLayerDQId, the following applies.

   – If PicSizeInMbs is less than or equal to 1620, with numIBLMbs being the number of macroblocks mbAddr with mbAddr = 0..(PicSizeInMbs – 1) for which mbType[mbAddr] is equal to I_BL and with numRefLayerIntraMbs being the number of macroblocks refLayerMbAddr with refLayerMbAddr = 0..(refLayerPicSizeInMbs – 1) for which refLayerMbType[refLayerMbAddr] is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL, the following constraint shall be obeyed.

     numRefLayerIntraMbs <= Ceil(1.5 * numIBLMbs * refLayerPicSizeInMbs / PicSizeInMbs) (G-370)

   – Otherwise (PicSizeInMbs is greater than 1620), with numIBLMbs being the number of macroblocks mbAddr in a particular slice of the layer representation with DQId equal to dqIdMax for which mbType[mbAddr] is equal to I_BL, with refLayerSlices be the set of slices of the layer representation with DQId equal to refLayerDQId that are required for decoding the particular slice of the layer representation with DQId equal to DQIdMax, and with numRefLayerIntraMbs being the number of macroblocks refLayerMbAddr in the slices of the set refLayerSlices for which refLayerMbType[refLayerMbAddr] is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL, the constraint specified in Equation G-370 shall be obeyed.

m) When ref_layer_dq_id is greater than or equal to 0 for a particular layer representation, the value of level_idc in the SVC sequence parameter set that is referenced by the particular layer representation shall be greater than or equal to the value of level_idc for the SVC sequence parameter set that is referenced by the layer representation with DQId equal to ref_layer_dq_id.

Table A-1 specifies the limits for each level. Entries marked "-" in Table A-1 denote the absence of a corresponding limit.

A level to which the bitstream conforms shall be indicated by the syntax element level_idc as follows.

– If level_idc is equal to 9, the indicated level is level 1b.

– Otherwise (level_idc is not equal to 9), level_idc is equal to a value of ten times the level number specified in Table A-1.

G.10.2.2 Profile specific level limits

The variable dqIdMax is set equal to the maximum value of DQId for the layer representation of the access unit.

A list of integer values specifying layer representation identifiers for the access unit is derived by invoking the process specified in subclause G.8.1.1 with the output being the list dqIdList. The variable numDQEntries is set equal to the number of elements in the list dqIdList.

The variable numSVCSlices is derived as specified by the following pseudo-code.

```
numSVCSlices = 0
for( i = 0; i < numDQEntries; i++ )                                    (G-371)
    numSVCSlices += number of slices in layer representation with DQId equal to dqIdList[ i ]
```

The variable svcPicSizeInMbs is derived as specified in subclause G.10.2.1.

The following constraints are specified.

a) In bitstreams conforming to the Scalable Baseline, Scalable High, or Scalable High Intra profiles, the removal time of access unit 0 shall satisfy the constraint that the number of slices numSVCSlices in picture 0 is less than or equal to ((svcPicSizeInMbs + MaxMBPS * (t_r(0) – $t_{r,n}$(0))) ÷ SliceRate), where SliceRate is the value that applies to picture 0 and MaxMBPS is the value specified in Table A-1. For Scalable Baseline profile, SliceRate is specified in Table G-15. For Scalable High and Scalable High Intra profiles, SliceRate is specified in Table A-4.

b) In bitstreams conforming to the Scalable Baseline, Scalable High, or Scalable High Intra profiles, the difference between consecutive removal time of access units n and n – 1 (with n > 0) shall satisfy the constraint that the number of slices numSVCSlices in picture n is less than or equal to MaxMBPS * (t_r(n) - t_r(n – 1)) ÷ SliceRate, where SliceRate is the value that applies to picture n and MaxMBPS is the value specified in Table A-1. For Scalable Baseline profile, SliceRate is specified in Table G-15. For Scalable High and Scalable High Intra profiles, SliceRate is specified in Table A-4.

c) In bitstreams conforming to the Scalable High or Scalable High Intra profiles, SVC sequence parameter sets shall have direct_8x8_inference_flag equal to 1 for the levels specified in Table A-4. In bitstreams conforming to Scalable Baseline profile, SVC sequence parameter sets shall have direct_8x8_inference_flag equal to 1.

d) In bitstreams conforming to the Scalable High or Scalable High Intra profiles, SVC sequence parameter sets shall have frame_mbs_only_flag equal to 1 for the levels specified in Table A-4.

e) In bitstreams conforming to the Scalable High or Scalable High Intra profiles, for all macroblocks mbAddr and macroblock partitions mbPartIdx, the value of subMbType[mbAddr][mbPartIdx] that is derived as specified in subclause G.8.1.5.1.1 shall not be equal to B_Bi_8x4, B_Bi_4x8, or B_Bi_4x4 for the levels in which MinLumaBiPredSize is shown as 8x8 in Table A-4. In bitstreams conforming to the Scalable Baseline profile, for all macroblocks mbAddr and macroblock partitions mbPartIdx, the value of subMbType[mbAddr][mbPartIdx] that is derived as specified in subclause G.8.1.5.1.1 shall not be equal to B_Bi_8x4, B_Bi_4x8, or B_Bi_4x4.

f) In bitstreams conforming to the Scalable Baseline profile, ($xInt_{max}$ – $xInt_{min}$ + 6) * ($yInt_{max}$ – $yInt_{min}$ + 6) <= MaxSubMbRectSize in macroblocks coded with macroblock type equal to P_8x8, P_8x8ref0 or B_8x8 for all invocations of the process specified in subclause 8.4.2.2.1 used to generate the predicted luma sample array for a single reference picture list (reference picture list 0 or reference picture list 1) for each 8x8 sub-macroblock, where NumSubMbPart(sub_mb_type) > 1, where MaxSubMbRectSize is specified in Table G-15 and

   – $xInt_{min}$ is the minimum value of $xInt_L$ among all luma sample predictions for the sub-macroblock

   – $xInt_{max}$ is the maximum value of $xInt_L$ among all luma sample predictions for the sub-macroblock

   – $yInt_{min}$ is the minimum value of $yInt_L$ among all luma sample predictions for the sub-macroblock

– $yInt_{max}$ is the maximum value of $yInt_L$ among all luma sample predictions for the sub-macroblock

g) In bitstreams conforming to the Scalable Baseline, Scalable High, or Scalable High Intra profiles, for the VCL HRD parameters, BitRate[SchedSelIdx] <= cpbBrVclFactor * MaxBR and CpbSize[SchedSelIdx] <= cpbBrVclFactor * MaxCPB for at least one value of SchedSelIdx, where cpbBrVclFactor is specified in Table G-16, BitRate[SchedSelIdx] is specified by Equation E-37 and CpbSize[SchedSelIdx] is specified by Equation E-38 when vcl_hrd_parameters_present_flag is equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of cpbBrVclFactor bits/s and cpbBrVclFactor bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1, inclusive.

h) In bitstreams conforming to the Scalable Baseline, Scalable High, or Scalable High Intra profiles, for the NAL HRD parameters, BitRate[SchedSelIdx] <= cpbBrNalFactor * MaxBR and CpbSize[SchedSelIdx] <= cpbBrNalFactor * MaxCPB for at least one value of SchedSelIdx, where cpbBrNalFactor is specified in Table G-16, BitRate[SchedSelIdx] is specified by Equation E-37 and CpbSize[SchedSelIdx] is specified by Equation E-38 when nal_hrd_parameters_present_flag is equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of cpbBrNalFactor bits/s and cpbBrNalFactor bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1, inclusive.

i) In bitstreams conforming to the Scalable Baseline, Scalable High, or Scalable High Intra profiles, the sum of the NumBytesInNALunit variables for access unit 0 is less than or equal to 384 * (svcPicSizeInMbs + MaxMBPS * ($t_r(0) - t_{r,n}(0)$)) ÷ MinCR, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture 0 and PicSizeInMbs is the number of macroblocks in picture 0.

j) In bitstreams conforming to the Scalable Baseline, Scalable High, or Scalable High Intra profiles, the sum of the NumBytesInNALunit variables for access unit n (with n > 0) is less than or equal to 384 * MaxMBPS * ($t_r(n) - t_{r,n}(n - 1)$) ÷ MinCR, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture n.

k) In bitstreams conforming to Scalable Baseline profile, picture parameter sets shall have entropy_coding_mode_flag equal to 0 and transform_8x8_mode_flag equal to 0 for level 2.1 and below.

l) In bitstreams conforming to Scalable Baseline, Scalable High, and Scalable High Intra profiles, when PicSizeInMbs is greater than 1620 for DQId equal to dqIdMax, the number of macroblocks in any coded slice shall not exceed MaxFS / 4, where MaxFS is specified in Table A-1.

Table G-15 – Scalable Baseline profile level limits

Level number	SliceRate	MaxSubMbRectSize
1	-	576
1b	-	576
1.1	-	576
1.2	-	576
1.3	-	576
2	-	576
2.1	22	576
2.2	22	576
3	22	576
3.1	60	1152
3.2	60	1152
4	60	1440
4.1	24	1440
4.2	24	1440
5	24	-
5.1	24	-

Table G-16 – Specification of cpbBrVclFactor and cpbBrNalFactor

Profile	cpbBrVclFactor	cpbBrNalFactor
Scalable Baseline Scalable High, or Scalable High Intra	1250	1500

G.11 Byte stream format

The specifications in Annex B apply.

G.12 Hypothetical reference decoder

The specifications in Annex C apply with substituting SVC sequence parameter set for sequence parameter set.

G.13 Supplemental enhancement information

The specifications in Annex D together with the extensions and modifications specified in this subclause apply.

G.13.1 SEI payload syntax

G.13.1.1 Scalability information SEI message syntax

scalability_info(payloadSize) {	C	Descriptor
temporal_id_nesting_flag	5	u(1)
priority_layer_info_present_flag	5	u(1)
priority_id_setting_flag	5	u(1)
num_layers_minus1	5	ue(v)
for(i = 0; i <= num_layers_minus1; i++) {		
layer_id[i]	5	ue(v)
priority_id[i]	5	u(6)
discardable_flag[i]	5	u(1)
dependency_id[i]	5	u(3)
quality_id[i]	5	u(4)
temporal_id[i]	5	u(3)
sub_pic_layer_flag[i]	5	u(1)
sub_region_layer_flag[i]	5	u(1)
iroi_division_info_present_flag[i]	5	u(1)
profile_level_info_present_flag[i]	5	u(1)
bitrate_info_present_flag[i]	5	u(1)
frm_rate_info_present_flag[i]	5	u(1)
frm_size_info_present_flag[i]	5	u(1)
layer_dependency_info_present_flag[i]	5	u(1)
parameter_sets_info_present_flag[i]	5	u(1)
bitstream_restriction_info_present_flag[i]	5	u(1)
exact_inter_layer_pred_flag[i]	5	u(1)
if(sub_pic_layer_flag[i] || iroi_division_info_present_flag[i])		
exact_sample_value_match_flag[i]	5	u(1)
layer_conversion_flag[i]	5	u(1)

layer_output_flag[i]	5	u(1)
if (profile_level_info_present_flag[i])		
layer_profile_level_idc[i]	5	u(24)
if(bitrate_info_present_flag[i]) {		
avg_bitrate[i]	5	u(16)
max_bitrate_layer[i]	5	u(16)
max_bitrate_layer_representation[i]	5	u(16)
max_bitrate_calc_window[i]	5	u(16)
}		
if(frm_rate_info_present_flag[i]) {		
constant_frm_rate_idc[i]	5	u(2)
avg_frm_rate[i]	5	u(16)
}		
if(frm_size_info_present_flag[i] || iroi_division_info_present_flag[i]) {		
frm_width_in_mbs_minus1[i]	5	ue(v)
frm_height_in_mbs_minus1[i]	5	ue(v)
}		
if(sub_region_layer_flag[i]) {		
base_region_layer_id[i]	5	ue(v)
dynamic_rect_flag[i]	5	u(1)
if(!dynamic_rect_flag[i]) {		
horizontal_offset[i]	5	u(16)
vertical_offset[i]	5	u(16)
region_width[i]	5	u(16)
region_height[i]	5	u(16)
}		
}		
if(sub_pic_layer_flag[i])		
roi_id[i]	5	ue(v)
if (iroi_division_info_present_flag[i]) {		
iroi_grid_flag[i]	5	u(1)
if (iroi_grid_flag[i]) {		
grid_width_in_mbs_minus1[i]	5	ue(v)
grid_height_in_mbs_minus1[i]	5	ue(v)
} else {		
num_rois_minus1[i]	5	ue(v)
for (j = 0; j <= num_rois_minus1[i]; j++) {		
first_mb_in_roi[i][j]	5	ue(v)
roi_width_in_mbs_minus1[i][j]	5	ue(v)
roi_height_in_mbs_minus1[i][j]	5	ue(v)
}		
}		
}		
if(layer_dependency_info_present_flag[i]) {		
num_directly_dependent_layers[i]	5	ue(v)
for(j = 0; j < num_directly_dependent_layers[i]; j++)		
directly_dependent_layer_id_delta_minus1[i][j]	5	ue(v)

} else		
layer_dependency_info_src_layer_id_delta[i]	5	ue(v)
if(parameter_sets_info_present_flag[i]) {		
num_seq_parameter_set_minus1[i]	5	ue(v)
for(j = 0; j <= num_seq_parameter_set_minus1[i]; j++)		
seq_parameter_set_id_delta[i][j]	5	ue(v)
num_subset_seq_parameter_set_minus1[i]	5	ue(v)
for(j = 0; j <= num_subset_seq_parameter_set_minus1[i]; j++)		
subset_seq_parameter_set_id_delta[i][j]	5	ue(v)
num_pic_parameter_set_minus1[i]	5	ue(v)
for(j = 0; j <= num_pic_parameter_set_minus1[i]; j++)		
pic_parameter_set_id_delta[i][j]	5	ue(v)
} else		
parameter_sets_info_src_layer_id_delta[i]	5	ue(v)
if(bitstream_restriction_info_present_flag[i]) {		
motion_vectors_over_pic_boundaries_flag[i]	5	u(1)
max_bytes_per_pic_denom[i]	5	ue(v)
max_bits_per_mb_denom[i]	5	ue(v)
log2_max_mv_length_horizontal[i]	5	ue(v)
log2_max_mv_length_vertical[i]	5	ue(v)
num_reorder_frames[i]	5	ue(v)
max_dec_frame_buffering[i]	5	ue(v)
}		
if(layer_conversion_flag[i]) {		
conversion_type_idc[i]	5	ue(v)
for(j=0; j < 2; j++) {		
rewriting_info_flag[i][j]	5	u(1)
if(rewriting_info_flag[i][j]) {		
rewriting_profile_level_idc[i][j]	5	u(24)
rewriting_avg_bitrate[i][j]	5	u(16)
rewriting_max_bitrate[i][j]	5	u(16)
}		
}		
}		
}		
if(priority_layer_info_present_flag) {		
pr_num_dId_minus1	5	ue(v)
for(i = 0; i <= pr_num_dId_minus1; i++) {		
pr_dependency_id[i]	5	u(3)
pr_num_minus1[i]	5	ue(v)
for(j = 0; j <= pr_num_minus1; j++) {		
pr_id[i][j]	5	ue(v)
pr_profile_level_idc[i][j]	5	u(24)
pr_avg_bitrate[i][j]	5	u(16)
pr_max_bitrate[i][j]	5	u(16)
}		
}		
}		

if(priority_id_setting_flag) {		
PriorityIdSettingUriIdx = 0		
do		
priority_id_setting_uri[PriorityIdSettingUriIdx]	5	b(8)
while(priority_id_setting_uri[PriorityIdSettingUriIdx++] != 0)		
}		
}		

G.13.1.2 Layers not present SEI message syntax

layers_not_present(payloadSize) {	C	Descriptor
num_layers	5	ue(v)
for(i = 0; i < num_layers; i++) {		
layer_id[i **]**	5	u(8)
}		
}		

G.13.1.3 Layer dependency change SEI message syntax

layer_dependency_change (payloadSize) {	C	Descriptor
num_layers_minus1	5	ue(v)
for(i = 0; i <= num_layers_minus1; i++) {		
layer_id[i **]**	5	u(8)
layer_dependency_info_present_flag[i **]**	5	u(1)
if (layer_dependency_info_present_flag[i]) {		
num_directly_dependent_layers[i **]**	5	ue(v)
for (j = 0; j < num_directly_dependent_layers[i]; j++)		
directly_dependent_layer_id_delta_minus1[i **][** j **]**	5	ue(v)
} else {		
layer_dependency_info_src_layer_id_delta_minus1[i **]**	5	ue(v)
}		
}		
}		

G.13.1.4 Sub-picture scalable layer SEI message syntax

sub_pic_scalable_layer(payloadSize) {	C	Descriptor
layer_id	5	ue(v)
}		

G.13.1.5 Non-required layer representation SEI message syntax

non_required_layer_rep(payloadSize) {	C	Descriptor
num_info_entries_minus1	5	ue(v)
for(i = 0; i <= num_info_entries_minus1; i++) {		
entry_dependency_id[i **]**	5	u(3)
num_non_required_layer_rep_minus1[i **]**	5	ue(v)
for(j = 0; j <= num_non_required_layer_rep_minus1**[** i **]**; j++) {		
non_required_layer_rep_dependency_id[i **][** j **]**	5	u(3)
non_required_layer_rep_quality_id[i **][** j **]**	5	u(4)
}		
}		
}		

G.13.1.6 Priority layer information SEI message syntax

priority_layer_info(payloadSize) {	C	Descriptor
pr_dependency_id	All	u(3)
num_priority_ids	5	u(4)
for(i = 0; i < num_priority_ids; i++) {		
alt_priority_id[i **]**	5	u(6)
}		
}		

G.13.1.7 Scalable nesting SEI message syntax

scalable_nesting(payloadSize) {	C	Descriptor
all_layer_representations_in_au_flag	5	u(1)
if(all_layer_representations_in_au_flag = = 0) {		
num_layer_representations_minus1	5	ue(v)
for(i = 0; i <= num_layer_representations_minus1; i++) {		
sei_dependency_id[i **]**	5	u(3)
sei_quality_id[i **]**	5	u(4)
}		
sei_temporal_id	5	u(3)
}		
while(!byte_aligned( ))		
sei_nesting_zero_bit /* equal to 0 */	5	f(1)
do		
sei_message( )	5	
while(more_rbsp_data( ))		
}		

G.13.1.8 Base layer temporal HRD SEI message syntax

base_layer_temporal_hrd (payloadSize) {	C	Descriptor
num_of_temporal_layers_in_base_layer_minus1	5	ue(v)
for(i = 0; i < num_of_temporal_layers_in_base_layer_minus1; i++){		
temporal_id[i **]**	5	u(3)
timing_info_present_flag[i **]**	5	u(1)
if(timing_info_present_flag[i]) {		
num_units_in_tick[i **]**	5	u(32)
time_scale[i **]**	5	u(32)
fixed_frame_rate_flag[i **]**	5	u(1)
}		
nal_hrd_parameters_present_flag[i **]**	5	u(1)
if(nal_hrd_parameters_present_flag[i])		
hrd_parameters( )		
vcl_hrd_parameters_present_flag[i **]**	5	u(1)
if(vcl_hrd_parameters_present_flag[i])		
hrd_parameters( )		
if(nal_hrd_parameters_present_flag[i] || vcl_hrd_parameters_present_flag[i])		
low_delay_hrd_flag[i **]**	5	u(1)
pic_struct_present_flag[i **]**	5	u(1)
}		
}		

G.13.1.9 Quality layer integrity check SEI message syntax

quality_layer_integrity_check(payloadSize) {	C	Descriptor
num_info_entries_minus1	5	ue(v)
for(i = 0; i <= num_info_entries_minus1; i++) {		
entry_dependency_id[i **]**	5	u(3)
quality_layer_crc[i **]**	5	u(16)
}		
}		

G.13.1.10 Redundant picture property SEI message syntax

redundant_pic_property(payloadSize) {	C	Descriptor
num_dId_minus1	5	ue(v)
for(i = 0; i <= num_dId_minus1; i++) {		
dependency_id[i **]**	5	u(3)
num_qId_minus1[i **]**	5	ue(v)
for(j = 0; j <= num_qId_minus1[i]; j++) {		
quality_id[i **][** j **]**	5	u(4)
num_redundant_pics_minus1[i **][** j **]**	5	ue(v)
for(k = 0; k <= num_redundant_pics_minus1[i][j]; k++) {		
redundant_pic_cnt_minus1[i **][** j **][** k **]**	5	ue(v)
pic_match_flag[i **][** j **][** k **]**	5	u(1)
if(!pic_match_flag[i][j][k]) {		
mb_type_match_flag[i **][** j **][** k **]**	5	u(1)
motion_match_flag[i **][** j **][** k **]**	5	u(1)
residual_match_flag[i **][** j **][** k **]**	5	u(1)
intra_samples_match_flag[i **][** j **][** k **]**	5	u(1)
}		
}		
}		
}		
}		

G.13.1.11 Temporal level zero dependency representation index SEI message syntax

tl0_dep_rep_index(payloadSize) {	C	Descriptor
tl0_dep_rep_idx	5	u(8)
effective_idr_pic_id	5	u(16)
}		

G.13.1.12 Temporal level switching point SEI message syntax

tl_switching_point(payloadSize) {	C	Descriptor
delta_frame_num	5	se(v)
}		

G.13.2 SEI payload semantics

Depending on payloadType, the corresponding SEI message semantics are extended as follows.

– If payloadType is equal to 3, 8, 19, 20, or 22, the following applies.

  – If the SEI message is not included in a scalable nesting SEI message, it applies to the layer representation of the current access unit with dependency_id and quality_id equal to 0.

  – Otherwise (the SEI message is included in a scalable nesting SEI message), it applies to all layer representations of the current access unit with DQId equal to ((sei_dependency_id[i] << 4) + sei_quality_id[i]) for any i in the range of 0 to num_layer_representations_minus1, inclusive.

– Otherwise, if payloadType is equal to 2, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 21, 23, 25, 27, 34, or 35, the following applies.

  – If the SEI message is not included in a scalable nesting SEI message, it applies to the dependency representation of the current access unit with dependency_id equal to 0.

  – Otherwise (the SEI message is included in a scalable nesting SEI message), the value of sei_quality_id[i] shall be equal to 0 for any i in the range of 0 to num_layer_representations_minus1, inclusive, and it applies to all dependency representations of the current access unit with dependency_id equal to sei_dependency_id[i] for any i in the range of 0 to num_layer_representations_minus1, inclusive. When payloadType is equal to 10 for the SEI message that is included in a scalable nesting SEI message, the semantics for sub_seq_layer_num of the sub-sequence information SEI message is modified as follows.

    sub_seq_layer_num specifies the sub-sequence layer number of the current picture. When the current picture resides in a sub-sequence whose first picture in decoding order is an IDR picture, the value of sub_seq_layer_num shall be equal to 0. For a non-paired reference field, the value of sub_seq_layer_num shall be equal to 0. sub_seq_layer_num shall be in the range of 0 to 255, inclusive.

– Otherwise, if payloadType is equal to 0 or 1, the following applies.

  – If the SEI message is not included in a scalable nesting SEI message, the following applies. When the SEI message and all other SEI messages with payloadType equal to 0 or 1 not included in a scalable nesting SEI message are used as the buffering period and picture timing SEI messages for checking the bitstream conformance according to Annex C and the decoding process specified in clauses 2-9 of this Recommendation | International Standard is used, the bitstream shall be conforming to this Recommendation | International Standard.

  – Otherwise (the SEI message is included in a scalable nesting SEI message), the following applies. When the SEI message and all other SEI messages with payloadType equal to 0 or 1 included in a scalable nesting SEI message with identical values of sei_temporal_id, sei_dependency_id[i], and sei_quality_id[i] are used as the buffering period and picture timing SEI messages for checking the bitstream conformance according to Annex C, the bitstream that would be obtained by invoking the bitstream extraction process as specified in subclause G.8.8.1 with tIdTarget equal to sei_temporal_id, dIdTarget equal to sei_dependency_id[i], and qIdTarget equal to sei_quality_id[i] shall be conforming to this Recommendation | International Standard.

– Otherwise (all remaining payloadType values), the corresponding SEI message semantics are not extended.

When an SEI NAL unit contains an SEI message with payloadType in the range of 24 to 35, inclusive, it shall not contain any SEI messages with payloadType less than 24 and the first SEI message in the SEI NAL unit shall have payloadType in the range of 24 to 35, inclusive.

When a scalable nesting SEI message (payloadType is equal to 30) is present in an SEI NAL unit, it shall be the only SEI message in the SEI NAL unit.

G.13.2.1 Scalability information SEI message semantics

Scalability information SEI messages contain scalability information for subsets of the bitstream. Each of these subsets is referred to as a scalable layer and is associated with a layer identifier. A scalable layer represents a set of coded slice NAL units with the same values of dependency_id, quality_id, and temporal_id and associated non-VCL NAL units. The bitstream subset that is required for decoding the scalable layer is referred to as the scalable layer representation or the representation of the scalable layer. Information such as bit rate, frame rate, and spatial resolution, among others, are signalled for the representation of each scalable layer as specified in the following.

Each scalable layer is associated with a layer identifier. A larger value of the layer identifier indicates a higher scalable layer. The scalable layer with layer identifier equal to 0 is the lowest scalable layer or scalable layer 0. Decoding of a scalable layer is independent of any higher scalable layer but may be dependent on a lower scalable layer. Therefore, the lowest scalable layer can be decoded independently, decoding of scalable layer 1 may be dependent on scalable layer 0, decoding of scalable layer 2 may be dependent on scalable layers 0 and 1, and so on. Decoding of a scalable layer requires the presence of the scalable layer itself and all the lower scalable layers the scalable layer directly or indirectly depends on. Scalable layer A is directly dependent on scalable layer B if there is at least one coded slice in scalable layer A that refers to one or more coded slices of scalable layer B through inter prediction or inter-layer prediction. Scalable layer A is indirectly dependent on layer B if scalable layer A is not directly dependent on scalable layer B but decoding of scalable layer A requires the presence of at one or more coded slices of the layer B.

NOTE 1 – For example, layer identifier values may be allocated as equal to (((dependency_id << 4) + quality_id) * 8 + temporal_id).

When present, a scalability information SEI message shall appear in an access unit for which all the VCL NAL units have nal_unit_type equal to 5 or idr_flag equal to 1. The contents of the scalability information SEI message with the exception of the layer dependency information, for which a change may be signalled by the presence of one or more layer dependency change SEI messages, apply for all access units until, but excluding, the access unit that contains the next scalability information SEI message. The set of access units for which the current SEI message applies is referred to as the target access unit set. Layer dependency information for a particular scalable layer is specified by the syntax elements num_directly_dependent_layers, directly_dependent_layer_id_delta_minus1, and layer_dependency_info_src_layer_id_delay. When a scalability information SEI message specifies that a scalable layer A does not directly or indirectly depend on a scalable layer B, this relationship applies to the complete target access unit set. When a scalability information SEI message specifies that a scalable layer A does directly or indirectly depend on a scalable layer B, a following layer dependency change SEI message may specify that this dependency does not apply for a subset of the target access unit set.

temporal_id_nesting_flag specifies whether inter prediction is additionally restricted for the target access unit set. Dependent on temporal_id_nesting_flag, the following applies.

– If temporal_id_nesting_flag is equal to 0, additional constraints may not obeyed.

– Otherwise (temporal_id_nesting_flag is equal to 1), the following constraint shall be obeyed for layer representations with any combination of dependency_id and quality_id values present in the target access unit set.

For each access unit auA with temporal_id equal to tIdA, an access unit auB with temporal_id equal to tIdB and tIdB less than or equal to tIdA shall not be referenced by inter prediction when there exists an access unit auC with temporal_id equal to tIdC and tIdC less than tIdB, which follows the access unit auB and precedes the access unit auA in decoding order.

NOTE 2 – The syntax element temporal_id_nesting_flag is used to indicate that temporal up-switching, i.e., switching from decoding of up to a specific temporal_id tIdN to decoding up to a temporal_id tIdM > tIdN, is always possible.

priority_layer_info_present_flag equal to 1 specifies that priority layer information SEI messages are present in the target access unit set and characteristic information of priority layers is present in the current scalability information SEI message. priority_layer_info_present_flag equal to 0 specifies that characteristic information of priority layers is not present in the current scalability information SEI message.

priority_id_setting_flag equal to 1 specifies that the syntax element priority_id_setting_uri is present and the priority_id value calculation method description is known. priority_id_setting_flag equal to 0 specifies that the syntax element priority_id_setting_uri is not present.

num_layers_minus1 plus 1 specifies the number of scalable layers contained in the target access unit set. The value of num_layers_minus1 shall be in the range of 0 to 2047, inclusive.

layer_id[i **]** specifies the layer identifier of the i-th scalable layer specified in the SEI message. layer_id[i] shall be in the range of 0 to 2047, inclusive.

From here to the end of this subclause, the scalable layer with layer identifier equal to the current value of layer_id[i] is referred to as the current scalable layer, and the representation of the current scalable layer is referred to as the current scalable layer representation.

priority_id[i] specifies that all VCL NAL units of the current scalable layer representation have a value of priority_id that is less than or equal to priority_id[i].

discardable_flag[i] equal to 1 specifies that all VCL NAL units of the current scalable layer have discardable_flag equal to 1. discardable_flag[i] equal to 0 specifies that the current scalable layer may contain a VCL NAL units with discardable_flag equal to 0.

dependency_id[i **]**, **quality_id[** i **]**, and **temporal_id[** i **]** are equal to dependency_id, quality_id, and temporal_id, respectively, of the NAL units in the current scalable layer. The value of dependency_id is identical in all VCL NAL units of the current scalable layer. The value of quality_id is identical in all VCL NAL units of the current scalable layer. The value of temporal_id is identical in all VCL NAL units of the current scalable layer.

sub_pic_layer_flag[i **]** equal to 1 specifies that the current scalable layer consists of sub-pictures. Each sub-picture consists of a proper subset of coded slices of a layer representation. sub_pic_layer_flag[i] equal to 0 specifies that no sub-pictures are associated with the current scalable layer in this SEI message.

A scalable layer consisting of sub-pictures is also referred to as a sub-picture layer. Any coded slice that is not included in the scalable layer representation of a sub-picture layer shall not be referred to in inter prediction or inter-layer prediction for decoding of the sub-picture layer.

NOTE 3 – The mapping of each sub-picture to a scalable layer may be signalled by the sub-picture scalable layer information SEI message.

sub_region_layer_flag[i **]** equal to 1 specifies that the current scalable layer consists of a region as specified later in the semantics of the scalability information SEI message. sub_region_layer_flag[i] equal to 0 specifies that the current scalable layer does not represent a region as specified later in the semantics of the scalability information SEI message.

iroi_division_info_present_flag[i **]** equal to 1 specifies that the region that is represented by the current scalable layer is divided along macroblock boundaries into multiple rectangular regions-of-interest, referred to as interactive regions-of-interest (IROIs), and the IROI division information is explicitly signalled in the scalability information SEI message. iroi_division_info_present_flag[i] equal to 0 specifies that the IROI division information for the current scalable layer is not present in the scalability information SEI message.

All coded slices covering a subset of the region of an IROI form the IROI. Any coded slice that is not included in the scalable layer representation of the IROI shall not be referred to in inter prediction or inter-layer prediction for decoding of the IROI.

profile_level_info_present_flag[i **]** equal to 1 specifies that profile_idc, constraint_set0_flag, constraint_set1_flag, constraint_set2_flag, constraint_set3_flag, and level_idc applicable for the current scalable layer representation are specified by the value of layer_profile_level_idc[i] as specified subsequently.

When profile_level_info_present_flag[i] is equal to 0, profile_idc, constraint_set0_flag, constraint_set1_flag, constraint_set2_flag, constraint_set3_flag, and level_idc applicable for the current scalable layer representation are not present in the scalability information SEI message.

bitrate_info_present_flag[i **]** equal to 1 specifies that the bit rate information for the current scalable layer representation is present in the scalability information SEI message. bitrate_info_present_flag[i] equal to 0 specifies that the bit rate information for the current scalable layer representation is not present in the scalability information SEI message.

frm_rate_info_present_flag[i **]** equal to 1 specifies that the frame rate information for the current scalable layer is present in the scalability information SEI message. frm_rate_info_present_flag[i] equal to 0 specifies that the frame rate information for the current scalable layer is not present in the scalability information SEI message.

frm_size_info_present_flag[i **]** equal to 1 specifies that the frame size information for the current scalable layer is present in the scalability information SEI message. frm_size_info_present_flag[i] equal to 0 specifies that the frame size information for the current scalable layer is not present in the scalability information SEI message.

layer_dependency_info_present_flag[i **]** equal to 1 specifies that the layer dependency information for the current scalable layer is present in the scalability information SEI message. layer_dependency_info_present_flag**[** i **]** equal to 0 specifies that layer_dependency_info_src_layer_id_delta[i] is present in the scalability information SEI message.

parameter_sets_info_present_flag[i **]** equal to 1 specifies that the values of seq_parameter_set_id of the sequence parameter set and subset sequence parameter set and the values of pic_parameter_set_id of the picture parameter sets that are referred to by the VCL NAL units of the current scalable layer representation are present in the scalability information SEI message. parameter_sets_info_present_flag[i] equal to 0 specifies that parameter_sets_info_src_layer_id_delta[i] is present in the scalability information SEI message.

bitstream_restriction_info_present_flag[i **]** equal to 1 specifies that the bitstream restriction information for the current scalable layer is present in the scalability information SEI message. bitstream_restriction_info_present_flag[i] equal to 0 specifies that the bitstream restriction information for the current scalable layer is not present in the scalability information SEI message.

exact_inter_layer_pred_flag[i **]** equal to 1 specifies that there is no mismatch in the inter-layer prediction reference signal when decoding the current scalable layer representation compared to the inter-layer prediction reference signal when the scalable layer representation was encoded. exact_inter_layer_pred_flag[i] equal to 0 specifies that a mismatch may exist.

NOTE 4 – The mismatch of the inter-layer prediction reference signal for encoding and decoding may be present, for example, because NAL units with quality_id greater than 0 that were used for inter-prediction during the encoding process are not included in the current scalable layer representation.

exact_sample_value_match_flag[i **]** specifies the exact sample value match of the sub-picture layer or the IROIs within the current scalable layer.

When sub_pic_layer_flag[i] is equal to 1, the following applies.

– Let scalLayerRepA be the set of all layer representations of the target access unit set that contain coded slices of the sub-picture layer.

– exact_sample_value_match_flag[i] equal to 1 specifies that the value of each reconstructed sample for decoding the sub-picture layer representation is exactly the same as the value of the sample at the same location that would be reconstructed when all the coded slices in scalLayerRepA were decoded.

– exact_sample_value_match_flag[i] equal to 0 specifies that the value of each reconstructed sample for decoding the sub-picture layer representation need not be the same as the value of the sample at the same location that would be reconstructed when all the coded slices in scalLayerRepA were decoded.

When iroi_division_info_present_flag[i] is equal to 1, for each IROI, the following applies.

– Let scalLayerRepB be the set of all the layer representations of the target access unit set that contain coded slices of the IROI.

– exact_sample_value_match_flag[i] equal to 1 specifies that the value of each reconstructed sample for decoding the IROI is exactly the same as the value of the sample at the same location that would be reconstructed when all the coded slices in scalLayerRepB were decoded.

– exact_sample_value_match_flag[i] equal to 0 specifies that the value of each reconstructed sample for decoding the IROI need not be the same as the value of the sample at the same location that would be reconstructed when all the coded slices in scalLayerRepB were decoded.

NOTE 5 – When disable_deblocking_filter_idc is equal to 2 in all slices in the target access unit set, exact_sample_value_match_flag should be equal to 1.

layer_conversion_flag[i **]** equal to 1 specifies that the representation of the current scalable layer can be converted into an alternative set of access units that conform to one or more of the profiles specified in Annex A and gives exactly the same decoding result as the current scalable layer representation and that this conversion can be done without full reconstruction and re-encoding. layer_conversion_flag[i] equal to 0 specifies that such a conversion of the current scalable layer representation may not be possible.

layer_output_flag[i **]** equal to 1 specifies that the decoding result for the current scalable layer representation is intended for output. layer_output_flag[i] equal to 0 specifies that the decoding result for the current scalable layer representation is not intended for output.

NOTE 6 – The decoding result for a scalable layer representation with layer_output_flag[i] equal to 0 may be inappropriate for output due to the low visual quality.

layer_profile_level_idc[i] specifies the profile and level compliancy of the representation of the current scalable layer. layer_profile_level_idc[i] is the exact copy of the three bytes comprised of profile_idc, constraint_set0_flag, constraint_set1_flag, constraint_set2_flag, constraint_set3_flag, reserved_zero_4bits and level_idc, if these syntax elements were used to specify the profile and level compliancy of the representation of the current scalable layer as specified in Annex A and Annex G.

avg_bitrate[i **]** specifies the average bit rate of the representation of the current scalable layer. The average bit rate for the representation of the current scalable layer in bits per second is given by BitRateBPS(avg_bitrate[i]) with the function BitRateBPS( ) being specified by

$$\text{BitRateBPS}(x) = (x \,\&\, 0x3fff) * 10^{(2 + (x >> 14))} \tag{G-372}$$

All NAL units of the representation of the current scalable layer are taken into account in the calculation. The average bit rate is derived according to the access unit removal time specified in Annex C of this Recommendation | International Standard. In the following, bTotal is the number of bits in all NAL units of the representation of the current scalable layer succeeding a scalability information SEI message (including the bits of the NAL units of the representation of the current scalable layer in the access unit) and preceding the next access unit (in decoding order) including a scalability information SEI message (if present) or the end of the stream (otherwise). t_1 is the removal time (in seconds) of the current access unit, and t_2 is the removal time (in seconds) of the latest access unit (in decoding order) before the next scalability information SEI message (if present) or the end of the stream (otherwise).

The following conditions shall be fulfilled with x specifying the value of avg_bitrate[i].

– If t_1 is not equal to t_2, the following condition shall be true.

$$(x \,\&\, 0x3fff) == \text{Round}(\text{bTotal} \div ((t_2 - t_1) * 10^{(2 + (x >> 14))})) \tag{G-373}$$

– Otherwise (t_1 is equal to t_2), the following condition shall be true.

$$(x \,\&\, 0x3fff) == 0 \tag{G-374}$$

max_bitrate_layer[i **]** specifies the maximum bit rate of the current scalable layer. The maximum bit rate of the current scalable layer in bits per second is given by BitRateBPS(max_bitrate_layer[i]) with the function BitRateBPS( ) being specified in Equation G-372. The maximum bit rate of the current scalable layer is calculated based on a time window specified by max_bitrate_calc_window[i].

max_bitrate_layer_representation[i **]** specifies the maximum bit rate of the representation of the current scalable layer. The maximum bit rate of the representation of the current scalable layer in bits per second is given by BitRateBPS(max_bitrate_layer_representation[i]) with the function BitRateBPS( ) being specified in Equation G-372. The maximum bit rate of the representation of the current scalable layer is calculated based on a time window specified by max_bitrate_calc_window[i].

max_bitrate_calc_window[i **]** specifies the length of the time window in units of 1/100 second, based on which max_bitrate_layer[i] and max_bitrate_layer_representation[i] are calculated.

constant_frm_rate_idc[i **]** specifies whether the output frame rate of the representation of the current scalable layer is constant. If the value of avg_frm_rate[i] as specified in below is constant over all temporal segments of the scalable layer representation, the frame rate is constant; otherwise the frame rate is not constant. constant_frm_rate_idc[i] equal to 0 specifies that the frame rate is not constant. constant_frm_rate_idc[i] equal to 1 specifies that the frame rate is constant, and constant_frm_rate_idc[i] equal to 2 specifies that the frame rate may be or may be not constant. The value of constantFrameRate shall be in the range of 0 to 2, inclusive.

avg_frm_rate[i **]** specifies the average frame rate, in units of frames per 256 seconds, of the representation of the current scalable layer. The semantics of avg_frm_rate[i] is identical to the semantics of average_frame_rate in sub-sequence layer characteristics SEI message when accurate_statistics_flag is equal to 1, except that herein the set of NAL units in the range of sub-sequence layers is replaced by the set of NAL units of the representation of the current scalable layer.

frm_width_in_mbs_minus1[i **]** and **frm_height_in_mbs_minus1[** i **]** specify the width and height, respectively, of the representation of the current scalable layer. When frame_mbs_only_flag is equal to 0, (frm_height_in_mbs_minus1[i] + 1) % 2 shall be equal to 0.

When sub_pic_layer_flag[i] is equal to 0, the width of a decoded picture of the representation of the current scalable layer is equal to frm_width_in_mbs_minus1[i] + 1 macroblocks, the height of a decoded picture of the representation of the current scalable layer is equal to ((frm_height_in_mbs_minus1[i] + 1) / (1 + field_pic_flag)) macroblocks.

When sub_pic_layer_flag[i] is equal to 1, the width of a decoded sub-picture of the representation of the current scalable layer is equal to frm_width_in_mbs_minus1[i] + 1 macroblocks, the height of a decoded sub-picture of the representation of the current scalable layer is equal to ((frm_height_in_mbs_minus1[i] + 1) / (1 + field_pic_flag)) macroblocks.

The variable FrmWidthInMbs[i] is derived as equal to (frm_width_in_mbs_minus1[i] + 1). The variable FrmHeightInMbs[i] is derived as equal to frm_height_in_mbs_minus1[i] + 1 . The variable FrmSizeInMbs[i] specifies the frame size in unit of macroblocks and is derived as equal to FrmWidthInMbs[i] * FrmHeightInMbs[i].

base_region_layer_id[i **]** specifies the layer identifier of scalable layer slA. The area of each decoded picture of the current scalable layer representation represents a subset of the area of the corresponding decoded picture of the scalable layer representation of the scalable layer slA. The current scalable layer represents a region within scalable layer slA, and the scalable layer slA is referred to as the base region.

dynamic_rect_flag[i **]** equal to 1 specifies that the region represented by the current scalable layer representation is a dynamically changing rectangular subset of the base region. dynamic_rect_flag[i] equal to 1 specifies that the region represented by the current scalable layer representation is a fixed rectangular subset of the base region and is specified by horizontal_offset[i], vertical_offset[i], region_width[i] and vertical_offset[i].

horizontal_offset[i **], vertical_offset[** i **], region_width[** i **]** and **region_height[** i **]** specify the position and size of the region represented by the current scalable layer. When frame_mbs_only_flag is equal to 0, (vertical_offset[i] + 1) % 2 and (region_height[i] + 1) % 2 shall both be equal to 0.

When sub_pic_layer_flag[i] is equal to 0, the horizontal and vertical offsets of the top-left pixel of the rectangular region represented by a decoded picture of the current scalable layer representation, relative to the top-left pixel of the base region, in units of luma samples of a decoded frame in the base region, are equal to horizontal_offset[i] and vertical_offset[i] / (1 + field_pic_flag), respectively, and the width and height of the rectangular region represented by a decoded picture of the current scalable layer representation, in units of luma samples of a decoded frame in the base region, are equal to region_width[i] and region_height[i] / (1 + field_pic_flag), respectively.

When sub_pic_layer_flag[i] is equal to 1, the horizontal and vertical offsets of the top-left pixel of the rectangular region represented by a decoded sub-picture of the current scalable layer representation, relative to the top-left pixel of the base region, in units of luma samples of a decoded frame in the base region, are equal to horizontal_offset[i] and vertical_offset[i] / (1 + field_pic_flag), respectively, and the width and height of the rectangular region represented by a decoded picture of the current scalable layer representation, in units of luma samples of a decoded frame in the base region, are equal to region_width[i] and region_height[i] / (1 + field_pic_flag), respectively.

roi_id[i] indicates the region-of-interest identifier of the region represented by the current scalable layer.

Let layerIdA and layerIdB with layerIdA less than layerIdB be the layer identifiers of the scalable layers A and B, respectively, both of which having sub_pic_layer_flag[i] equal to 1, and roiIdA and roidIdB be the region-of-interest identifiers of the scalable layers A and B respectively. roiIdA shall not be greater than roidIdB.

iroi_grid_flag[i] specifies how the IROI division information is coded for the current scalable layer. iroi_grid_flag[i] equal to 1 specifies that all IROIs for the current scalable layer have the same size. iroi_grid_slice_flag[i] equal to 0 specifies that the IROIs for the current scalable layer may have different sizes.

grid_width_in_mbs_minus1[i] and **grid_height_in_mbs_minus1**[i] specify the size of the IROI grids in the current scalable layer. When frame_mbs_only_flag is equal to 0, (grid_height_in_mbs_minus1 + 1) % 2 shall be equal to 0.

The width and height of a decoded sub-picture of the IROI grids in the current scalable layer are equal to grid_width_in_mbs_minus1[i] + 1 and (grid_height_in_mbs_minus1[i] + 1) / (1 + field_pic_flag), respectively, in unit of macroblocks, with the following exceptions:

– When (FrmWidthInMbs[i] % (grid_width_in_mbs_minus1[i] + 1)) is not equal to 0, the decoded sub-picture of an IROI in the very right grid column of the current scalable layer have a width equal to (FrmWidthInMbs[i] % (grid_width_in_mbs_minus1[i] + 1)) macroblocks.

– When (FrmHeightInMbs[i] % (grid_height_in_mbs_minus1[i] + 1)) is not equal to 0, the decoded sub-picture of an IROI in the very bottom grid row of the current scalable layer have a height equal to (FrmHeightInMbs[i] % (grid_height_in_mbs_minus1[i] + 1)) / (1 + field_pic_flag) macroblocks.

num_rois_minus1[i] plus 1 specifies the number of IROIs in the current scalable layer.

first_mb_in_roi[i][j] specifies the macroblock address of the first macroblock of the j-th IROI in the current scalable layer. The value of first_mb_in_roi[i][j] shall be equal to the syntax element first_mb_in_slice of the coded slices that belong to the current scalable layer and that cover the top-left macroblock of the j-th IROI. For each combination of i, j, and k, with k not equal to j, first_mb_in_roi[i][j] shall be different then first_mb_in_roi[i][k].

roi_width_in_mbs_minus1[i][j] and **roi_height_in_mbs_minus1**[i][j] specify the size of the IROIs in the current scalable layer. When frame_mbs_only_flag is equal to 0, (roi_height_in_mbs_minus1 + 1) % 2 shall be equal to 0.

The width and height of a decoded sub-picture of the j-th IROI in the current scalable layer are equal to roi_width_in_mbs_minus1[i][j] + 1 and (roi_height_in_mbs_minus1[i][j] + 1) / (1 + field_pic_flag), respectively, in unit of macroblocks.

num_directly_dependent_layers[i **]** specifies the number of scalable layers that the current scalable layer is directly dependent on. The value of num_directly_dependent_layers shall be in the range of 0 to 255, inclusive.

directly_dependent_layer_id_delta_minus1[i **][** j **]** plus 1 specifies the difference between layer_id[i] and the layer identifier of the j-th scalable layer that the current scalable layer is directly dependent on. The layer identifier of the j-th directly dependent scalable layer is equal to (layer_id[i] – directly_dependent_layer_id_delta_minus1[i][j] – 1).

layer_dependency_info_src_layer_id_delta[i] greater than 0 specifies that the current scalable layer has the same layer dependency information as the layer with layer identifier equal to (layer_id[i] – layer_dependency_info_src_layer_id_delta[i]). layer_dependency_info_src_layer_id_delta[i] equal to 0 specifies that the layer dependency information of the current scalable layer is not present in the SEI message.

num_seq_parameter_set_minus1[i **]** plus 1 specifies the number of different sequence parameter sets that are referred to by the VCL NAL units of the current scalable layer representation.

seq_parameter_set_id_delta[i **][** j **]** specifies the smallest value of the seq_parameter_set_id of any sequence parameter set required for decoding the representation of the current scalable layer, if j is equal to 0. Otherwise (j is greater than 0), seq_parameter_set_id_delta[i][j] specifies the difference between the value of the seq_parameter_set_id of the j-th required sequence parameter set and the value of the seq_parameter_set_id of the (j – 1)-th required sequence parameter set for decoding the representation of the current scalable layer. The sequence parameter sets are logically ordered in ascending order of the value of seq_parameter_set_id.

num_subset_seq_parameter_set_minus1[i **]** plus 1 specifies the number of different subset sequence parameter sets that are referred to by the VCL NAL units of the current scalable layer representation.

subset_seq_parameter_set_id_delta[i **][** j **]** specifies the smallest value of the seq_parameter_set_id of any subset sequence parameter set required for decoding the representation of the current scalable layer, if j is equal to 0. Otherwise (j is greater than 0), subset_seq_parameter_set_id_delta[i][j] specifies the difference between the value of the seq_parameter_set_id of the j-th required subset sequence parameter set and the value of the seq_parameter_set_id of the (j – 1)-th required subset sequence parameter set for decoding the representation of the current scalable layer. The subset sequence parameter sets are logically ordered in ascending order of the value of seq_parameter_set_id.

num_pic_parameter_set_minus1[i **]** plus 1 specifies the number of different picture parameter sets that are referred to by the VCL NAL units of the current scalable layer representation.

pic_parameter_set_id_delta[i **][** j **]** specifies the smallest value of the pic_parameter_set_id of any picture parameter set required for decoding the representation of the current scalable layer, if j is equal to 0. Otherwise (j is greater than 0), pic_parameter_set_id_delta[i][j] specifies the difference between the value of the pic_parameter_set_id of the j-th required picture parameter set and the value of the pic_parameter_set_id of the (j – 1)-the required picture parameter set for decoding the representation of the current scalable layer. The picture parameter sets are logically ordered in ascending order of the value of pic_parameter_set_id.

parameter_sets_info_src_layer_id_delta[i] greater than 0 specifies that the values of seq_parameter_set_id of the sequence parameter sets and subset sequence parameter sets and the values of pic_parameter_set_id of the picture parameter sets that are referred to by the VCL NAL units of the current scalable layer representation are the same as those for the scalable layer representation with layer identifier equal to (layer_id[i] – parameter_sets_info_src_layer_id_delta[i]).

parameter_sets_info_src_layer_id_delta[i] equal to 0 specifies that the values of seq_parameter_set_id of the sequence parameter sets and subset sequence parameter sets and the values of pic_parameter_set_id of the picture parameter sets that are referred to by the VCL NAL units of the current scalable layer are not present in the SEI message.

motion_vectors_over_pic_boundaries_flag[i **]** specifies the value of motion_vectors_over_pic_boundaries_flag, as specified in subclause E.2.1, for the current scalable layer. When the motion_vectors_over_pic_boundaries_flag[i] syntax element is not present, motion_vectors_over_pic_boundaries_flag value for the current scalable layer shall be inferred to be equal to 1.

max_bytes_per_pic_denom[i **]** specifies the max_bytes_per_pic_denom value, as specified in subclause E.2.1, for the current scalable layer. When the max_bytes_per_pic_denom[i] syntax element is not present, the value of max_bytes_per_pic_denom for the current scalable layer shall be inferred to be equal to 2.

max_bits_per_mb_denom[i **]** specifies the max_bits_per_mb_denom value, as specified in subclause E.2.1, for the current scalable layer. When the max_bits_per_mb_denom[i] is not present, the value of max_bits_per_mb_denom for the current scalable layer shall be inferred to be equal to 1.

log2_max_mv_length_horizontal[i **]** and **log2_max_mv_length_vertical[** i **]** specify the values of log2_max_mv_length_horizontal and log2_max_mv_length_vertical, as specified in subclause E.2.1, for the current scalable layer. When log2_max_mv_length_horizontal[i] is not present, the values of log2_max_mv_length_horizontal and log2_max_mv_length_vertical for the current scalable layer shall be inferred to be equal to 16.

NOTE 7 – The maximum absolute value of a decoded vertical or horizontal motion vector component is also constrained by profile and level limits as specified in Annex A.

num_reorder_frames[i **]** specifies the value of num_reorder_frames, as specified in subclause E.2.1, for the current scalable layer. The value of num_reorder_frames[i] shall be in the range of 0 to max_dec_frame_buffering, inclusive. When the num_reorder_frames[i] syntax element is not present, the value of num_reorder_frames for the current scalable layer shall be inferred to be equal to max_dec_frame_buffering.

max_dec_frame_buffering[i **]** specifies the value of max_dec_frame_buffering, as specified in subclause E.2.1, for the current scalable layer. The value of max_dec_frame_buffering[i] shall be in the range of num_ref_frames[i] to MaxDpbSize (as specified in subclause A.3.1 or A.3.2), inclusive. When the max_dec_frame_buffering[i] syntax element is not present, the value of max_dec_frame_buffering for the current scalable layer shall be inferred to be equal to MaxDpbSize.

conversion_type_idc[i] equal to 0 specifies that tcoeff_level_prediction_flag is equal to 1 for all the coded slices of the current scalable layer representation excluding those having no_inter_layer_pred_flag equal to 1.

conversion_type_idc[i] equal to 1 specifies that the slice_header_restriction_flag in the sequence parameter sets referred to by the current scalable layer is equal to 1, and slice_skip_flag in all VCL NAL units with no_inter_layer_pred_flag equal to 0 in the current scalable layer representation is equal to 1.

conversion_type_idc[i] equal to 2 specifies that slice_header_restriction_flag in the sequence parameter sets referred to by the current scalable layer is equal to 1, and no_inter_layer_pred_flag in all VCL NAL units in the current scalable layer is equal to 1.

The value of conversion_type_idc[i] shall be in the range of 0 to 2, inclusive.

conversion_type_idc[i] equal to 0 specifies that the information specified by the syntax elements rewriting_profile_level_idc[i][j], rewriting_avg_bitrate[i][j], and rewriting_max_bitrate[i][j], when present, is correct, though the method for converting the current scalable layer representation into an alternative set of access units that conforms to one or more profiles specified in Annex A and gives exactly the same decoding result as the current scalable layer representation is unspecified.

conversion_type_idc[i] equal to 1 specifies that the alternative set of access units obtained by applying the following operations in sequential order to the current scalable layer representation complies to one or more of the profiles specified in Annex A.

1. Remove all NAL units with nal_unit_type equal to 20 and skip_slice_flag equal to 1
2. Remove all NAL units with nal_unit_type equal to 14
3. Remove the NAL unit header SVC extension from NAL units with nal_unit_type equal to 20
4. For NAL units with nal_unit_type equal to 20 and idr_flag equal to 1, set nal_unit_type equal to 5
5. For NAL units with nal_unit_type equal to 20 and idr_flag equal to 0, set nal_unit_type equal to 1
6. Remove all SEI NAL units
7. For all picture parameter set NAL units referred to by NAL units with nal_unit_type equal to 1 or 5, change the value of seq_parameter_set_id to be equal to the seq_parameter_set_id in a subset sequence parameter set NAL unit with profile_idc equal to 83 or 86
8. Remove all NAL units with nal_unit_type equal to 7
9. For all NAL units with nal_unit_type equal to 15, set nal_unit_type equal to 7, remove all the syntax elements after the syntax structure seq_parameter_set_data( ) and before the rbsp_trailing_bits( ) syntax structure, replace the three bytes starting from profile_idc as specified by rewriting_profile_level_idc[i][entropy_coding_mode_flag], when present, and change RBSP trailing bits appropriately.

conversion_type_idc[i] equal to 2 indicates that the alternative bitstream obtained by applying the following operations in sequential order to the current scalable layer representation conforms to one or more of the profiles specified in Annex A.

1. Remove all NAL units with nal_unit_type equal to 14
2. Remove the NAL unit header SVC extension from NAL units with nal_unit_type equal to 20
3. For NAL units with nal_unit_type equal to 20 and idr_flag equal to 1, set nal_unit_type equal to 5
4. For NAL units with nal_unit_type equal to 20 and idr_flag equal to 0, set nal_unit_type equal to 1
5. Remove all SEI NAL units
6. For all NAL units with nal_unit_type equal to 15, set nal_unit_type equal to 7, remove all the syntax elements after the syntax structure seq_parameter_set_data( ) and before the rbsp_trailing_bits( ) syntax structure, replace the three bytes starting from profile_idc as specified by rewriting_profile_level_idc[i][entropy_coding_mode_flag], when present, and change RBSP trailing bits appropriately.

rewriting_info_flag[i][j] equal to 1 specifies that information is present about the alternative set of access units obtained by converting the current scalable layer representation. It is asserted that the signalled information is correct, though the method for constructing the alternative set of access units is unspecified. The variable j specifies the value of entropy_coding_mode_flag for the alternative set of access units, with values for j equal to 0 or 1 indicating use of the CAVLC or CABAC entropy coding methods, respectively.

rewriting_profile_level_idc[i][j] specifies the profile compliancy of the alternative set of access units for the current scalable layer representation after conversion. rewriting_profile_level_idc[i] is the exact copy of the three bytes consist of profile_idc, constraint_set0_flag, constraint_set1_flag, constraint_set2_flag, constraint_set3_flag, reserved_zero_4bits, and level_idc, if these syntax elements were used to specify the profile and level compliancy of the alternative set of access units obtained by converting the scalable layer representation as specified in Annex A.

rewriting_avg_bitrate[i **]**[j] specifies the average bit rate of the alternative set of access units obtained by converting the representation of the current scalable layer. The average bit rate of the alternative set of access units in bits per second is given by BitRateBPS(rewriting_avg_bitrate[i][j]) with the function BitRateBPS( ) being specified in Equation G-372.

rewriting_max_bitrate[i **]**[j] specifies the maximum bit rate of the alternative set of access units obtained by converting the representation of the current scalable layer, in any one-second time window of access unit removal time as specified in Annex C. The maximum bit rate of the alternative set of access units in bits per second is given by BitRateBPS(rewriting_max_bitrate[i][j]) with the function BitRateBPS( ) being specified in Equation G-372.

pr_num_dId_minus1 plus 1 specifies the number of dependency layers for which the priority layer characteristic information is present in the SEI message. A dependency layer consists of all the VCL NAL units of the target access unit set with a particular value of dependency_id and the associated non-VCL NAL units.

pr_dependency_id[i **]** specifies the value of dependency_id of the dependency layer for which the priority layer characteristic information is signalled by the following syntax elements.

pr_num_minus1[i **]** plus 1 specifies the number of priority layers corresponding to the dependency layer with dependency_id equal to pr_dependency_id[i]. A priority layer represents the set of coded slice NAL units of a dependency layer that have a value of priority_id that is less than or equal to a specified value of priority_id and the associated non-VCL NAL units. The bitstream subset that is required for decoding the priority layer is referred to as priority layer representation. The value of ql_num_minus1 shall be in the range of 0 to the greatest value of the syntax element alt_priority_id[i] in all priority layer information SEI messages in the target access unit set, inclusive.

pr_id[i **][** j **]** specifies the identifier of the priority layer for the dependency layer with dependency_id equal to pr_dependency_id[i]. The priority layer identified by pr_dependency_id[i] and pr_id[i][j] consists of all VCL NAL units with a value of alt_priority_id[i], specified by the priority layer information SEI message, less than or equal to pr_id[i][j], and the associated non-VCL NAL units.

pr_profile_level_idc[i **][** j **]** specifies the profile and level compliancy of the priority layer representation for the priority layer identified by pr_dependency_id[i] and pr_id[i][j]. pr_profile_level_idc[i] is the exact copy of the three bytes consisting of profile_idc, constraint_set0_flag, constraint_set1_flag, constraint_set2_flag, constraint_set3_flag, reserved_zero_4bits, and level_idc, if these syntax elements were used to specify the profile and level compliancy of the bitstream subset of the priority layer representation for the priority layer identified by pr_dependency_id[i] and pr_id[i][j] as specified in Annex A or Annex G.

pr_avg_bitrate[i **][** j **]** specifies the average bit rate of the bitstream subset of the priority layer identified by ql_dependency_id[i] and ql_id[i][j]. The average bit rate of the bitstream subset of the priority layer identified by ql_dependency_id[i] and pr_id[i][j] in bits per second is given by BitRateBPS(pr_avg_bitrate[i][j]) with the function BitRateBPS( ) being specified in Equation G-372. The average bit rate is derived according to the access unit removal time specified in Annex C of the Recommendation | International Standard. In the following, bTotal is the number of bits in all NAL units of the priority layer identified by pr_dependency_id[i] and pr_id[i][j] succeeding a scalability information SEI message (including the bits of the NAL units of the quality layer identified by pr_dependency_id[i] and pr_id[i][j] in the access unit) and preceding the next access unit (in decoding order) including a scalability information SEI message (if present) or the end of the stream (otherwise). t_1 is the removal time (in seconds) of the current access unit, and t_2 is the removal time (in seconds) of the latest access unit (in decoding order) before the next scalability information SEI message (if present) or the end of the stream (otherwise).

The following conditions shall be fulfilled with x specifying the value of pr_avg_bitrate[i].

– If t_1 is not equal to t_2, the condition specified in Equation G-373 shall be fulfilled.

– Otherwise (t_1 is equal to t_2), the condition specified in Equation G-374 shall be fulfilled.

pr_max_bitrate[i **][** j **]** specifies the maximum bit rate of the bitstream subset of the priority layer identified by pr_dependency_id[i] and pr_id[i][j] in any one-second time window of access unit removal time as specified in Annex C. The maximum bit rate of the priority layer identified by pr_dependency_id[i] and pr_id[i][j] in bits per second is given by BitRateBPS(pr_max_bitrate[i][j]) with the function BitRateBPS( ) being specified in Equation G-372.

priority_id_setting_uri[PriorityIdSettingUriIdx **]** is the PriorityIdSettingUriIdx-th byte of a null-terminated string encoded in UTF-8 characters, specifying the universal resource identifier (URI) of the description of the method used to calculate the priority_id values in the NAL unit headers for the target access unit set.

G.13.2.2 Layers not present SEI message semantics

When present, this SEI message applies to the target access unit set that consists of the current access unit and all the subsequent access units, in decoding order, until the next layers not present SEI message, the next scalability information SEI message, or the end of the bitstream, whichever is the earliest in decoding order. The layers not present SEI message identifies the scalable layers indicated by the preceding scalability information SEI message that are not present in the target access unit set. A layers not present SEI message always refers to the most recent scalability SEI message in decoding order.

NOTE – Layers not present SEI messages do not have a cumulative effect.

num_layers specifies the number of scalable layers that are not present in the target access unit set. num_layers equal to 0 indicates that all scalable layers specified in the most recent scalability information SEI message in decoding order are present in the target access unit set. The value of num_layers shall be in the range of 0 to 2047, inclusive.

layer_id[i **]** specifies the identifier of a scalable layer that is not present in the target access unit set. The layer_id[i] values refer to, and shall be among to, the layer_id[i] values included in the most recent scalability information SEI message in decoding order. The value of layer_id[i] shall be in the range of 0 to 2047, inclusive.

G.13.2.3 Layer dependency change SEI message semantics

Layer dependency change SEI message specifies a change of scalable layer dependency relationship. When present, the layer dependency change SEI message applies to the target access unit set that consists of the current access unit and all the subsequent access units, in decoding order, until the next layer dependency change SEI message, the next layers not present SEI message, the next scalability information SEI message, or the end of the bitstream, whichever is the earliest in decoding order. The presence of the layer dependency change SEI message specifies that the layer dependency relationships for the scalable layers identified by layer_id[i] for all values of i changes for the target access unit set relative to the layer dependency relationship specifies by the most recent scalability information SEI message in decoding order. For a scalable layer with the layer identifier not equal to layer_id[i] for any value of i, the layer dependency relationship remains the same as specified in the most recent scalability information SEI message in decoding order.

If, according to the layer dependency information indicated in the most recent scalability information SEI message in decoding order, a scalable layer A does not directly or indirectly depend on another scalable layer B, the layer dependency change SEI message shall not specify layer dependency relationship between layers A and B. A layer dependency change SEI message always refers to the most recent scalability information SEI message in decoding order.

NOTE – Layer dependency change SEI messages do not have a cumulative effect.

num_layers_minus1 plus 1 specifies the number of scalable layers for which the layer dependency information changes for the target access unit set relative to the layer dependency relationship indicated by the most recent scalability information SEI message in decoding order. The value of num_layers_minus1 is in the range of 0 to 2047, inclusive.

layer_id[i] specifies the identifier of a scalable layer for which the layer dependency information changes. The layer_id[i] values refer to, and shall be among to, the layer_id[i] values included in the most recent scalability information SEI message in decoding order. The value of layer_id[i] shall be in the range of 0 to 2047, inclusive.

layer_dependency_info_present_flag[i] equal to 1 specifies the presence of layer dependency information for the scalable layer with layer identifier equal to layer_id[i] in the layer dependency change SEI message. layer_dependency_info_present_flag[i] equal to 0 specifies that the layer dependency information for the scalable layer with layer identifier equal to layer_id[i] is not present in the layer dependency change SEI message, and is the same as the layer dependency information for the scalable layer indicated by layer_dependency_info_src_layer_id_delta_minus1[i].

num_directly_dependent_layers[i] specifies the number of scalable layers that the scalable layer with layer identifier equal to layer_id[i] is directly dependent on. The value of num_directly_dependent_layers shall be in the range of 0 to 2047, inclusive.

directly_dependent_layer_id_delta_minus1[i][j] specifies the difference between layer_id[i] and the layer identifier of the j-th scalable layer that the scalable layer with layer identifier equal to layer_id[i] is directly dependent on. The layer identifier of the directly dependent scalable layer is equal to (layer_id[i] – directly_dependent_layer_id_delta_minus1 – 1).

layer_dependency_info_src_layer_id_delta_minus1[i] specifies the layer identifier of the scalable layer that has the same layer dependency information as the scalable layer with layer identifier equal to layer_id[i]. The layer identifier of the scalable layer that has the same layer dependency information as the scalable layer with layer identifier equal to layer_id[i] is equal to (layer_id[i] – layer_dependency_info_src_layer_id_delta_minus1[i] – 1).

G.13.2.4 Sub-picture scalable layer SEI message semantics

When present, the sub-picture scalable layer SEI message shall immediately succeed, in decoding order, a motion-constrained slice group set SEI message and both of these SEI messages shall be present in the same SEI NAL unit. The slice group set identified by the motion-constrained slice group set SEI message is referred to as the associated slice group set of the sub-picture layer information SEI message.

layer_id specifies the layer identifier of the scalable layer to which the coded slice NAL units in the associated slice group set belong to. The value of layer_id shall be in the range of 0 to 2047, inclusive.

G.13.2.5 Non-required layer representation SEI message semantics

num_info_entries_minus1 plus 1 specifies the number of the information entries following this syntax element. The value of num_info_entries_minus1 shall be in the range of 0 to 7, inclusive.

entry_dependency_id[i **]** specifies the dependency_id value of the layer representation, which is referred to as the target layer representation in the following, for which the information of non-required layer representations is specified by the following syntax elements. The instances of entry_dependency_id[i] shall appear in the increasing order of the value of entry_dependency_id[i]. The quality_id value of the target layer representation is equal to 0. A non-required layer representation for the target layer representation is not required in decoding of any other layer representation in the coded video sequence having the same dependency_id value and quality_id value as the target layer representation.

NOTE 1 – A layer representation having quality_id greater than 0 has the same set of non-required layer representations as the layer representation having the same dependency_id value and quality_id equal to 0.

num_non_required_layer_rep_minus1[i **]** plus 1 specifies the number of non-required layer representations for the target layer representation. The value of num_non_required_layer_rep_minus1[i] shall be in the range of 0 to 127, inclusive.

non_required_layer_rep_dependency_id[i **][** j **]** specifies the dependency_id value of the j-th non-required layer representation for the target layer representation.

non_required_layer_rep_quality_id[i **][** j **]** specifies the quality_id value of the j-th non-required layer representation for the target layer representation. In addition, those layer representations that have dependency_id equal to non_required_layer_rep_dependency_id[i][j] and quality_id greater than non_required_layer_rep_quality_id[i][j] are also non-required layer representations for the target layer representation. Furthermore, additional non-required layer representations are derived as follows.

– When a layer representation having dependency_id equal to A is not a non-required layer representation for the layer representation having dependency_id equal to B wherein B is greater than or equal to A, then all the non-required layer representations for the layer representation having dependency_id equal to A are also non-required layer representations for the layer representation having dependency_id equal to B.

– When dIdMax is not equal to entry_dependency_id[i] for any value of i and dIdMax is greater than entry_dependency_id[i] for at least one value of i, the following applies.

  – Let dIdC be equal to the greatest value of entry_dependency_id[i] less than dIdMax.

  – The layer representation having dependency_id equal to dIdMax shall have the same set of non-required layer representations as the layer representation having dependency_id equal to dIdC and quality_id equal to 0.

NOTE 2 – When dIdMax is less then entry_dependency_id[i] for all values of i, there is no non-required layer representation in the associated access unit for the layer representation having dependency_id equal to dIdMax.

G.13.2.6 Priority layer information SEI message semantics

The information conveyed in this SEI message specifies alternative values for priority_id for the NAL units with the given value of dependency_id inside the current access unit. The alternative values for priority_id specify priority layers.

pr_dependency_id specifies the value of dependency_id for the NAL units inside the access unit for which the SEI message applies.

num_priority_ids specifies the number of layer representations within the dependency representation with dependency_id equal to pr_dependency_id for which alternative values of priority_id are specified by this SEI message.

alt_priority_id[i **]** specifies the alternative value for priority_id for the NAL units with dependency_id equal to pr_dependency_id and quality_id equal to i inside the current access unit.

G.13.2.7 Scalable nesting SEI message semantics

A scalable nesting SEI message shall contain one or more SEI messages of payloadType not equal to 30. An SEI message contained in a scalable nesting SEI message is referred to as a nested SEI message. An SEI message not contained in a scalable nesting SEI message is referred to as a non-nested SEI message. The scope to which the nested SEI message applies is indicated by the syntax elements all_layer_representations_in_au_flag, num_layer_representations_minus1, sei_dependency_id[i], sei_quality_id[i], and sei_temporal_id, when present.

A buffering period SEI message and an SEI message of any other type shall not be nested in the same scalable nesting SEI message. When a buffering period SEI message is included in a scalable nesting SEI message, which is referred to as the SEI message under consideration, the following applies.

– Any SEI message preceding the SEI message under consideration in decoding order within the same access unit shall be a buffering period SEI message or a scalable nesting SEI message with a buffering period SEI message as payload.

– Additionally, the following applies.

  – If the value of all_layer_representations_in_au_flag in the SEI message under consideration is equal to 1, no scalable nesting SEI message shall precede the SEI message under consideration in decoding order within the same access unit.

  – Otherwise (the value of all_layer_representations_in_au_flag in the SEI message under consideration is equal to 0), for any scalable nesting SEI message that precedes the SEI message under consideration in decoding order within the same access unit, the values (sei_dependency_id[i] << 4) + sei_quality_id[i] for all present i shall be less than any of the values (sei_dependency_id[i] << 4) + sei_quality_id[i] for the SEI message under consideration.

A picture timing SEI message and an SEI message of any other type shall not be nested in the same scalable nesting SEI message.

all_layer_representations_in_au_flag equal to 1 specifies that the nested SEI message applies to all the layer representations of the access unit. all_layer_representations_in_au_flag equal to 0 specifies that the applicable scope of the nested SEI message is specified by the syntax elements num_layer_representations_minus1, sei_dependency_id[i], sei_quality_id[i], and sei_temporal_id.

num_layer_representations_minus1 plus 1 specifies the number of layer representation to which the nested SEI message applies. When num_layer_representations_minus1 is not present, it is inferred to be equal to (numSVCLayers – 1) with numSVCLayers being the number of layer representations that are present in the access unit.

sei_dependency_id[i] and **sei_quality_id**[i] specify the dependency_id and the quality_id, respectively, of the i-th layer representation to which the nested SEI message applies. When num_layer_representations_minus1 is not present, the values of sei_dependency_id[i] and sei_quality_id[i] for i in the range of 0 to num_layer_representations_minus1 (with num_layer_representations_minus1 being the inferred value), inclusive, are inferred as follows.

– Let setDQId be the set of the values DQId for all layer representations that are present in the access unit.

– For i proceeding from 0 to num_layer_representations_minus1, inclusive, the following applies.

  – sei_dependency_id[i] and sei_quality_id[i] are inferred to be equal to (minDQId >> 4) and (minDQId & 15), respectively, with minDQId being the smallest value (smallest value of DQId) in setDQId.

  – The smallest value (smallest value of DQId) of the set setDQId is removed from setDQId and thus the number of elements in setDQId is decreased by 1.

sei_temporal_id specifies the temporal_id of the bitstream subset to which the nested SEI message applies.

When sei_temporal_id is not present, it shall be inferred to be equal to temporal_id of the access unit.

When the nested SEI message is a buffering period SEI message or a picture timing SEI message, sei_temporal_id indicates the bitstream subset for which the nested buffering period SEI message or picture timing SEI message applies. For a buffering period SEI message or picture timing SEI message that is nested in a scalable nesting SEI message, sei_dependency_id[i], sei_quality_id[i] and sei_temporal_id specify the greatest dependency_id, quality_id, and temporal_id values, respectively, of the bitstream subsets for which the nested buffering period SEI message or picture timing SEI message applies.

For a nested SEI message for which payloadType is in the range of 2 to 3, inclusive, or 6 to 35, inclusive, sei_temporal_id shall be equal to temporal_id of the access unit.

sei_nesting_zero_bit shall be equal to 0.

G.13.2.8 Base layer temporal HRD SEI message semantics

When present, this SEI message applies to the target access unit set that consists of the current access unit and all the subsequent access units, in decoding order, until the next base layer temporal HRD SEI message or the end of the bitstream, whichever is the earliest in decoding order.

num_of_temporal_layers_in_base_layer_minus1 plus 1 specifies the number of bitstream subsets inside the target access unit set for which the following syntax elements apply.

temporal_id[i **]** specifies the temporal_id value of the i-th bitstream subset.

Let the i-th bitstream subset for the target access unit set that is obtained by invoking the bitstream extraction process as specified in subclause G.8.8.1 with tIdTarget equal to temporal_id[i], dIdTarget equal to 0, and qIdTarget equal to 0 as input.

timing_info_present_flag[i **]** specifies the value of timing_info_present_flag that applies for the i-th bitstream subset.

num_units_in_tick[i **]** specifies the value of num_units_in_tick that applies for the i-th bitstream subset. num_units_in_tick[i] shall be greater than 0.

time_scale[i **]** specifies the value of time_scale that applies for the i-th bitstream subset. time_scale[i] shall be greater than 0.

fixed_frame_rate_flag[i **]** specifies the value of fixed_frame_rate_flag that applies for the i-th bitstream subset.

nal_hrd_parameters_present_flag[i **]** specifies the value of nal_hrd_parameters_present_flag that applies for the i-th bitstream subset.

vcl_hrd_parameters_present_flag[i **]** specifies the value of vcl_hrd_parameters_present_flag that applies for the i-th bitstream subset.

low_delay_hrd_flag[i **]** specifies the value of low_delay_hrd_flag that applies for the i-th bitstream subset.

pic_struct_present_flag[i **]** specifies the value of pic_struct_present_flag that applies for the i-th bitstream subset.

G.13.2.9 Quality layer integrity check SEI message semantics

num_info_entries_minus1 plus 1 specifies the number of syntax elements entry_dependency_id[i] and quality_layer_crc[i]. The value of num_info_entries_minus1 shall be in the range of 0 to 7, inclusive.

entry_dependency_id[i **]** specifies the dependency_id value of the dependency representation for which quality_layer_crc[i] is indicated. The instances of entry_dependency_id[i] shall appear in increasing order of their values.

quality_layer_crc[i **]** specifies the cyclic redundancy check for all the VCL NAL units with quality_id greater than 0 in the dependency representation.

quality_layer_crc[i] shall be equal to the value obtained by the following ordered steps.

1. Let the variable qNalUnits[ ] be the one-dimensional array of bytes that contains a concatenation, in network byte order, of the bytes of all the VCL NAL units with quality_id greater than 0 in the dependency representation having dependency_id equal to entry_dependency_id[i], in decoding order.
2. Let the variable pLen be the number of bytes in qNalUnits[ ].
3. The value of quality_layer_crc[i] shall be equal to the value of crcVal obtained by performing the following pseudo code process.

```
qNalUnits[pLen     ] = 0
qNalUnits[pLen + 1] = 0
crcVal = 0xFFFF
for( bitIdx = 0; bitIdx < ( pLen + 2 ) * 8; bitIdx++ ) {
   crcMsb = ( crcVal >> 15 ) & 1
   bitVal = (qNalUnits[bitIdx >> 3] >> ( 7 - ( bitIdx & 7 ) ) ) & 1
   crcVal = ( ( ( crcVal << 1 ) + bitVal ) & 0xFFFF ) ^ ( crcMsb * 0x1021 )
}
```

G.13.2.10 Redundant picture property SEI message semantics

num_dId_minus1 plus 1 specifies the number of the dependency representations for which the redundant picture properties are specified by the following syntax elements.

dependency_id[i **]** specifies the dependency_id value of the dependency representation for which the redundant picture properties are specified by the following syntax elements.

num_qId_minus1[i **]** plus 1 specifies the number of the layer representations inside the dependency representation having dependency_id equal to dependency_id[i] for which the redundant picture properties are specified by the following syntax elements.

quality_id[i **][** j **]** specifies the quality_id value of the layer representation having dependency_id equal to dependency_id[i] for which the redundant picture properties are specified by the following syntax elements.

num_redundant_pics_minus1[i **][** j **]** plus 1 specifies the number of redundant coded pictures in the layer representation having dependency_id equal to dependency_id[i] and quality_id equal to quality_id[i][j] for which the redundant picture properties are specified by the following syntax elements.

redundant_pic_cnt_minus1[i **][** j **][** k **]** plus 1 specifies the redundant_pic_cnt value of the redundant coded picture having dependency_id equal to dependency_id[i] and quality_id equal to quality_id[i][j] for which the redundant picture properties are specified by the following syntax elements.

The redundant coded picture having dependency_id equal to dependency_id[i], quality_id equal to quality_id[i][j], and redundant_pic_cnt equal to (redundant_pic_cnt_minus1[i][j][k] + 1) is referred to as the target redundant coded picture. The layer representation having dependency_id equal to dependency_id[i], quality_id equal to quality_id[i][j], and redundant_pic_cnt equal to 0 is referred to as the primary layer representation.

pic_match_flag[i **][** j **][** k **]** equal to 1 specifies that the target redundant coded picture is an exact copy of the primary layer representation, with the only difference in the value of redundant_pic_cnt.

mb_type_match_flag[i **][** j **][** k **]** equal to 1 specifies that the syntax element mb_type for all macroblocks in the target redundant coded picture are identical to the corresponding syntax element in the primary layer representation.

motion_match_flag[i **][** j **][** k **]** equal to 1 specifies that the mb_type of all inter-coded macroblocks and the associated reference indices and motion vectors for all macroblocks in the redundant coded picture are identical to the corresponding syntax elements in the primary layer representation.

residual_match_flag[i **][** j **][** k **]** equal to 1 specifies that the reconstructed residual sample values as specified in subclause G.8.5.3 for all inter-coded macroblocks in the redundant coded picture is identical or close to the reconstructed residual sample values for the corresponding macroblocks in the primary layer representation.

intra_samples_match_flag[i **][** j **][** k **]** equal to 1 specifies that the reconstructed sample values for all intra coded macroblocks in the redundant coded picture are identical or close to the reconstructed sample values of the corresponding macroblocks in the primary layer representation.

G.13.2.11 Temporal level zero dependency representation index SEI message semantics

The temporal level zero dependency representation index SEI message provides a mechanism to detect whether a dependency representation with temporal_id equal to 0 needed for decoding the current access unit is available when NAL unit losses are expected during transport.

Let setOfDId be a set of values that is derived as follows.

– If the temporal level zero dependency representation index SEI message is not included in a scalable nesting SEI message, setOfDId consists of exactly one value, which is set equal to 0.

– Otherwise (the temporal level zero dependency representation index SEI message is included in a scalable nesting SEI message), setOfDId consists of the values sei_dependency_id[i] for all i in the range of 0 to num_layer_representations_minus1, inclusive, that are associated with the temporal level zero dependency representation index SEI message.

tl0_dep_rep_idx specifies the temporal level zero index for the associated dependency representations, if temporal_id is equal to 0. Otherwise (temporal_id is greater than 0), tl0_dep_rep_idx specifies the temporal level zero index of the associated dependency representations of the most recent access unit with temporal_id equal to 0 in decoding order.

For each value of dId of the set setOfDId, the following constraints on tl0_dep_rep_idx shall be obeyed.

– If the dependency representation with dependency_id equal to dId contains a NAL unit with nal_unit_type equal to 5 or a NAL unit with nal_unit_type equal to 20 and idr_flag equal to 1, tl0_dep_rep_idx shall be equal to 0.

– Otherwise (the dependency representation with dependency_id equal to dId does not contain a NAL unit with nal_unit_type equal to 5 or a NAL unit with nal_unit_type equal to 20 and idr_flag equal to 1), the following applies.

  – Let prevTL0DepRep be the dependency representation with dependency_id equal to dId of the most recent access unit with temporal_id equal to 0 in decoding order that includes a dependency representation with dependency_id equal to dId.

  – Let prevTL0DepRepIdx be equal to tl0_dep_rep_idx of the dependency representation prevTL0DepRep.

  – Depending on temporal_id of the current access unit, the following applies.

    – If temporal_id of the current access unit is equal to 0, tl0_dep_rep_idx shall be equal to (prevTL0DepRepIdx + 1) % 256.

    – Otherwise (temporal_id of the current access unit is greater than 0), tl0_dep_rep_idx shall be equal to prevTL0DepRepIdx.

NOTE – For the tl0_dep_rep_idx mechanism to be effectively used, transport mechanisms should ensure that the information is present in every packet that carries data for the particular values of dependency_id.

effective_idr_pic_id specifies the latest value of idr_pic_id in decoding order present in this access unit or any preceding access unit for dependency representations indicated by sei_dependency_id[i].

For each value of dId of the set setOfDId, the following constraints on effective_idr_pic_id shall be obeyed.

– If the dependency representation with dependency_id equal to dId contains a NAL unit with nal_unit_type equal to 5 or a NAL unit with nal_unit_type equal to 20 and idr_flag equal to 1, effective_idr_pic_id shall be equal to idr_pic_id of the dependency representation with dependency_id equal to dId.

– Otherwise (the dependency representation with dependency_id equal to dId does not contain a NAL unit with nal_unit_type equal to 5 or a NAL unit with nal_unit_type equal to 20 and idr_flag equal to 1), effective_idr_pic_id shall be equal to idr_pic_id of the previous dependency representation in decoding order with dependency_id equal to dId that contains a NAL unit with nal_unit_type equal to 5 or a NAL unit with nal_unit_type equal to 20 and idr_flag equal to 1.

G.13.2.12 Temporal level switching point SEI message semantics

Temporal layer switching point SEI messages provide information on temporal layer switching points. If a layer representation is associated with a temporal layer switching point SEI message, then it is a temporal layer switching point as specified subsequently and constrained by delta_frame_num. Otherwise, the layer representation may or may not be a temporal layer switching point.

In the following, let tId be equal to the value of temporal_id associated with the access unit in which the temporal layer switching point SEI message is included.

NOTE 1 – Let dId be the value of dependency_id that a bitstream adaptation process has used to generate a bitstream subset subBitstreamA that contains dependency representations with dependency_id less than or equal to dId and temporal_id less than tId until the current access unit, exclusive. The bitstream adaptation process can infer from a temporal layer switching point SEI message whether or not the bitstream subset containing subBitstreamA and the dependency representations with dependency_id less than or equal to dId and temporal_id less than or equal to tId starting from the current access unit, inclusive, is conforming to this Recommendation | International Standard.

The temporal layer switching point SEI message shall not be present in access units for which temporal_id is equal to 0, or in access units that do not contain NAL units with nal_unit_type equal to 20 and in which no prefix NAL units are present.

The temporal layer switching point SEI message shall not be present in a supplemental enhancement information RBSP unless it is included within a scalable nesting SEI message.

The semantics apply independently to layer representations indicated by each pair of values of sei_dependency_id[i] and sei_quality_id[i] of the scalable nesting SEI message containing this SEI message.

Let the switch-to layer representation be the layer representation in the access unit containing this SEI message having dependency_id equal to sei_dependency_id[i] and quality_id equal to sei_quality_id[i].

delta_frame_num indicates the difference of the frame_num values between the switch-to layer representation and the required layer representation as specified subsequently. Let currFrameNum be the frame_num of the switch-to layer representation and requiredFrameNum be the frame_num of the required layer representation. Let the variable requiredFrameNum be set equal to currFrameNum – delta_frame_num. Let the required layer representation be the layer representation of the previous access unit, in decoding order, having frame_num equal to requiredFrameNum, dependency_id equal to sei_dependency_id[i], and quality_id equal to sei_quality_id[i].

NOTE 2 – The decoding process for the switch-to layer representation may use the required layer representation and any subsequent layer representation, in decoding order, having temporal_id less than tId and dependency_id is less than or equal to sei_dependency_id[i] in the decoding process.

The switch-to layer representation and any subsequent layer representation in decoding order for which temporal_id is equal to tId and dependency_id is less than or equal to sei_dependency_id[i] shall not use any layer representation preceding the required layer representation in decoding order for which temporal_id is equal to tId – 1 and dependency_id is less than or equal to sei_dependency_id[i] in the decoding process.

The switch-to layer representation and any subsequent layer representation in decoding order for which temporal_id is equal to tId and dependency_id is less than or equal to sei_dependency_id[i] shall not use any layer representation preceding the access unit containing the switch-to layer representation in decoding order for which temporal_id is equal to tId and dependency_id is less than or equal to sei_dependency_id[i] in the decoding process.

NOTE 3 – All layer representations that follow the switch-to layer representation in decoding order, inclusive, for which temporal_id is equal to tId and dependency_id is less than or equal to sei_dependency_id[i], can be decoded, when all layer representations have been decoded starting from the required layer representation to the layer representation in the access unit preceding the access unit that includes the switch-to layer representation in decoding order, inclusive, for which temporal_id is less than tId and dependency_id is less than or equal to sei_dependency_id[i].

G.14 SVC video usability information extension

The specifications in Annex E apply with substituting SVC sequence parameter set for sequence parameter set. Additionally, the following applies.

G.14.1 SVC VUI parameters extension syntax

svc_vui_parameters_extension( ) {	C	Descriptor
num_layers_minus1	0	ue(v)
for(i = 0; i <= num_layers_minus1; i++) {		
dependency_id[i **]**	0	u(3)
quality_id[i **]**	0	u(4)
temporal_id[i **]**	0	u(3)
timing_info_present_flag[i **]**	0	u(1)
if(timing_info_present_flag[i]) {		
num_units_in_tick[i **]**	0	u(32)
time_scale[i **]**	0	u(32)
fixed_frame_rate_flag[i **]**	0	u(1)
}		
nal_hrd_parameters_present_flag[i **]**	0	u(1)
if(nal_hrd_parameters_present_flag[i])		
hrd_parameters( )		
vcl_hrd_parameters_present_flag[i **]**	0	u(1)
if(vcl_hrd_parameters_present_flag[i])		
hrd_parameters( )		
if(nal_hrd_parameters_present_flag[i] || vcl_hrd_parameters_present_flag[i])		
low_delay_hrd_flag[i **]**	0	u(1)
pic_struct_present_flag[i **]**	0	u(1)
}		
}		

G.14.2 SVC VUI parameters extension semantics

num_layer_minus1 plus 1 specifies the number of temporal_id, dependency_id, and quality_id three-tuples for which timing information, NAL HRD parameters, VCL HRD parameters and the pic_struct_present_flag may be present.

dependency_id[i] indicates the i-th dependency layer.

quality_id[i] indicates the i-th quality layer.

temporal_id[i] indicates the i-th temporal layer.

The following syntax elements apply to the coded video sequence that is obtained by the sub-bitstream extraction process as specified in subclause G.8.8.1 with tIdTarget equal to temporal_id[i], dIdTarget equal to dependency_id[i], and qIdTarget equal to quality_id[i] as the input and the i-th sub-bitstream as the output.

timing_info_present_flag[i] specifies the timing_info_present_flag value of the i-th sub-bitstream.

num_units_in_tick[i] specifies the num_units_in_tick value of the i-th sub-bitstream.

time_scale[i] specifies the time_scale value of the i-th sub-bitstream.

fixed_frame_rate_flag[i] specifies the fixed_frame_rate_flag value of the i-th sub-bitstream.

nal_hrd_parameters_present_flag[i] specifies the nal_hrd_parameters_present_flag value of the i-th sub-bitstream.

vcl_hrd_parameters_present_flag[i] specifies the vcl_hrd_parameters_present_flag value of the i-th sub-bitstream.

low_delay_hrd_flag[i] specifies the low_delay_hrd_flag value of the i-th sub-bitstream.

pic_struct_present_flag[i] specifies the pic_struct_present_flag value of the i-th sub-bitstream.

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APPENDIX H26402



H.264 : Support of additional colour spaces and removal of the High 4:4:4 Profile

Recommendation H.264 (2005) Amendment 1 (06/06)

Table of Contents

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English	Word	346112 bytes	2006-10-18	E 29689	
	Zip (Word)	87758 bytes	2006-10-18		
Arabic	Word	276480 bytes	2009-10-01	A 31486	
Chinese	Word	593408 bytes	2007-11-19	C 31738	
	Zip (Components)	403810 bytes	2007-11-19		
Español	Word	347136 bytes	2007-04-18	S 29691	
	Zip (Word)	88246 bytes	2007-04-18		
Français	Word	344576 bytes	2007-04-18	F 29690	
	Zip (Word)	86633 bytes	2007-04-18		
Russian	Word	289280 bytes	2009-06-23	R 31514	
	Zip (Components)	75316 bytes	2009-06-23		

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International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

H.264

Amendment 1

(06/2006)

SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Infrastructure of audiovisual services – Coding of moving video

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Advanced video coding for generic audiovisual services

Amendment 1: Support of additional colour spaces and removal of the High 4:4:4 Profile

ITU-T Recommendation H.264 (2005) – Amendment 1

ITU-T H-SERIES RECOMMENDATIONS

AUDIOVISUAL AND MULTIMEDIA SYSTEMS

CHARACTERISTICS OF VISUAL TELEPHONE SYSTEMS	H.100–H.199
INFRASTRUCTURE OF AUDIOVISUAL SERVICES	
General	H.200–H.219
Transmission multiplexing and synchronization	H.220–H.229
Systems aspects	H.230–H.239
Communication procedures	H.240–H.259
Coding of moving video	**H.260–H.279**
Related systems aspects	H.280–H.299
Systems and terminal equipment for audiovisual services	H.300–H.349
Directory services architecture for audiovisual and multimedia services	H.350–H.359
Quality of service architecture for audiovisual and multimedia services	H.360–H.369
Supplementary services for multimedia	H.450–H.499
MOBILITY AND COLLABORATION PROCEDURES	
Overview of Mobility and Collaboration, definitions, protocols and procedures	H.500–H.509
Mobility for H-Series multimedia systems and services	H.510–H.519
Mobile multimedia collaboration applications and services	H.520–H.529
Security for mobile multimedia systems and services	H.530–H.539
Security for mobile multimedia collaboration applications and services	H.540–H.549
Mobility interworking procedures	H.550–H.559
Mobile multimedia collaboration inter-working procedures	H.560–H.569
BROADBAND AND TRIPLE-PLAY MULTIMEDIA SERVICES	
Broadband multimedia services over VDSL	H.610–H.619

For further details, please refer to the list of ITU-T Recommendations.

Advanced video coding for generic audiovisual services

Amendment 1

Support of additional colour spaces and removal of the High 4:4:4 Profile

Summary

This amendment contains, in the form of a list of changes, alterations to ITU-T Rec. H.264 | ISO/IEC 14496-10 Advanced Video Coding to specify the support of additional colour spaces and to remove the definition of the High 4:4:4 Profile.

NOTE – ITU-T Rec. H.264 is a twin text with ISO/IEC 14496-10 and this amendment is published in two different documents in the ISO/IEC series:

- The removal of the High 4:4:4 profile is found in ISO/IEC 14496-10:2005/Cor.2.
- The specification for support of additional colour space will be found in ISO/IEC 14496-10:2005/Amd.1 (currently under FPDAM stage of the ISO/IEC approval process).

Source

Amendment 1 to ITU-T Recommendation H.264 (2005) was approved on 13 June 2006 by ITU-T Study Group 16 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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CONTENTS

Page

Amendment 1 – Support of additional colour spaces and removal of the High 4:4:4 Profile 1

1) Clause 0.6 "Overview of the design characteristics" 1

2) Clause 0.7 "How to read this specification" 1

3) Clause A.2.7 "High 4:4:4 profile" 1

4) Clause A.3.2 "Level limits common to the High, High 10, High 4:2:2, and High 4:4:4 profiles" 1

5) Clause A.3.3 "Profile-specific limits" 2

6) Clause A.3.3.2 "Main, High, High 10, High 4:2:2, or High 4:4:4 profile limits" 2

7) Clause E.2 2

Advanced video coding for generic audiovisual services

Amendment 1

Support of additional colour spaces and removal of the High 4:4:4 Profile

1) Clause 0.6 "Overview of the design characteristics"

In clause 0.6, replace the sentence:

With the exception of the transform bypass mode of operation for lossless coding in the High 4:4:4 profile and the I_PCM mode of operation in all profiles, the algorithm is typically not lossless, as the exact source sample values are typically not preserved through the encoding and decoding processes.

with

The algorithm is typically not lossless, as the exact source sample values are typically not preserved through the encoding and decoding processes.

2) Clause 0.7 "How to read this specification"

In clause 0.7, replace the sentence:

Annex A specifies seven profiles (Baseline, Main, Extended, High, High 10, High 4:2:2 and High 4:4:4), each being tailored to certain application domains, and defines the so-called levels of the profiles.

with

Annex A specifies six profiles (Baseline, Main, Extended, High, High 10 and High 4:2:2), each being tailored to certain application domains, and defines the so-called levels of the profiles.

3) Clause A.2.7 "High 4:4:4 profile"

Remove clause A.2.7.

4) Clause A.3.2 "Level limits common to the High, High 10, High 4:2:2, and High 4:4:4 profiles"

a) *Replace the title of clause A.3.2 with:*

Level limits common to the High, High 10, and High 4:2:2 profiles

b) *In clause A.3.2, replace the sentence:*

Bitstreams conforming to the High, High 10, High 4:2:2, or High 4:4:4 profiles at a specified level shall obey the following constraints:

with

Bitstreams conforming to the High, High 10, or High 4:2:2 profiles at a specified level shall obey the following constraints:

5) Clause A.3.3 "Profile-specific limits"

a) *In clause A.3.3 replace all occurrences of:*

In bitstreams conforming to the Main, High, High 10, High 4:2:2, or High 4:4:4

with

In bitstreams conforming to the Main, High, High 10, or High 4:2:2

b) *In clause A.3.3 replace all occurrences of:*

In bitstreams conforming to the High, High 10, High 4:2:2, or High 4:4:4 profiles

with

In bitstreams conforming to the High, High 10, or High 4:2:2 profiles

c) *In clause A.3.3 replace all occurrences of:*

... in Table A-4 for the Main, High, High 10, High 4:2:2, and High 4:4:4 profiles ...

with

... in Table A-4 for the Main, High, High 10, and High 4:2:2 profiles ...

d) *In clause A.3.3, replace Table A-2 with the following:*

Profile	cpbBrVclFactor	cpbBrNalFactor
High	1 250	1 500
High 10	3 000	3 600
High 4:2:2	4 000	4 800

6) Clause A.3.3.2 "Main, High, High 10, High 4:2:2, or High 4:4:4 profile limits"

a) *Replace the title of clause A.3.3.2 with:*

Main, High, High 10, and High 4:2:2 profile limits

b) *In clause A.3.3.2, replace the sentence:*

Table A-4 specifies limits for each level that are specific to bitstreams conforming to the Main, High, High 10, High 4:2:2, or High 4:4:4 profiles.

with

Table A-4 specifies limits for each level that are specific to bitstreams conforming to the Main, High, High 10, or High 4:2:2 profiles.

c) *In clause A.3.3.2, replace the title of Table A-4 with:*

Table A-4 – Main, High, High 10, or High 4:2:2 profile level limits

7) Clause E.2

a) *In clause E.2, replace Table E-3 with the following:*

Table E-3 – Colour primaries

Value	Primaries			Informative Remark
0	Reserved			For future use by ITU-T | ISO/IEC
1	primary	x	y	ITU-R Rec. BT.709-5, ITU-R Rec. BT.1361 conventional colour gamut system and extended colour gamut system, IEC 61966-2-4
	green	0.300	0.600	
	blue	0.150	0.060	
	red	0.640	0.330	
	white D65	0.3127	0.3290	

Table E-3 – Colour primaries

Value	Primaries			Informative Remark
2	Unspecified			Image characteristics are unknown or are determined by the application.
3	Reserved			
4	primary	x	y	ITU-R Rec. BT.470-6 System M
	green	0.21	0.71	
	blue	0.14	0.08	
	red	0.67	0.33	
	white C	0.310	0.316	
5	primary	x	y	ITU-R Rec. BT.470-6 System B, G
	green	0.29	0.60	
	blue	0.15	0.06	
	red	0.64	0.33	
	white D65	0.3127	0.3290	
6	primary	x	y	Society of Motion Picture and Television Engineers 170M (1999)
	green	0.310	0.595	
	blue	0.155	0.070	
	red	0.630	0.340	
	white D65	0.3127	0.3290	
7	primary	x	y	Society of Motion Picture and Television Engineers 240M (1999)
	green	0.310	0.595	
	blue	0.155	0.070	
	red	0.630	0.340	
	white D65	0.3127	0.3290	
8	primary	x	y	Generic film (colour filters using Illuminant C)
	green	0.243	0.692 (Wratten 58)	
	blue	0.145	0.049 (Wratten 47)	
	red	0.681	0.319 (Wratten 25)	
	white C	0.310	0.316	
9-255	Reserved			For future use by ITU-T | ISO/IEC

b) *In clause E.2, replace Table E-4 with the following:*

Table E-4 – Transfer characteristics

Value	Transfer Characteristic		Informative Remark
0	Reserved		For future use by ITU-T | ISO/IEC
1	$V = 1.099 * L_c^{0.45} - 0.099$	for $1 \geq L_c \geq 0.018$	ITU-R Rec. BT.709-5, ITU-R Rec. BT.1361 conventional colour gamut system
	$V = 4.500 * L_c$	for $0.018 > L_c \geq 0$	
2	Unspecified		Image characteristics are unknown or are determined by the application.
3	Reserved		For future use by ITU-T | ISO/IEC
4	Assumed display gamma 2.2		ITU-R Rec. BT.470-6 System M
5	Assumed display gamma 2.8		ITU-R Rec. BT.470-6 System B, G
6	$V = 1.099 * L_c^{0.45} - 0.099$	for $1 \geq L_c \geq 0.018$	Society of Motion Picture and Television Engineers 170M (1999)
	$V = 4.500 * L_c$	for $0.018 > L_c \geq 0$	
7	$V = 1.1115 * L_c^{0.45} - 0.1115$	for $1 \geq L_c \geq 0.0228$	Society of Motion Picture and Television Engineers 240M (1999)
	$V = 4.0 * L_c$	for $0.0228 > L_c \geq 0$	
8	$V = L_c$	for $1 > L_c \geq 0$	Linear transfer characteristics

Table E-4 – Transfer characteristics

Value	Transfer Characteristic		Informative Remark
9	$V = 1.0 – Log10(L_c) \div 2$ $V = 0.0$	for $1 \geq L_c \geq 0.01$ for $0.01 > L_c \geq 0$	Logarithmic transfer characteristic (100:1 range)
10	$V = 1.0 – Log10(L_c) \div 2.5$ $V = 0.0$	for $1 \geq L_c \geq 0.0031622777$ for $0.0031622777 > L_c \geq 0$	Logarithmic transfer characteristic (316.22777:1 range)
11	$V = 1.099 * L_c^{0.45} – 0.099$ $V = 4.500 * L_c$ $V = –1.099 * (–L_c)^{0.45} + 0.099$	for $L_c \geq 0.018$ for $0.018 > L_c > –0.018$ for $–0.018 \geq L_c$	IEC 61966-2-4
12	$V = 1.099 * L_c^{0.45} – 0.099$ $V = 4.500 * L_c$ $V = –(1.099 * (–4 * L_c)^{0.45} – 0.099) \div 4$	for $1.33 > L_c \geq 0.018$ for $0.018 > L_c \geq –0.0045$ for $–0.0045 > L_c \geq –0.25$	ITU-R Rec. BT.1361 extended colour gamut system
13..255	Reserved		For future use by ITU-T | ISO/IEC

c) *In clause E.2, replace the semantics of matrix_coefficients and Table E-5 with:*

matrix_coefficients describes the matrix coefficients used in deriving luma and chroma signals from the green, blue, and red primaries, as specified in Table E-5.

matrix_coefficients shall not be equal to 0 unless both of the following conditions are true

- $BitDepth_C$ is equal to $BitDepth_Y$
- chroma_format_idc is equal to 3 (4:4:4)

The specification of the use of matrix_coefficients equal to 0 under all other conditions is reserved for future use by ITU-T | ISO/IEC.

matrix_coefficients shall not be equal to 8 unless one or both of the following conditions are true

- $BitDepth_C$ is equal to $BitDepth_Y$
- $BitDepth_C$ is equal to $BitDepth_Y + 1$ and chroma_format_idc is equal to 3 (4:4:4)

The specification of the use of matrix_coefficients equal to 8 under all other conditions is reserved for future use by ITU-T | ISO/IEC.

When the matrix_coefficients syntax element is not present, the value of matrix_coefficients shall be inferred to be equal to 2.

The interpretation of matrix_coefficients is defined as follows.

- If transfer_characteristics is not equal to 11 or 12, E'_R, E'_G, and E'_B are analog with values in the range of 0 to 1.
- Otherwise (transfer_characteristics is equal to 11 (IEC 61966-2-4) or 12 (ITU-R BT.1361 extended colour gamut system)), E'_R, E'_G and E'_B are analog with a larger range not specified in this Recommendation.
- Nominal white is specified as having E'_R equal to 1, E'_G equal to 1, and E'_B equal to 1.
- Nominal black is specified as having E'_R equal to 0, E'_G equal to 0, and E'_B equal to 0.
- If video_full_range_flag is equal to 0, the following equations apply.
  - If matrix_coefficients is equal to 1, 4, 5, 6, or 7, the following equations apply.

$$Y = Clip1_Y(Round((1 << (BitDepth_Y – 8)) * (219 * E'_Y + 16))) \quad \text{(E-1)}$$

$$Cb = Clip1_C(Round((1 << (BitDepth_C – 8)) * (224 * E'_{PB} + 128))) \quad \text{(E-2)}$$

$$Cr = Clip1_C(Round((1 << (BitDepth_C – 8)) * (224 * E'_{PR} + 128))) \quad \text{(E-3)}$$

– Otherwise, if matrix_coefficients is equal to 0 or 8, the following equations apply.

$$R = Clip1_C((1 << (BitDepth_Y – 8)) * (219 * E'_R + 16)) \quad (E\text{-}4)$$

$$G = Clip1_Y((1 << (BitDepth_Y – 8)) * (219 * E'_G + 16)) \quad (E\text{-}5)$$

$$B = Clip1_C((1 << (BitDepth_Y – 8)) * (219 * E'_B + 16)) \quad (E\text{-}6)$$

– Otherwise, if matrix_coefficients is equal to 2, the interpretation of the matrix_coefficients syntax element is unknown or is determined by the application.

– Otherwise (matrix_coefficients is not equal to 0, 1, 2, 4, 5, 6, 7, or 8), the interpretation of the matrix_coefficients syntax element is reserved for future definition by ITU-T | ISO/IEC.

– Otherwise (video_full_range_flag is equal to 1), the following equations apply.

– If matrix_coefficients is equal to 1, 4, 5, 6, or 7, the following equations apply.

$$Y = Clip1_Y(Round(((1 << BitDepth_Y) – 1) * E'_Y)) \quad (E\text{-}7)$$

$$Cb = Clip1_C(Round(((1 << BitDepth_C) – 1) * E'_{PB} + (1 << (BitDepth_C – 1)))) \quad (E\text{-}8)$$

$$Cr = Clip1_C(Round(((1 << BitDepth_C) – 1) * E'_{PR} + (1 << (BitDepth_C – 1)))) \quad (E\text{-}9)$$

– Otherwise, if matrix_coefficients is equal to 0 or 8, the following equations apply.

$$R = Clip1_Y(((1 << BitDepth_Y) – 1) * E'_R) \quad (E\text{-}10)$$

$$G = Clip1_Y(((1 << BitDepth_Y) – 1) * E'_G) \quad (E\text{-}11)$$

$$B = Clip1_Y(((1 << BitDepth_Y) – 1) * E'_B) \quad (E\text{-}12)$$

– Otherwise, if matrix_coefficients is equal to 2, the interpretation of the matrix_coefficients syntax element is unknown or is determined by the application.

– Otherwise (matrix_coefficients is not equal to 0, 1, 2, 4, 5, 6, 7, or 8), the interpretation of the matrix_coefficients syntax element is reserved for future definition by ITU-T | ISO/IEC.

– If matrix_coefficients is not equal to 0 or 8, the following equations apply.

$$E'_Y = K_R * E'_R + (1 – K_R – K_B) * E'_G + K_B * E'_B \quad (E\text{-}13)$$

$$E'_{PB} = 0.5 * (E'_B – E'_Y) \div (1 – K_B) \quad (E\text{-}14)$$

$$E'_{PR} = 0.5 * (E'_R – E'_Y) \div (1 – K_R) \quad (E\text{-}15)$$

NOTE 2 – E'_Y is analog with the value 0 associated with nominal black and the value 1 associated with nominal white. E'_{PB} and E'_{PR} are analog with the value 0 associated with both nominal black and nominal white. When transfer_characteristics is not equal to 11 or 12, E'_Y is analog with values in the range of 0 to 1. When transfer_characteristics is not equal to 11 or 12, E'_{PB} and E'_{PR} are analog with values in the range of –0.5 to 0.5. When transfer_characteristics is equal to 11 (IEC 61966-2-4), or 12 (ITU-R BT.1361 extended colour gamut system), E'_Y, E'_{PB} and E'_{PR} are analog with a larger range not specified in this Recommendation.

– Otherwise, if matrix_coefficients is equal to 0, the following equations apply.

$$Y = Round(G) \quad \text{(E-16)}$$

$$Cb = Round(B) \quad \text{(E-17)}$$

$$Cr = Round(R) \quad \text{(E-18)}$$

– Otherwise (matrix_coefficients is equal to 8), the following applies.
  – If $BitDepth_C$ is equal to $BitDepth_Y$, the following equations apply.

$$Y = Round(0.5 * G + 0.25 * (R + B)) \quad \text{(E-19)}$$

$$Cb = Round(0.5 * G – 0.25 (R + B)) + (1 << (BitDepth_C – 1)) \quad \text{(E-20)}$$

$$Cr = Round(0.5 * (R – B)) + (1 << (BitDepth_C – 1)) \quad \text{(E-21)}$$

NOTE 3 – For purposes of the YCgCo nomenclature used in Table E-5, Cb and Cr of Equations E-20 and E-21 may be referred to as Cg and Co, respectively. The inverse conversion for the above four equations should be computed as.

$$t = Y – (Cb – (1 << (BitDepth_C – 1))) \quad \text{(E-22)}$$

$$G = Clip1_Y(Y + (Cb – (1 << (BitDepth_C – 1)))) \quad \text{(E-23)}$$

$$B = Clip1_Y(t – (Cr – (1 << (BitDepth_C – 1)))) \quad \text{(E-24)}$$

$$R = Clip1_Y(t + (Cr – (1 << (BitDepth_C – 1)))) \quad \text{(E-25)}$$

– Otherwise ($BitDepth_C$ is not equal to $BitDepth_Y$), the following equations apply.

$$Cr = Round(R) – Round(B) + (1 << (BitDepth_C – 1)) \quad \text{(E-26)}$$

$$t = Round(B) + ((Cr – (1 << (BitDepth_C – 1))) >> 1) \quad \text{(E-27)}$$

$$Cb = Round(G) – t + (1 << (BitDepth_C – 1)) \quad \text{(E-28)}$$

$$Y = t + ((Cb – (1 << (BitDepth_C – 1))) >> 1) \quad \text{(E-29)}$$

NOTE 4 – For purposes of the YCgCo nomenclature used in Table E-5, Cb and Cr of Equations E-28 and E-26 may be referred to as Cg and Co, respectively. The inverse conversion for the above four equations should be computed as.

$$t = Y – ((Cb – (1 << (BitDepth_C – 1))) >> 1) \quad \text{(E-30)}$$

$$G = Clip1_Y(t + (Cb – (1 << (BitDepth_C – 1)))) \quad \text{(E-31)}$$

$$B = Clip1_Y(t – ((Cr – (1 << (BitDepth_C – 1))) >> 1)) \quad \text{(E-32)}$$

$$R = Clip1_Y(B + (Cr – (1 << (BitDepth_C – 1)))) \quad \text{(E-33)}$$

Table E-5 – Matrix coefficients

Value	Matrix	Informative remark
0	GBR	Typically referred to as RGB; see Equations E-16 to E-18
1	$K_R = 0.2126$; $K_B = 0.0722$	ITU-R Rec. BT.709-5, ITU-R Rec. BT.1361 conventional colour gamut system and extended colour gamut system, IEC 61966-2-4 $xvYCC_{709}$, Society of Motion Picture and Television Engineers RP 177 (1993)
2	Unspecified	Image characteristics are unknown or are determined by the application.
3	Reserved	For future use by ITU-T | ISO/IEC
4	$K_R = 0.30$; $K_B = 0.11$	United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20)
5	$K_R = 0.299$; $K_B = 0.114$	ITU-R Rec. BT.470-6 System B, G, IEC 61966-2-4 $xvYCC_{601}$
6	$K_R = 0.299$; $K_B = 0.114$	Society of Motion Picture and Television Engineers 170M (1999)
7	$K_R = 0.212$; $K_B = 0.087$	Society of Motion Picture and Television Engineers 240M (1999)
8	YCgCo	See Equations E-19 to E-33
9-255	Reserved	For future use by ITU-T | ISO/IEC

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Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	**Audiovisual and multimedia systems**
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
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Series L	Construction, installation and protection of cables and other elements of outside plant
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Series N	Maintenance: international sound programme and television transmission circuits
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APPENDIX H26403



H.264 : New profiles for professional applications

Recommendation H.264 (2005) Amendment 2 (04/07)

Summary

Approved in 2007-04-06

Status : Superseded

H.264 (2005) Amd.2 (2007) was available only as pre-published text since it was superseded by H.264 (11/2007) before its publication

Access : Freely available items

Available languages and formats :

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Access : TIES users

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TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

H.264

Amendment 2
(04/2007)

SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Infrastructure of audiovisual services – Coding of moving video

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Amendment 2: New profiles for professional applications

CAUTION !

PREPUBLISHED RECOMMENDATION

This prepublication is an unedited version of a recently approved Recommendation. It will be replaced by the published version after editing. Therefore, there will be differences between this prepublication and the published version.

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NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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ITU-T Recommendation H.264 Amendment 2

~~All-Intra and High 4:4:4 Predictive~~New profiles for professional applications

ITU-T Recommendation H.264 Amendment 2

Summary

Amendment 2 to ITU-T Rec. H.264 (a twin text Recommendation with ISO/IEC 14496-10) "*Advanced video coding for generic audiovisual services*" creates a set of new video coding profiles intended primarily for professional applications. It also defines two new types of supplemental enhancement information (SEI) messages.

One such new profile is the High 4:4:4 Predictive profile. The High 4:4:4 Predictive profile, as drafted herein, has two different 4:4:4 operation modes depending upon the value of a new syntax element, separate_colour_plane_flag that is present in the sequence parameter set. When separate_colour_plane_flag is equal to 0, each macroblock contains both luma and chroma samples, and a decoding process similar to the luma decoding process that is used in the other profiles is used to decode the luma and chroma samples in each such macroblock. When separate_colour_plane_flag is equal to 1, the decoding process for monochrome sampled pictures as found in the other profiles is used to decode each colour plane individually as a distinct picture. In addition, a new intra decoding process that can be used by encoders to enable relatively-efficient lossless coding is also added for use when the qpprime_y_zero_transform_bypass_flag syntax element is equal to 1 and QP'_Y is equal to 0. In the new High 4:4:4 Predictive profile, the bit depth is also extended up to 14 bits per sample.

In addition to adding the definition of the High 4:4:4 Predictive profile, four other profiles are also specified in this amendment. These profiles, referred to as the High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles, serve to enable applications demanding simple random-access and editing applications with low delay capability. Each of these profiles contains coding capabilities that similar to those of another corresponding profile, except for elimination of support for the decoding processes that involve inter-picture prediction and, in the case of the CAVLC 4:4:4 Intra profile, the additional elimination of support for the CABAC parsing process.

The two added SEI messages are the post-filter hint SEI message and the tone mapping information SEI message. The post-filter hint SEI message provides the coefficients of a post-filter or correlation information for the design of a post-filter for potential use in post-processing of the output decoded pictures to obtain improved displayed quality. The tone mapping information SEI message provides information to enable remapping of the colour samples of the output decoded pictures for customization to particular display environments.

CONTENTS

1) Subclause 0.4, “Publication and versions of this specification” 5
2) Subclause 0.6, “Overview of the design characteristics”....6
3) Subclause 0.7, “How to read this specification”....6
4) Subclause 3.6, “arbitrary slice order” 6
5) Subclause 3.75 “macroblock”....6
6) Subclause 3.136 “slice” 6
7) Subclause 6.2 “Source, decoded, and output picture formats” 7
8) Subclause 6.3 “Spatial subdivision of pictures and slices”....8
9) New subclause 6.4.3.1 “Inverse 4x4 Cb or Cr block scanning process for ChromaArrayType equal to 3”....8
10) New subclause 6.4.4.1 “Inverse 8x8 Cb or Cr block scanning process for ChromaArrayType equal to 3”....9
11) Subclause 6.4.8 “Derivation processes for neighbouring macroblocks, blocks, and partitions” 9
12) New subclause 6.4.8.2.1 “Derivation process for neighbouring 8x8 chroma blocks for ChromaArrayType equal to 3”9
13) Subclause 6.4.8.4 “Derivation process for neighbouring 4x4 chroma blocks”....9
14) New subclause 6.4.8.4.1 “Derivation process for neighbouring 4x4 chroma blocks for ChromaArrayType equal to 3”10
15) Subclause 7.3.2.1 “Sequence parameter set RBSP syntax”....10
16) Subclause 7.3.2.2 “Picture parameter set RBSP syntax”....10
17) Subclause 7.3.2.9.2 “Slice data partition B RBSP syntax”....10
18) Subclause 7.3.2.9.3 “Slice data partition C RBSP syntax”....11
19) Subclause 7.3.3 “Slice header syntax”....11
20) Subclause 7.3.3.2 “Prediction weight table syntax” 12
21) Subclause 7.3.5.1 “Macroblock prediction syntax”....13
22) Subclause 7.3.5.3 “Residual data syntax”....13
23) Subclause 7.3.5.3.2 “Residual block CABAC syntax”....14
24) New Subclause 7.3.5.3.3 "Residual luma data syntax” 15
25) Subclause 7.4.1.2.5 “Order of VCL NAL units and association to coded pictures”....15
26) Subclause 7.4.2.1 “Sequence parameter set RBSP semantics”....16
27) Subclause 7.4.2.1.2 “Sequence parameter set extension RBSP semantics”....19
28) Subclause 7.4.2.2 “Picture parameter set RBSP semantics”....19
29) Subclause 7.4.2.9.1 “Slice data partition A RBSP semantics” 19
30) Subclause 7.4.2.9.2 “Slice data partition B RBSP semantics”....20
31) Subclause 7.4.2.9.3 “Slice data partition C RBSP semantics”....20
32) Subclause 7.4.3 “Slice header semantics” 20
33) Subclause 7.4.5 “Macroblock layer semantics”....20
34) Subclause 7.4.5.1 “Macroblock prediction semantics”....21

35) Subclause 7.4.5.3 “Residual data semantics” 22
36) Subclause 7.4.5.3.2 “Residual block CABAC semantics”....22
37) New Subclause 7.4.5.3.3 "Residual luma data semantics” 23
38) Clause 8 and all subclauses of clause 8 “Decoding process”....23
39) Clause 8 “Decoding process” 23
40) Subclause 8.3.4 “Intra prediction for chroma samples”....24
41) Subclause 8.3.4.1 “Specification of Intra_Chroma_DC prediction mode”....24
42) New Subclause 8.3.4.5 “Intra prediction for chroma samples with ChromaArrayType equal to 3” 25
43) Subclause 8.4 “Inter prediction process”....26
44) Subclause 8.4.1 “Derivation process for motion vector components and reference indices” 26
45) Subclause 8.4.2.1 “Reference picture selection process” 26
46) Subclause 8.4.2.2 “Fractional sample interpolation process” 27
47) Subclause 8.4.2.2.2 “Chroma sample interpolation process” 28
48) Subclause 8.5 “Transform coefficient decoding process and picture construction process prior to deblocking filter process”....28
49) Subclause 8.5.1 “Specification of transform decoding process for 4x4 luma residual blocks” 28
50) Subclause 8.5.2 “Specification of transform decoding process for luma samples of Intra_16x16 macroblock prediction mode” 29
51) Subclause 8.5.3 “Specification of transform decoding process for 8x8 luma residual blocks” 29
52) Subclause 8.5.4 “Specification of transform decoding process for chroma samples” 29
53) New subclause 8.5.4.1 “Specification of transform decoding process for chroma samples with ChromaArrayType equal to 3” 30
54) Subclause 8.5.6 “Inverse scanning process for 8x8 luma transform coefficients” 31
55) Subclause 8.5.7 “Derivation process for the chroma quantisation parameters and scaling function” 31
56) Subclause 8.5.8 “Scaling and transformation process for luma DC transform coefficients for Intra_16x16 macroblock type”....32
57) Subclause 8.5.9 “Scaling and transformation process for chroma DC transform coefficients”....33
58) Subclause 8.5.10 “Scaling and transformation process for residual 4x4 blocks” 35
59) Subclause 8.5.11 “Scaling and transformation process for residual 8x8 luma blocks” 35
60) Subclause 8.5.12 “Picture construction process prior to deblocking filter process”....36
61) Subclause 8.5.13 “Residual colour transform process” 37
62) Subclause 8.7 “Deblocking filter process” 38
63) Subclause 8.7.2.3 “Filtering process for edges with bS less than 4” 40
64) Subclause 8.7.2.4 “Filtering process for edges for bS equal to 4”....41
65) Clause 9 and all subclauses of clause 9 “Parsing process” 42
66) Subclause 9.1.2 “Mapping process for coded block pattern” 43
67) Subclause 9.2 “CAVLC parsing process for transform coefficient levels” 43
68) Subclause 9.2.1 “Parsing process for total number of transform coefficient levels and trailing ones”....43
69) Subclause 9.3.1.1 “Initialisation process for context variables”....44
70) Subclause 9.3.2 “Binarization process”....55

71) Subclause 9.3.2.6 “Binarization process for coded block pattern” 58
72) Subclause 9.3.3.1 “Derivation process for ctxIdx” 58
73) Subclause 9.3.3.1.1.9 “Derivation process of ctxIdxInc for the syntax element coded_block_flag” 58
74) Subclause 9.3.3.1.3 “Assignment process of ctxIdxInc for syntax elements significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1” 60
75) Subclause A.2.4 “High profile” 61
76) Subclause A.2.5 “High 10 profile” 62
77) Subclause A.2.6 “High 4:2:2 profile” 62
78) New subclause A.2.7 “High 4:4:4 Predictive profile” 62
79) New subclause A.2.8 “High 10 Intra profile” 63
80) New subclause A.2.9 “High 4:2:2 Intra profile” 64
81) Subclause A.2.10 “High 4:4:4 Intra profile” 64
82) Subclause A.2.11 “CAVLC 4:4:4 Intra profile” 65
83) Subclause A.3.2 “Level limits common to the High, High 10, High 4:2:2, and High 4:4:4 profiles” 65
84) Subclause A.3.3 “Profile-specific level limits” 66
85) Subclause D.1 “SEI payload syntax” 67
86) New subclause D.1.22.1 “Post-filter hint SEI message syntax” 68
87) New subclause D.1.22.2 “Tone mapping information SEI message syntax” 68
88) Subclause D.2.19 “Motion-constrained slice group set SEI message semantics” 69
89) New subclause D.2.22.1 “Post-filter hint SEI message semantics“ 69
90) New subclause D.2.22.2 “Tone mapping information SEI message semantics” 70
91) Subclause E.2.1 “VUI parameters semantics” 72

1) Subclause 0.4, “Publication and versions of this specification”

In subclause 0.4, replace the following.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 4 (the current specification) refers to the integrated text containing the first technical corrigendum (2004), the first amendment (the "Fidelity range extensions"), and an additional technical corrigendum (2005). In the ITU-T, the next published version after version 2 was version 4 (due to the completion of the drafting work for version 4 prior to the approval opportunity for a final version 3 text).

with the following.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 4 refers to the integrated text containing the first technical corrigendum (2004), the first amendment (the "Fidelity range extensions"), and an additional technical corrigendum (2005). In the ITU-T, the next published version after version 2 was version 4 (due to the completion of the drafting work for version 4 prior to the approval opportunity for a final version 3 text).

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 5 refers to the integrated version 4 text with its specification of the High 4:4:4 profile removed.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 6 refers to the integrated version 5 text after its amendment to support additional colour space indicators. In the ITU-T, the changes for versions 5 and 6 were approved and published as a single amendment.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 7 refers to the integrated version 6 text after its amendment to define five new profiles intended primarily for professional applications (the High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, CAVLC 4:4:4 Intra, and High 4:4:4 Predictive profiles) and two new types of supplemental

enhancement information (SEI) messages (the post-filter hint SEI message and the tone mapping information SEI message).

2) Subclause 0.6, "Overview of the design characteristics"

In the second paragraph of subclause 0.6, replace the sentence

The algorithm is typically not lossless, as the exact source sample values are typically not preserved through the encoding and decoding processes.

with

With the exception of the transform bypass mode of operation for lossless coding in the High 4:4:4 Intra, CAVLC 4:4:4 Intra, and High 4:4:4 Predictive profiles, and the I_PCM mode of operation in all profiles, the algorithm is typically not lossless, as the exact source sample values are typically not preserved through the encoding and decoding processes.

3) Subclause 0.7, "How to read this specification"

In the third paragraph of subclause 0.6, replace the following sentence.

Annex A specifies six profiles (Baseline, Main, Extended, High, High 10 and High 4:2:2), each being tailored to certain application domains, and defines the so-called levels of the profiles.

with

Annex A specifies eleven profiles (Baseline, Main, Extended, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra), each being tailored to certain application domains, and defines the so-called levels of the profiles.

4) Subclause 3.6, "arbitrary slice order"

Replace subclause 3.6 with the following.

3.6 **arbitrary slice order**: A *decoding order* of *slices* in which the *macroblock address* of the first *macroblock* of some *slice* of a *picture* may be less than the *macroblock address* of the first *macroblock* of some other preceding *slice* of the same *coded picture* or, in the case of a *picture* that is coded using three separate colour planes, some other preceding *slice* of the same colour plane.

5) Subclause 3.75 "macroblock"

Replace subclause 3.75 with the following.

3.75 **macroblock**: A 16x16 *block* of *luma* samples and two corresponding *blocks* of *chroma* samples of a *picture* that has three sample arrays; or a 16x16 *block* of samples of a monochrome *picture* or a *picture* that is coded using three separate colour planes. The division of a *slice* or a *macroblock pair* into macroblocks is a *partitioning*.

6) Subclause 3.136 "slice"

Replace subclause 3.136 with the following.

3.136 **slice**: An integer number of *macroblocks* or *macroblock pairs* ordered consecutively in the *raster scan* within a particular *slice group*. For the *primary coded picture*, the division of each *slice group* into slices is a *partitioning*. Although a slice contains *macroblocks* or *macroblock pairs* that are consecutive in the *raster scan* within a *slice group*, these *macroblocks* or *macroblock pairs* are not necessarily consecutive in

the *raster scan* within the *picture*. The addresses of the *macroblocks* are derived from the address of the first *macroblock* in a slice (as represented in the *slice header*), the *macroblock to slice group map*, and, when a *picture* is coded using three separate colour planes, a colour plane identifier.

7) Subclause 6.2 "Source, decoded, and output picture formats"

In subclause 6.2, make the following changes.

Replace the following.

The variables SubWidthC, and SubHeightC are specified in Table 6-1, depending on the chroma format sampling structure, which is specified through chroma_format_idc. An entry marked as "-" in Table 6-1 denotes an undefined value for SubWidthC or SubHeightC. Other values of chroma_format_idc, SubWidthC, and SubHeightC may be specified in the future by ITU-T | ISO/IEC.

Table 6-1 –SubWidthC, and SubHeightC values derived from chroma_format_idc

chroma_format_idc	Chroma Format	SubWidthC	SubHeightC
0	monochrome	-	-
1	4:2:0	2	2
2	4:2:2	2	1
3	4:4:4	1	1

with the following

The variables SubWidthC and SubHeightC are specified in Table 6-1, depending on the chroma format sampling structure, which is specified through chroma_format_idc and separate_colour_plane_flag. An entry marked as "-" in Table 6-1 denotes an undefined value for SubWidthC or SubHeightC. Other values of chroma_format_idc, SubWidthC, and SubHeightC may be specified in the future by ITU-T | ISO/IEC.

Table 6-1 –SubWidthC, and SubHeightC values derived from chroma_format_idc and separate_colour_plane_flag

chroma_format_idc	separate_colour_plane_flag	Chroma Format	SubWidthC	SubHeightC
0	0	monochrome	-	-
1	0	4:2:0	2	2
2	0	4:2:2	2	1
3	0	4:4:4	1	1
3	1	4:4:4	-	-

Replace the following paragraph.

In 4:4:4 sampling, each of the two chroma arrays has the same height and width as the luma array.

with

In 4:4:4 sampling, depending on the value of separate_colour_plane_flag, the following applies.

– If separate_colour_plane_flag is equal to 0, each of the two chroma arrays has the same height and width as the luma array.

– Otherwise (separate_colour_plane_flag is equal to 1), the three colour planes are separately processed as monochrome sampled pictures.

Replace the following paragraph

The number of bits necessary for the representation of each of the samples in the luma and chroma arrays in a video sequence is in the range of 8 to 12, and the number of bits used in the luma array may differ from the number of bits used in the chroma arrays.

with

The number of bits necessary for the representation of each of the samples in the luma and chroma arrays in a video sequence is in the range of 8 to 14, and the number of bits used in the luma array may differ from the number of bits used in the chroma arrays.

Replace the following paragraph.

– If chroma_format_idc is equal to 0 (monochrome), MbWidthC and MbHeightC are both equal to 0 (as no chroma arrays are specified for monochrome video).

with the following.

– If chroma_format_idc is equal to 0 (monochrome) or separate_colour_plane_flag is equal to 1, MbWidthC and MbHeightC are both set equal to 0.

8) Subclause 6.3 "Spatial subdivision of pictures and slices"

In subclause 6.3, make the following changes.

Replace the following

Each macroblock is comprised of one 16x16 luma array and, when the video format is not monochrome, two corresponding chroma sample arrays. When macroblock-adaptive frame/field decoding is not in use, each macroblock represents a spatial rectangular region of the picture. For example, a picture may be divided into two slices as shown in Figure 6-7.

with the following

Each macroblock is comprised of one 16x16 luma array and, when the chroma sampling format is not equal to 4:0:0 and separate_colour_plane_flag is equal to 0, two corresponding chroma sample arrays. When separate_colour_plane_flag is equal to 1, each macroblock is comprised of one 16x16 luma or chroma sample array. When macroblock-adaptive frame/field decoding is not in use, each macroblock represents a spatial rectangular region of the picture. For example, a picture may be divided into two slices as shown in Figure 6-7.

When a picture is coded using three separate colour planes (separate_colour_plane_flag is equal to 1), a slice contains only macroblocks of one colour component being identified by the corresponding value of colour_plane_id, and each colour component array of a picture consists of slices having the same colour_plane_id value. Coded slices with different values of colour_plane_id within an access unit can be interleaved with each other under the constraint that for each value of colour_plane_id, the coded slice NAL units with that value colour_plane_id shall be in the order of increasing macroblock address for the first macroblock of each coded slice NAL unit.

9) New subclause 6.4.3.1 "Inverse 4x4 Cb or Cr block scanning process for ChromaArrayType equal to 3"

Insert a new subclause 6.4.3.1 as follows.

6.4.3.1 Inverse 4x4 Cb or Cr block scanning process for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The inverse 4x4 chroma block scanning process is identical to inverse 4x4 luma block scanning process as specified in subclause 6.4.3 when substituting the term "luma" with the term "Cb" or the term "Cr", and substituting the term "luma4x4BlkIdx" with the term "cb4x4BlkIdx" or the term "cr4x4BlkIdx" in all places in subclause 6.4.3.

10) New subclause 6.4.4.1 “Inverse 8x8 Cb or Cr block scanning process for ChromaArrayType equal to 3”

Insert a new subclause 6.4.4.1 as follows.

6.4.4.1 Inverse 8x8 Cb or Cr block scanning process for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The inverse 8x8 chroma block scanning process is identical to inverse 8x8 luma block scanning process as specified in subclause 6.4.4 when substituting the term “luma” with the term “Cb” or the term “Cr”, and substituting the term “luma8x8BlkIdx” with the term “cb8x8BlkIdx” or the term “cr8x8BlkIdx” in all places in subclause 6.4.4.

11) Subclause 6.4.8 “Derivation processes for neighbouring macroblocks, blocks, and partitions”

In subclause 6.4.8, make the following changes.

Insert the following sentence after the paragraph starting with **“**Subclause 6.4.8.2 specifies*”*.

Subclause 6.4.8.2.1 specifies the derivation process for neighbouring 8x8 chroma blocks for ChromaArrayType equal to 3.

Insert the following sentence after the paragraph starting with **“**Subclause 6.4.8.4 specifies”.

Subclause 6.4.8.4.1 specifies the derivation process for neighbouring 4x4 chroma blocks for ChromaArrayType equal to 3.

Replace the paragraph starting with “Table 6-2 specifies*” with the following.*

Table 6-2 specifies the values for the difference of luma location (xD, yD) for the input and the replacement for N in mbAddrN, mbPartIdxN, subMbPartIdxN, luma8x8BlkIdxN, cb8x8BlkIdxN, cr8x8BlkIdxN, luma4x4BlkIdxN, cb4x4BlkIdxN, cr4x4BlkIdxN, and chroma4x4BlkIdxN for the output. These input and output assignments are used in subclauses 6.4.8.1 to 6.4.8.5. The variable predPartWidth is specified when Table 6-2 is referred to.

12) New subclause 6.4.8.2.1 “Derivation process for neighbouring 8x8 chroma blocks for ChromaArrayType equal to 3”

Insert a new subclause 6.4.8.2.1 as follows.

6.4.8.2.1 Derivation process for neighbouring 8x8 chroma blocks for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The derivation process for neighbouring 8x8 chroma block is identical to the derivation process for neighbouring 8x8 luma block as specified in subclause 6.4.8.2 when substituting the term “luma” with the term “Cb” or the term “Cr”, and substituting the term “luma8x8BlkIdx” with the term “cb8x8BlkIdx” or the term “cr8x8BlkIdx” in all places in subclause 6.4.8.2.

13) Subclause 6.4.8.4 “Derivation process for neighbouring 4x4 chroma blocks”

In subclause 6.4.8.4, make the following changes.

Replace the paragraph starting with “Depending on chroma_format_idc” *with the following*

The position (x, y) of the upper-left sample of the 4x4 chroma block with index chroma4x4BlkIdx is derived by

x = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 0) (6-25)
y = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 1) (6-26)

Update all equation numbers in the subsequent subclauses due to the removal of equation 6-27 and 6-28.

14) New subclause 6.4.8.4.1 "Derivation process for neighbouring 4x4 chroma blocks for ChromaArrayType equal to 3"

Insert a new subclause 6.4.8.4.1 as follows.

6.4.8.4.1 Derivation process for neighbouring 4x4 chroma blocks for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The derivation process for neighbouring 4x4 chroma block in 4:4:4 chroma format is identical to the derivation process for neighbouring 4x4 luma block as specified in subclause 6.4.8.3 when substituting the term "luma" with the term "Cb" or the term "Cr", and substituting the term "luma4x4BlkIdx" with the term "cb4x4BlkIdx" or the term "cr4x4BlkIdx" in all places in subclause 6.4.8.3.

15) Subclause 7.3.2.1 "Sequence parameter set RBSP syntax"

In subclause 7.3.2.1, make the following changes.

Replace the syntax element "**residual_colour_transform_flag***" with the syntax element* "**separate_colour_plane_flag**".

Replace the expression "profile_idc = = 144*" with* "profile_idc = = 44 || profile_idc = = 244".

Replace the expression "i < 8*" with* "i < ((chroma_format_idc ! = 3) ? 8 : 12)".

16) Subclause 7.3.2.2 "Picture parameter set RBSP syntax"

In subclause 7.3.2.2, replace the expression "i < 6 + 2* transform_8x8_mode_flag*" with* "i < 6 + ((chroma_format_idc ! = 3) ? 2 : 6) * transform_8x8_mode_flag".

17) Subclause 7.3.2.9.2 "Slice data partition B RBSP syntax"

Replace the slice data partition B RBSP syntax table of subclause 7.3.2.9.2 with the following.

slice_data_partition_b_layer_rbsp( ) {	C	Descriptor
slice_id	All	ue(v)
if(separate_colour_plane_flag = = 1)		
colour_plane_id	All	u(2)
if(redundant_pic_cnt_present_flag)		
redundant_pic_cnt	All	ue(v)
slice_data( ) /* only category 3 parts of slice_data( ) syntax */	3	
rbsp_slice_trailing_bits( )	3	
}		

18) Subclause 7.3.2.9.3 “Slice data partition C RBSP syntax”

Replace the slice data partition B RBSP syntax table of subclause 7.3.2.9.3 as follows.

slice_data_partition_c_layer_rbsp( ) {	C	Descriptor
slice_id	All	ue(v)
if(separate_colour_plane_flag = = 1)		
colour_plane_id	All	u(2)
if(redundant_pic_cnt_present_flag)		
redundant_pic_cnt	All	ue(v)
slice_data( ) /* only category 4 parts of slice_data( ) syntax */	4	
rbsp_slice_trailing_bits( )	4	
}		

19) Subclause 7.3.3 “Slice header syntax”

Replace the slice header syntax table of subclause 7.3.3 with the following.

slice_header( ) {	C	Descriptor
first_mb_in_slice	2	ue(v)
slice_type	2	ue(v)
pic_parameter_set_id	2	ue(v)
if(separate_colour_plane_flag = = 1)		
colour_plane_id	2	u(2)
frame_num	2	u(v)
if(!frame_mbs_only_flag) {		
field_pic_flag	2	u(1)
if(field_pic_flag)		
bottom_field_flag	2	u(1)
}		
if(nal_unit_type = = 5)		
idr_pic_id	2	ue(v)
if(pic_order_cnt_type = = 0) {		
pic_order_cnt_lsb	2	u(v)
if(pic_order_present_flag && !field_pic_flag)		
delta_pic_order_cnt_bottom	2	se(v)
}		
if(pic_order_cnt_type = = 1 && !delta_pic_order_always_zero_flag) {		
delta_pic_order_cnt[0 **]**	2	se(v)
if(pic_order_present_flag && !field_pic_flag)		
delta_pic_order_cnt[1 **]**	2	se(v)
}		
if(redundant_pic_cnt_present_flag)		
redundant_pic_cnt	2	ue(v)
if(slice_type = = B)		
direct_spatial_mv_pred_flag	2	u(1)

if(slice_type = = P | | slice_type = = SP | | slice_type = = B) {		
num_ref_idx_active_override_flag	2	u(1)
if(num_ref_idx_active_override_flag) {		
num_ref_idx_l0_active_minus1	2	ue(v)
if(slice_type = = B)		
num_ref_idx_l1_active_minus1	2	ue(v)
}		
}		
ref_pic_list_reordering( )	2	
if((weighted_pred_flag && (slice_type = = P | | slice_type = = SP)) | | (weighted_bipred_idc = = 1 && slice_type = = B))		
pred_weight_table( )	2	
if(nal_ref_idc != 0)		
dec_ref_pic_marking( )	2	
if(entropy_coding_mode_flag && slice_type != I && slice_type != SI)		
cabac_init_idc	2	ue(v)
slice_qp_delta	2	se(v)
if(slice_type = = SP | | slice_type = = SI) {		
if(slice_type = = SP)		
sp_for_switch_flag	2	u(1)
slice_qs_delta	2	se(v)
}		
if(deblocking_filter_control_present_flag) {		
disable_deblocking_filter_idc	2	ue(v)
if(disable_deblocking_filter_idc != 1) {		
slice_alpha_c0_offset_div2	2	se(v)
slice_beta_offset_div2	2	se(v)
}		
}		
if(num_slice_groups_minus1 > 0 && slice_group_map_type >= 3 && slice_group_map_type <= 5)		
slice_group_change_cycle	2	u(v)
}		

20) Subclause 7.3.3.2 “Prediction weight table syntax”

In the syntax table of subclause 7.3.2.2, replace the syntax expression

chroma_format_idc != 0

with the following

ChromaArrayType != 0

(in all 3 occurences)

21) Subclause 7.3.5.1 “Macroblock prediction syntax”

In the syntax table of subclause 7.3.5.1, replace the syntax expression

chroma_format_idc != 0

with the following

ChromaArrayType == 1 || ChromaArrayType == 2

(in one occurrence)

22) Subclause 7.3.5.3 “Residual data syntax”

Replace the content of subclause 7.3.5.3 with the following.

residual( ) {	C	Descriptor
if(!entropy_coding_mode_flag)		
residual_block = residual_block_cavlc		
else		
residual_block = residual_block_cabac		
residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8)		
Intra16x16DCLevel = i16x16DClevel		
Intra16x16ACLevel = i16x16AClevel		
LumaLevel = level		
LumaLevel8x8 = level8x8		
if(ChromaArrayType == 1 || ChromaArrayType == 2) {		
NumC8x8 = 4 / (SubWidthC * SubHeightC)		
for(iCbCr = 0; iCbCr < 2; iCbCr++)		
if(CodedBlockPatternChroma & 3) /* chroma DC residual present*/		
residual_block(ChromaDCLevel[iCbCr], 4 * NumC8x8)	3 | 4	
else		
for(i = 0; i < 4 * NumC8x8; i++)		
ChromaDCLevel[iCbCr][i] = 0		
for(iCbCr = 0; iCbCr < 2; iCbCr++)		
for(i8x8 = 0; i8x8 < NumC8x8; i8x8++)		
for(i4x4 = 0; i4x4 < 4; i4x4++)		
if(CodedBlockPatternChroma & 2) /* chroma AC residual present */		
residual_block(ChromaACLevel[iCbCr][i8x8*4+i4x4],15)	3 | 4	
else		
for(i = 0; i < 15; i++)		
ChromaACLevel[iCbCr][i8x8*4+i4x4][i] = 0		
} else if(ChromaArrayType == 3) {		
residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8)		
CbIntra16x16DCLevel = i16x16DClevel		
CbIntra16x16ACLevel = i16x16AClevel		
CbLevel = level		
CbLevel8x8 = level8x8		
residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8)		

CrIntra16x16DCLevel = i16x16DClevel		
CrIntra16x16ACLevel = i16x16AClevel		
CrLevel = level		
CrLevel8x8 = level8x8		
}		
}		

23) Subclause 7.3.5.3.2 “Residual block CABAC syntax”

Replace the content of subclause 7.3.5.3.2 with the following.

residual_block_cabac(coeffLevel, maxNumCoeff) {	C	Descriptor
if(maxNumCoeff != 64 || (ChromaArrayType == 3))		
coded_block_flag	3 | 4	ae(v)
if(coded_block_flag) {		
numCoeff = maxNumCoeff		
i = 0		
do {		
significant_coeff_flag[i **]**	3 | 4	ae(v)
if(significant_coeff_flag[i]) {		
last_significant_coeff_flag[i **]**	3 | 4	ae(v)
if(last_significant_coeff_flag[i]) {		
numCoeff = i + 1		
for(j = numCoeff; j < maxNumCoeff; j++)		
coeffLevel[j] = 0		
}		
}		
i++		
} while(i < numCoeff - 1)		
coeff_abs_level_minus1[numCoeff - 1 **]**	3 | 4	ae(v)
coeff_sign_flag[numCoeff - 1 **]**	3 | 4	ae(v)
coeffLevel[numCoeff - 1] = (coeff_abs_level_minus1[numCoeff – 1] + 1) * (1 – 2 * coeff_sign_flag[numCoeff – 1])		
for(i = numCoeff - 2; i >= 0; i--)		
if(significant_coeff_flag[i]) {		
coeff_abs_level_minus1[i **]**	3 | 4	ae(v)
coeff_sign_flag[i **]**	3 | 4	ae(v)
coeffLevel[i] = (coeff_abs_level_minus1[i] + 1) * (1 – 2 * coeff_sign_flag[i])		
} else		
coeffLevel[i] = 0		
} else		
for(i = 0; i < maxNumCoeff; i++)		
coeffLevel[i] = 0		
}		

24) New Subclause 7.3.5.3.3 "Residual luma data syntax"

Insert a new subclause 7.3.5.3.3 as follows.

7.3.5.3.3 Residual luma data syntax

residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8) {	C	Descriptor
if(!entropy_coding_mode_flag)		
residual_block = residual_block_cavlc		
else		
residual_block = residual_block_cabac		
if(MbPartPredMode(mb_type, 0) = = Intra_16x16)		
residual_block(i16x16DClevel, 16)	3	
for(i8x8 = 0; i8x8 < 4; i8x8++)		
if(!transform_size_8x8_flag || !entropy_coding_mode_flag)		
for(i4x4 = 0; i4x4 < 4; i4x4++) {		
if(CodedBlockPatternLuma & (1 << i8x8))		
if(MbPartPredMode(mb_type, 0) = = Intra_16x16)		
residual_block(i16x16AClevel[i8x8*4+ i4x4], 15)	3	
else		
residual_block(level[i8x8 * 4 + i4x4], 16)	3 | 4	
else if(MbPartPredMode(mb_type, 0) = = Intra_16x16)		
for(i = 0; i < 15; i++)		
i16x16AClevel[i8x8 * 4 + i4x4][i] = 0		
else		
for(i = 0; i < 16; i++)		
level[i8x8 * 4 + i4x4][i] = 0		
if(!entropy_coding_mode_flag && transform_size_8x8_flag)		
for(i = 0; i < 16; i++)		
level8x8[i8x8][4 * i + i4x4] = level[i8x8 * 4 + i4x4][i]		
}		
else if(CodedBlockPatternLuma & (1 << i8x8))		
residual_block(level8x8[i8x8], 64)	3 | 4	
else		
for(i = 0; i < 64; i++)		
level8x8[i8x8][i] = 0		
}		

25) Subclause 7.4.1.2.5 "Order of VCL NAL units and association to coded pictures"

In subclause 7.4.1.2.5, replace the following paragraph.

- Otherwise (arbitrary slice order is not allowed), the order of coded slice of an IDR picture NAL units shall be in the order of increasing macroblock address for the first macroblock of each coded slice of an IDR picture NAL unit.

with

- Otherwise (arbitrary slice order is not allowed), the following applies.

- If separate_colour_plane_flag is equal to 0, the order of coded slices of IDR picture NAL units shall be in the order of increasing macroblock address for the first macroblock of each coded slice of an IDR picture NAL unit.
- Otherwise (separate_colour_plane_flag is equal to 1), the order of coded slices of IDR picture NAL units for each value of colour_plane_id shall be in the order of increasing macroblock address for the first macroblock of each coded slice of the particular value of colour_plane_id of an IDR picture NAL unit.

  NOTE – When separate_colour_plane_flag is equal to 1, the relative ordering of coded slices having different values of colour_plane_id is not constrained.

26) Subclause 7.4.2.1 "Sequence parameter set RBSP semantics"

In subclause 7.4.2.1, make the following changes

Replace the paragraphs that state as follows.

NOTE – When one or more than one of constraint_set0_flag, constraint_set1_flag, or constraint_set2_flag are equal to 1, the bitstream must obey the constraints of all of the indicated subclauses of subclause A.2. When profile_idc is equal to 100, 110, 122, or 144, the values of constraint_set0_flag, constraint_set1_flag, and constraint_set2_flag must all be equal to 0.

constraint_set3_flag indicates the following.

– If profile_idc is equal to 66, 77, or 88 and level_idc is equal to 11, constraint_set3_flag equal to 1 indicates that the bitstream obeys all constraints specified in Annex A for level 1b and constraint_set3_flag equal to 0 indicates that the bitstream may or may not obey all constraints specified in Annex A for level 1b.

– Otherwise (profile_idc is equal to 100, 110, 122, or 144 or level_idc is not equal to 11), the value of 1 for constraint_set3_flag is reserved for future use by ITU-T | ISO/IEC. constraint_set3_flag shall be equal to 0 in bitstreams conforming to this Recommendation | International Standard when profile_idc is equal to 100, 110, 122, or 144 or level_idc is not equal to 11. Decoders conforming to this Recommendation | International Standard shall ignore the value of constraint_set3_flag when profile_idc is equal to 100, 110, 122, or 144 or level_idc is not equal to 11.

with the following.

NOTE – When one or more than one of constraint_set0_flag, constraint_set1_flag, or constraint_set2_flag are equal to 1, the bitstream must obey the constraints of all of the indicated subclauses of subclause A.2. When profile_idc is equal to 44, 100, 110, 122, or 244, the values of constraint_set0_flag, constraint_set1_flag, and constraint_set2_flag must all be equal to 0.

constraint_set3_flag indicates the following.

– If profile_idc is equal to 66, 77, or 88 and level_idc is equal to 11, constraint_set3_flag equal to 1 indicates that the bitstream obeys all constraints specified in Annex A for level 1b and constraint_set3_flag equal to 0 indicates that the bitstream may or may not obey all constraints specified in Annex A for level 1b.

– Otherwise, if profile_idc is equal to 100 or 110, constraint_set3_flag equal to 1 indicates that the bitstream obeys all constraints specified in Annex A for the High 10 Intra profile, and constraint_set3_flag equal to 0 indicates that the bitstream may or may not obey these corresponding constraints.

– Otherwise, if profile_idc is equal to 122, constraint_set3_flag equal to 1 indicates that the bitstream obeys all constraints specified in Annex A for the High 4:2:2 Intra profile, and constraint_set3_flag equal to 0 indicates that the bitstream may or may not obey these corresponding constraints.

– Otherwise, if profile_idc is equal to 44, constraint_set3_flag shall be equal to 1. When profile_idc is equal to 44, the value of 0 for constraint_set3_flag is forbidden.

– Otherwise, if profile_idc is equal to 244, constraint_set3_flag equal to 1 indicates that the bitstream obeys all constraints specified in Annex A for the High 4:4:4 Intra profile, and constraint_set3_flag equal to 0 indicates that the bitstream may or may not obey these corresponding constraints.

– Otherwise (profile_idc is equal to 66, 77, 88 and level_idc is not equal to 11), the value of 1 for constraint_set3_flag is reserved for future use by ITU-T | ISO/IEC. constraint_set3_flag shall be equal to 0 in bitstreams conforming to this Recommendation | International Standard when profile_idc is equal to 66, 77, or 88 and level_idc is not equal to 11. Decoders conforming to this Recommendation | International Standard shall ignore the value of constraint_set3_flag when profile_idc is equal to 66, 77, or 88 and level_idc is not equal to 11.

Delete the paragraph starting with "residual_colour_transform_flag**".**

*Add the following paragraph before the paragraph starting with "*bit_depth_luma_minus8*".*

separate_colour_plane_flag equal to 1 specifies that the three colour components of the 4:4:4 chroma format are coded separately. separate_colour_plane_flag equal to 0 specifies that the three colour components of the 4:4:4 chroma format are not coded separately. When separate_colour_plane_flag is not present, it shall be inferred to be equal to 0. When separate_colour_plane_flag is equal to 1, the primary coded picture consists of three separate components, each of which consists of coded samples of one colour plane (Y or Cb or Cr) that conforms to the monochrome coding syntax. In this case, each picture is associated with a specific colour_plane_id value.

NOTE – There is no dependency in decoding processes between the colour planes having different colour_plane_id values. For example, the decoding process of a monochrome picture with one value of colour_plane_id does not use any date from monochrome pictures having different values of colour_plane_id for inter prediction.

Depending on the value of separate_colour_plane_flag, assign the value of the variable ChromaArrayType as follows.

– If separate_colour_plane_flag is equal to 0, ChromaArrayType is set equal to chroma_format_idc.

– Otherwise (separate_colour_plane_flag is equal to 1), ChromaArrayType is set equal to 0.

*Replace the paragraph starting with "*bit_depth_luma_minus8**" with the following.***

bit_depth_luma_minus8 specifies the bit depth of the samples of the luma array and the value of the luma quantisation parameter range offset $QpBdOffset_Y$, as specified by

$$BitDepth_Y = 8 + bit\_depth\_luma\_minus8 \quad (7\text{-}1)$$

$$QpBdOffset_Y = 6 * bit\_depth\_luma\_minus8 \quad (7\text{-}2)$$

When bit_depth_luma_minus8 is not present, it shall be inferred to be equal to 0. bit_depth_luma_minus8 shall be in the range of 0 to 6, inclusive.

Replace the paragraph starting with "bit_depth_chroma_minus8**" with the following.**

bit_depth_chroma_minus8 specifies the bit depth of the samples of the chroma arrays and the value of the chroma quantisation parameter range offset $QpBdOffset_C$, as specified by

$$BitDepth_C = 8 + bit\_depth\_chroma\_minus8 \quad (7\text{-}3)$$

$$QpBdOffset_C = 6 * bit\_depth\_chroma\_minus8 \quad (7\text{-}4)$$

When bit_depth_chroma_minus8 is not present, it shall be inferred to be equal to 0. bit_depth_chroma_minus8 shall be in the range of 0 to 6, inclusive.

NOTE – The value of bit_depth_chroma_minus8 is not used in the decoding process when ChromaArrayType is equal to 0. In particular, when separate_colour_plane_flag is equal to 1, each colour plane is decoded as a distinct monochrome picture using the luma component decoding process (except for the selection of scaling matrices) and the luma bit depth is used for all three colour components.

*Replace the paragraph starting with "*seq_scaling_matrix_present_flag equal to 1*" with the following.*

seq_scaling_matrix_present_flag equal to 1 specifies that the flags seq_scaling_list_present_flag[i] for i = 0..11 are present. seq_scaling_matrix_present_flag equal to 0 specifies that these flags are not present and the sequence-level scaling list specified by Flat_4x4_16 shall be inferred for i = 0..5 and the sequence-level scaling list specified by Flat_8x8_16 shall be inferred for i = 6..11. When seq_scaling_matrix_present_flag is not present, it shall be inferred to be equal to 0.

Replace Table 7–2 *with the following.*

Table 7-2 – Assignment of mnemonic names to scaling list indices and specification of fall-back rule

Value of scaling list index	Mnemonic name	Block size	MB prediction type	Component	Scaling list fall-back rule set A	Scaling list fall-back rule set B	Default scaling list
0	Sl_4x4_Intra_Y	4x4	Intra	Y	default scaling list	sequence-level scaling list	Default_4x4_Intra
1	Sl_4x4_Intra_Cb	4x4	Intra	Cb	scaling list for i = 0	scaling list for i = 0	Default_4x4_Intra
2	Sl_4x4_Intra_Cr	4x4	Intra	Cr	scaling list for i = 1	scaling list for i = 1	Default_4x4_Intra
3	Sl_4x4_Inter_Y	4x4	Inter	Y	default scaling list	sequence-level scaling list	Default_4x4_Inter
4	Sl_4x4_Inter_Cb	4x4	Inter	Cb	scaling list for i = 3	scaling list for i = 3	Default_4x4_Inter
5	Sl_4x4_Inter_Cr	4x4	Inter	Cr	scaling list for i = 4	scaling list for i = 4	Default_4x4_Inter
6	Sl_8x8_Intra_Y	8x8	Intra	Y	default scaling list	sequence-level scaling list	Default_8x8_Intra
7	Sl_8x8_Inter_Y	8x8	Inter	Y	default scaling list	sequence-level scaling list	Default_8x8_Inter
8	Sl_8x8_Intra_Cb	8x8	Intra	Cb	scaling list for i = 6	scaling list for i = 6	Default_8x8_Intra
9	Sl_8x8_Inter_Cb	8x8	Inter	Cb	scaling list for i = 7	scaling list for i = 7	Default_8x8_Inter
10	Sl_8x8_Intra_Cr	8x8	Intra	Cr	scaling list for i = 8	scaling list for i = 8	Default_8x8_Intra
11	Sl_8x8_Inter_Cr	8x8	Inter	Cr	scaling list for i = 9	scaling list for i = 9	Default_8x8_Inter

Replace the paragraph starting with "frame_crop_left_offset, frame_crop_right_offset, frame_crop_top_offset, frame_crop_bottom_offset**"** *with the following.*

frame_crop_left_offset, frame_crop_right_offset, frame_crop_top_offset, frame_crop_bottom_offset specify the samples of the pictures in the coded video sequence that are output from the decoding process, in terms of a rectangular region specified in frame coordinates for output.

The variables CropUnitX and CropUnitY are derived as follows:

– If ChromaArrayType is equal to 0, CropUnitX and CropUnitY are derived as

CropUnitX = 1 (7-16)
CropUnitY = 2 – frame_mbs_only_flag (7-17)

– Otherwise (ChromaArrayType is equal to 1, 2, or 3), CropUnitX and CropUnitY are derived as

CropUnitX = SubWidthC (7-18)
CropUnitY = SubHeightC * (2 – frame_mbs_only_flag) (7-19)

The frame cropping rectangle contains luma samples with horizontal frame coordinates from CropUnitX * frame_crop_left_offset to $PicWidthInSamples_L$ – (CropUnitX * frame_crop_right_offset + 1) and

vertical frame coordinates from CropUnitY * frame_crop_top_offset to (16 * FrameHeightInMbs) – (CropUnitY * frame_crop_bottom_offset + 1), inclusive. The value of frame_crop_left_offset shall be in the range of 0 to ($PicWidthInSamples_L$ / CropUnitX) – (frame_crop_right_offset + 1), inclusive; and the value of frame_crop_top_offset shall be in the range of 0 to (16 * FrameHeightInMbs / CropUnitY) – (frame_crop_bottom_offset + 1), inclusive.

When frame_cropping_flag is equal to 0, the values of frame_crop_left_offset, frame_crop_right_offset, frame_crop_top_offset, and frame_crop_bottom_offset shall be inferred to be equal to 0.

When ChromaArrayType is not equal to 0, the corresponding specified samples of the two chroma arrays are the samples having frame coordinates (x / SubWidthC, y / SubHeightC), where (x, y) are the frame coordinates of the specified luma samples.

For decoded fields, the specified samples of the decoded field are the samples that fall within the rectangle specified in frame coordinates.

27) Subclause 7.4.2.1.2 "Sequence parameter set extension RBSP semantics"

In subclause 7.4.2.1 replace the text

The value of chroma_format_idc

with

The value of chroma_format_idc and the value of ChromaArrayType

(in one occurrence)

28) Subclause 7.4.2.2 "Picture parameter set RBSP semantics"

Add the following note at the end of subclause 7.4.2.2.

NOTE – The values of bit_depth_chroma_minus8, chroma_qp_index_offset and second_chroma_qp_index_offset are not used in the decoding process when ChromaArrayType is equal to 0. In particular, when separate_colour_plane_flag is equal to 1, each colour plane is decoded as a distinct monochrome picture using the luma component decoding process (except for the selection of scaling matrices), including the application of the luma quantisation parameter derivation process without application of an offset for the decoding of the pictures having colour_plane_id not equal to 0.

29) Subclause 7.4.2.9.1 "Slice data partition A RBSP semantics"

In subclause 7.4.2.9.1, replace the paragraph that states as follows.

slice_id identifies the slice associated with the data partition. Each slice shall have a unique slice_id value within the coded picture that contains the slice. When arbitrary slice order is not allowed as specified in Annex A, the first slice of a coded picture, in decoding order, shall have slice_id equal to 0 and the value of slice_id shall be incremented by one for each subsequent slice of the coded picture in decoding order.

with

slice_id identifies the slice associated with the data partition. The value of slice_id is constrained as follows.

- If separate_colour_plane_flag is equal to 0, the following applies.
  - If arbitrary slice order is not allowed as specified in Annex A, the first slice of a coded picture, in decoding order, shall have slice_id equal to 0 and the value of slice_id shall be incremented by one for each subsequent slice of the coded picture in decoding order.
  - Otherwise (arbitrary slice order is allowed), each slice shall have a unique slice_id value within the set of slices of the coded picture.

– Otherwise (separate_colour_plane_flag is equal to 1), the following applies.

  – If arbitrary slice order is not allowed as specified in Annex A, the first slice of a coded picture having each value of colour_plane_id, in decoding order, shall have slice_id equal to 0 and the value of slice_id shall be incremented by one for each subsequent slice of the coded picture having the same value of colour_plane_id, in decoding order.

  – Otherwise (arbitrary slice order is allowed) each slice shall have a unique slice_id value within each set of slices of the coded picture that have the same value of colour_plane_id.

30) Subclause 7.4.2.9.2 "Slice data partition B RBSP semantics"

In subclause 7.4.2.9.2, insert the following after the paragraph starting with "**slice_id**".

colour_plane_id specifies the colour plane associated with the current slice RBSP when separate_colour_plane_flag is equal to 1. The value of colour_plane_id shall be in the range of 0 to 2, inclusive. colour_plane_id equal to 0, 1, and 2 correspond to the Y, Cb, and Cr planes, respectively.

NOTE – There is no dependency between the decoding processes of pictures having different values of colour_plane_id.

31) Subclause 7.4.2.9.3 "Slice data partition C RBSP semantics"

In subclause 7.4.2.9.3, insert the following after the paragraph starting with "**slice_id**".

colour_plane_id has the same semantics as specified in subclause 7.4.2.9.2.

32) Subclause 7.4.3 "Slice header semantics"

In subclause 7.4. 3, make the following changes.

Replace the following paragraph.

first_mb_in_slice specifies the address of the first macroblock in the slice. When arbitrary slice order is not allowed as specified in Annex A, the value of first_mb_in_slice shall not be less than the value of first_mb_in_slice for any other slice of the current picture that precedes the current slice in decoding order.

with the following.

first_mb_in_slice specifies the address of the first macroblock in the slice. When arbitrary slice order is not allowed as specified in Annex A, the value of first_mb_in_slice is constrained as follows.

– If separate_colour_plane_flag is equal to 0, the value of first_mb_in_slice shall not be less than the value of first_mb_in_slice for any other slice of the current picture that precedes the current slice in decoding order.

– Otherwise (separate_colour_plane_flag is equal to 1), the value of first_mb_in_slice shall not be less than the value of first_mb_in_slice for any other slice of the current picture that precedes the current slice in decoding order and has the same value of colour_plane_id.

Insert the following after the paragraph starting with "**pic_parameter_set_id**".

colour_plane_id has the same semantics as specified in subclause 7.4.2.9.2.

33) Subclause 7.4.5 "Macroblock layer semantics"

In subclause 7.4.5, make the following changes.

Replace the paragraph starting with "**transform_size_8x8_flag** equal to 1" *with the following.*

transform_size_8x8_flag equal to 1 specifies that for the current macroblock the transform coefficient decoding process and picture construction process prior to deblocking filter process for residual 8x8 blocks shall be invoked

for luma samples, and when ChromaArrayType = = 3 also for Cb and Cr samples. transform_size_8x8_flag equal to 0 specifies that for the current macroblock the transform coefficient decoding process and picture construction process prior to deblocking filter process for residual 4x4 blocks shall be invoked for luma samples, and when ChromaArrayType = = 3 also for Cb and Cr samples. When transform_size_8x8_flag is not present in the bitstream, it shall be inferred to be equal to 0.

Replace the paragraph starting with **"**To each Intra_16x16*" with the following..*

To each Intra_16x16 prediction macroblock, an Intra16x16PredMode is assigned, which specifies the Intra_16x16 prediction mode.

The meaning of the variables CodedBlockPatternChroma and CodedBlockPatternLuma is specified with the semantics of coded_block_pattern.

Replace the following paragraphs.

pcm_sample_luma[i] is a sample value. The first pcm_sample_luma[i] values represent luma sample values in the raster scan within the macroblock. The number of bits used to represent each of these samples is $BitDepth_Y$. When profile_idc is not equal to 100, 110, 122, or 144, pcm_sample_luma[i] shall not be equal to 0.

pcm_sample_chroma[i] is a sample value. The first MbWidthC * MbHeightC pcm_sample_chroma[i] values represent Cb sample values in the raster scan within the macroblock and the remaining MbWidthC * MbHeightC pcm_sample_chroma[i] values represent Cr sample values in the raster scan within the macroblock. The number of bits used to represent each of these samples is $BitDepth_C$. When profile_idc is not equal to 100, 110, 122, or 144, pcm_sample_chroma[i] shall not be equal to 0.

with the following.

pcm_sample_luma[i] is a sample value. The first pcm_sample_luma[i] values represent luma sample values in the raster scan within the macroblock. The number of bits used to represent each of these samples is $BitDepth_Y$. When profile_idc is not equal to 44, 100, 110, 122, or 244, pcm_sample_luma[i] shall not be equal to 0.

pcm_sample_chroma[i] is a sample value. The first MbWidthC * MbHeightC pcm_sample_chroma[i] values represent Cb sample values in the raster scan within the macroblock and the remaining MbWidthC * MbHeightC pcm_sample_chroma[i] values represent Cr sample values in the raster scan within the macroblock. The number of bits used to represent each of these samples is $BitDepth_C$. When profile_idc is not equal to 44, 100, 110, 122, or 244, pcm_sample_chroma[i] shall not be equal to 0.

*Delete the paragraph starting with "*When coded_block_pattern is present, CodedBlockPatternLuma specifies*"*.

*Insert the following paragraph before the paragraph starting with "*mb_qb_delta".

Depending on the value of ChromaArrayType, the following meaning is assigned to CodedBlockPatternLuma and the following restrictions are imposed on CodedBlockPatternChroma.

– If ChromaArrayType is equal to 0, CodedBlockPatternLuma specifies whether and where, for the luma component, non-zero AC transform coefficient levels are present and the derivation of the variable CodedBlockPatternChroma shall result in a value that is equal to 0.

– Otherwise, if ChromaArrayType is equal to 1 or 2, CodedBlockPatternLuma specifies whether, for the luma component, non-zero AC transform coefficient levels are present and CodedBlockPatternChroma may be in the range of 0 to 2, inclusive.

– Otherwise (ChromaArrayType is equal to 3), CodedBlockPatternLuma specifies whether and where, for the luma and the Cb and Cr component, non-zero AC transform coefficient levels are present and the derivation of the variable CodedBlockPatternChroma shall result in a value that is equal to 0.

34) Subclause 7.4.5.1 "Macroblock prediction semantics"

In subclause 7.4.5.1, make the following changes.

Replace the paragraph starting with **"**prev_intra4x4_pred_mode_flag**"** *with the following.*

prev_intra4x4_pred_mode_flag[luma4x4BlkIdx] and **rem_intra4x4_pred_mode**[luma4x4BlkIdx] specify the Intra_4x4 prediction of the 4x4 luma block with index luma4x4BlkIdx = 0..15. When ChromaArrayType is equal to 3, prev_intra4x4_pred_mode_flag[luma4x4BlkIdx] and rem_intra4x4_pred_mode[luma4x4BlkIdx] also

specify the Intra_4x4 prediction of the 4x4 Cb block and 4x4 Cr block with luma4x4BlkIdx equal to index cb4x4BlkIdx = 0..15 or cr4x4BlkIdx = 0..15.

Replace the paragraph starting with **"**prev_intra8x8_pred_mode_flag**"** *with the following.*

prev_intra8x8_pred_mode_flag[luma8x8BlkIdx] and **rem_intra8x8_pred_mode**[luma8x8BlkIdx] specify the Intra_8x8 prediction of the 8x8 luma block with index luma8x8BlkIdx = 0..3. When ChromaArrayType is equal to 3, prev_intra8x8_pred_mode_flag[luma8x8BlkIdx] and rem_intra8x8_pred_mode[luma8x8BlkIdx] also specify the Intra_8x8 prediction of the 8x8 Cb block and 8x8 Cr block with index luma8x8BlkIdx equal to cb8x8BlkIdx = 0..3 or cr8x8BlkIdx = 0..3.

35) Subclause 7.4.5.3 "Residual data semantics"

Replace the content of subclause 7.4.5.3 with the following.

The syntax structure residual_block( ), which is used for parsing the transform coefficient levels, is assigned as follows.

– If entropy_coding_mode_flag is equal to 0, residual_block is set equal to residual_block_cavlc, which is used for parsing the syntax elements for transform coefficient levels.

– Otherwise (entropy_coding_mode_flag is equal to 1), residual_block is set equal to residual_block_cabac, which is used for parsing the syntax elements for transform coefficient levels.

The syntax structure residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8) is used with the variables in brackets being its output and being assigned as follows. Intra16x16DCLevel is set equal to i16x16DClevel, Intra16x16ACLevel is set equal to i16x16AClevel, LumaLevel is set equal to level, and LumaLevel8x8 is set equal to level8x8.

When ChromaArrayType is equal to 1 or 2, the following applies.

– For each chroma component, indexed by iCbCr = 0..1, the DC transform coefficient levels of the 4 * NumC8x8 4x4 chroma blocks are parsed into the iCbCr-th list ChromaDCLevel[iCbCr].

– For each of the 4x4 chroma blocks, indexed by i4x4 = 0..3 and i8x8 = 0..NumC8x8 – 1, of each chroma component, indexed by iCbCr = 0..1, the 15 AC transform coefficient levels are parsed into the (i8x8*4 + i4x4)-th list of the iCbCr-th chroma component ChromaACLevel[iCbCr][i8x8*4 + i4x4].

When ChromaArrayType is equal to 3, the following applies.

– The syntax structure residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8) is used for the Cb component with the variables in brackets being its output and being assigned as follows. CbIntra16x16DCLevel is set equal to i16x16DClevel, CbIntra16x16ACLevel is set equal to i16x16AClevel, CbLevel is set equal to level, and CbLevel8x8 is set equal to level8x8.

– The syntax structure residual_luma(i16x16DClevel, i16x16AClevel, level, level8x8) is used for the Cr component with the variables in brackets being its output and being assigned as follows. CrIntra16x16DCLevel is set equal to i16x16DClevel, CrIntra16x16ACLevel is set equal to i16x16AClevel, CrLevel is set equal to level, and CrLevel8x8 is set equal to level8x8.

36) Subclause 7.4.5.3.2 "Residual block CABAC semantics"

In subclause 7.4.5.3.2, replace the paragraph starting with "coded_block_flag" *with the following.*

coded_block_flag specifies whether the block contains non-zero transform coefficient levels as follows.

– If coded_block_flag is equal to 0, the block contains no non-zero transform coefficient levels.

– Otherwise (coded_block_flag is equal to 1), the block contains at least one non-zero transform coefficient level.

When maxNumCoeff is equal to 64 and ChromaArrayType is not equal to 3, coded_block_flag is set equal to 1.

37) New Subclause 7.4.5.3.3 "Residual luma data semantics”

Insert a new subclause 7.4.5.3.3 as follows.

7.3.5.3.3 Residual luma data semantics

Output of this syntax structure are the variables i16x16DClevel, i16x16AClevel, level, and level8x8.

The syntax structure residual_block( ), which is used for parsing the transform coefficient levels, is assigned as follows.

– If entropy_coding_mode_flag is equal to 0, residual_block is set equal to residual_block_cavlc, which is used for parsing the syntax elements for transform coefficient levels.

– Otherwise (entropy_coding_mode_flag is equal to 1), residual_block is set equal to residual_block_cabac, which is used for parsing the syntax elements for transform coefficient levels.

Depending on mb_type the syntax structure residual_block(coeffLevel, maxNumCoeff) is used with the arguments coeffLevel, which is a list containing the maxNumCoeff transform coefficient levels that are parsed in residual_block( ) and maxNumCoeff as follows. Depending on MbPartPredMode(mb_type, 0), the following applies.

– If MbPartPredMode(mb_type, 0) is equal to Intra_16x16, the transform coefficient levels are parsed into the list i16x16DClevel and into the 16 lists i16x16AClevel[i]. i16x16DClevel contains the 16 transform coefficient levels of the DC transform coefficient levels for each 4x4 luma block. For each of the 16 4x4 luma blocks indexed by i = 0..15, the 15 AC transform coefficients levels of the i-th block are parsed into the i-th list i16x16AClevel[i].

– Otherwise (MbPartPredMode(mb_type, 0) is not equal to Intra_16x16), the following applies.

  – If transform_size_8x8_flag is equal to 0, for each of the 16 4x4 luma blocks indexed by i = 0..15, the 16 transform coefficient levels of the i-th block are parsed into the i-th list level[i].

  – Otherwise (transform_size_8x8_flag is equal to 1), for each of the 4 8x8 luma blocks indexed by i8x8 = 0..3, the following applies.

    – If entropy_coding_mode_flag is equal to 0, first for each of the 4 4x4 luma blocks indexed by i4x4 = 0..3, the 16 transform coefficient levels of the i4x4-th block are parsed into the (i8x8 * 4 + i4x4)-th list level[i8x8 * 4 + i4x4]. Then, the 64 transform coefficient levels of the i8x8-th 8x8 luma block which are indexed by 4 * i + i4x4, where i = 0..15 and i4x4 = 0..3, are derived as level8x8[i8x8][4 * i + i4x4] = level[i8x8 * 4 + i4x4][i].

      NOTE – The 4x4 luma blocks with luma4x4BlkIdx = i8x8 * 4 + i4x4 containing every fourth transform coefficient level of the corresponding i8x8-th 8x8 luma block with offset i4x4 are assumed to represent spatial locations given by the inverse 4x4 luma block scanning process in subclause 6.4.3.

    – Otherwise (entropy_coding_mode_flag is equal to 1), the 64 transform coefficient levels of the i8x8-th block are parsed into the i8x8-th list level8x8[i8x8].

38) Clause 8 and all subclauses of clause 8 “Decoding process”

In clause 8 and all subclauses of clause 8, make the following changes.

Replace all occurences of “chroma_format_idc” *with* “ChromaArrayType”.

Delete all occurences of “(monochrome)”.

39) Clause 8 “Decoding process”

In clause 8, make the following changes.

After the first sentence, insert the following.

Depending on the value of chroma_format_idc, the number of sample arrays of the current picture is as follows.

– If chroma_format_idc is equal to 0, the current picture consists of 1 sample array S_L.

– Otherwise (chroma_format_idc is not equal to 0), the current picture consists of 3 sample arrays S_L, S_{Cb}, S_{Cr}.

Replace the paragraph that starts with "Each picture referred*" with the following*

Each picture referred to in this clause is a complete or part of a primary coded picture. Each slice referred to in this clause is a slice of a primary picture. Each slice data partition referred to in this clause is a slice data partition of a primary picture.

Depending on the value of separate_colour_plane_flag, the decoding process is structured as follows.

– If separate_colour_plane_flag is equal to 0, the decoding process is invoked a single time with the current picture being the output.

– Otherwise (separate_colour_plane_flag is equal to 1), the decoding process is invoked three times. Inputs to the decoding process are all NAL units of the primary coded picture with identical value of colour_plane_id. The decoding process of NAL units with a particular value of colour_plane_id is specified as if only a coded video sequence with monochrome colour format with that particular value of colour_plane_id would be present in the bitstream. The output of each of the three decoding processes is assigned to the 3 sample arrays of the current picture with the NAL units with colour_plane_id equal to 0 being assigned to S_L, the NAL units with colour_plane_id equal to 1 being assigned to S_{Cb}, and the NAL units with colour_plane_id equal to 2 being assigned to S_{Cr}.

NOTE - The variable ChromaArrayType is derived as 0 when separate_colour_plane_flag is equal to 1 and chroma_format_idc is equal to 3. In the decoding process, the value of this variable is evaluated resulting in operations identical to that of monochrome pictures with chroma_format_idc being equal to 0.

40) Subclause 8.3.4 "Intra prediction for chroma samples"

In subclause 8.3.4, after the second paragraph, insert the following.

Depending on the value of ChromaArrayType, the following applies.

– If ChromaArrayType is equal to 3, the Intra prediction chroma samples for the current macroblock $pred_{Cb}[x, y]$ and $pred_{Cr}[x, y]$ are derived using the Intra prediction process for chroma samples with ChromaArrayType equal to 3 as specified in subclause 8.3.4.5.

– Otherwise (ChromaArrayType is equal to 1 or 2), the following text specifies the Intra prediction chroma samples for the current macroblock $pred_{Cb}[x, y]$ and $pred_{Cr}[x, y]$.

41) Subclause 8.3.4.1 "Specification of Intra_Chroma_DC prediction mode"

In subclause 8.3.4.1, make the following changes.

Replace the following

– Depending on chroma_format_idc, the position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx is derived as follows

  – If chroma_format_idc is equal to 1 or 2, the following applies

```
xO = InverseRasterScan( chroma4x4BlkIdx, 4, 4, 8, 0 )                    (8-124)

yO = InverseRasterScan( chroma4x4BlkIdx, 4, 4, 8, 1 )                    (8-125)
```

  – Otherwise (chroma_format_idc is equal to 3), the following applies

```
xO = InverseRasterScan( chroma4x4BlkIdx / 4, 8, 8, 16, 0 ) +
          InverseRasterScan( chroma4x4BlkIdx % 4, 4, 4, 8, 0 )           (8-126)
```

yO = InverseRasterScan(chroma4x4BlkIdx / 4, 8, 8, 16, 1) +
InverseRasterScan(chroma4x4BlkIdx % 4, 4, 4, 8, 1) (8-127)

with

– The position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx is derived as

xO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 0) (8-124)

yO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 1) (8-125)

– Depending on the values of xO and yO, the following applies.

Indent all succeeding If/Otherwise statements as necessary.

Update all following equation numbers in clause 8 as necessary.

42) New Subclause 8.3.4.5 "Intra prediction for chroma samples with ChromaArrayType equal to 3"

Insert a new subclause 8.3.4.5 as follows.

8.3.4.5 Intra prediction for chroma samples with ChromaArrayType equal to 3

This process is invoked when ChromaArrayType is equal to 3. This process is invoked for I and SI macroblock types. It specifies how the Intra prediction chroma samples for the current macroblock are derived when ChromaArrayType is equal to 3.

Inputs to this process are constructed samples prior to the deblocking filter process from neighbouring Cb and Cr blocks and for Intra_NxN (where NxN is equal to 4x4 or 8x8) prediction mode, the associated values of IntraNxNPredMode from neighbouring macroblocks.

Outputs of this process are the Intra prediction samples of the Cb and Cr components of the macroblock or in case of the Intra_NxN prediction process, the outputs are NxN Cb sample arrays as part of the 16x16 Cb array of prediction samples of the macroblock, and NxN Cb sample arrays as part of the 16x16 Cb array of prediction samples of the macroblock.

Each Cb, Cr, and luma block with the same block index of the macroblock shall use the same prediction mode. The prediction mode is applied to each of the Cb and Cr blocks separately. The process specified in this subclause is invoked for each Cb and Cr block.

Depending on the macroblock prediction mode, the following applies.

– If the macroblock prediction mode is equal to Intra_4x4, the following applies.
  – The same process described in subclause 8.3.1 shall also be applied to Cb or Cr samples, substituting luma with Cb or Cr, substituting luma4x4BlkIdx with cb4x4BlkIdx or cr4x4BlkIdx, and substituting $pred4x4_L$ with $pred4x4_{Cb}$ or $pred4x4_{Cr}$.
  – The output variable Intra4x4PredMode[luma4x4BlkIdx] from the process described in subclause 8.3.1.1 shall also be used for the 4x4 Cb or 4x4 Cr blocks with index luma4x4BlkIdx equal to index cb4x4BlkIdx or cr4x4BlkIdx.
  – The process to derive prediction Cb or Cr samples shall be identical to the process described in subclause 8.3.1.2 and its subsequent subclauses when substituting luma with Cb or Cr, and substituting $pred4x4_L$ with $pred4x4_{Cb}$ or $pred4x4_{Cr}$.
– Otherwise, if the macroblock prediction mode is equal to Intra_8x8, the following applies.
  – The same process described in subclause 8.3.2 shall also be applied to Cb or Cr samples, substituting luma with Cb or Cr, substituting luma8x8BlkIdx with cb8x8BlkIdx or cr8x8BlkIdx, and substituting $pred8x8_L$ with $pred8x8_{Cb}$ or $pred8x8_{Cr}$.

– The output variable Intra8x8PredMode[luma8x8BlkIdx] from the process described in subclause 8.3.2.1 shall also be used for the 8x8 Cb or 8x8 Cr blocks with index luma8x8BlkIdx equal to index cb8x8BlkIdx or cr8x8BlkIdx.

– The process to derive prediction Cb or Cr samples shall be identical to the process described in subclause 8.3.2.2 and its subsequent subclauses when substituting luma with Cb or Cr, and substituting $pred8x8_L$ with $pred8x8_{Cb}$ or $pred8x8_{Cr}$.

– Otherwise, if the macroblock prediction mode is equal to Intra_16x16, the following applies.

– The same process described in subclause 8.3.3 and in the subsequent subclause 8.3.3.1 to 8.3.3.4 shall also be applied to Cb or Cr samples, substituting luma with Cb or Cr, and substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$.

43) Subclause 8.4 "Inter prediction process"

In subclause 8.4, replace the paragraph starting with "Outputs of this process are*" with the following*

Outputs of this process are Inter prediction samples for the current macroblock that are a 16x16 array $pred_L$ of luma samples and when ChromaArrayType is not equal to 0 two (MbWidthC)x(MbHeightC) arrays $pred_{Cr}$ and $pred_{Cb}$ of chroma samples, one for each of the chroma components Cb and Cr.

44) Subclause 8.4.1 "Derivation process for motion vector components and reference indices"

In subclause 8.4.1, replace the paragraph starting with "Outputs of this process are" *with the following.*

Outputs of this process are

– luma motion vectors mvL0 and mvL1 and when ChromaArrayType is not equal to 0, the chroma motion vectors mvCL0 and mvCL1

Replace the paragraph starting with "For the derivation of the variables for the chroma motion vectors" with the following

When ChromaArrayType is not equal to 0 and predFlagLX (with X being either 0 or 1) is equal to 1, the derivation process for chroma motion vectors in subclause 8.4.1.4 is invoked with mvLX and refIdxLX as input and the output being mvCLX.

45) Subclause 8.4.2.1 "Reference picture selection process"

In subclause 8.4.2.1, make the following changes.

Replace the paragraph starting with "Output of this process" *with the following*

Output of this process is a reference picture consisting of a two-dimensional array of luma samples $refPicLX_L$ and when ChromaArrayType is not equal to 0, two two-dimensional arrays of chroma samples $refPicLX_{Cb}$ and $refPicLX_{Cr}$.

Replace the paragraph starting with "The reference picture sample arrays" *with the following*

Depending on separate_colour_plane_flag the following applies.

- If separate_colour_plane_flag is equal to 0, the reference picture sample arrays $refPicLX_L$, $refPicLX_{Cb}$ (if available), and $refPicLX_{Cr}$ (if available) correspond to decoded sample arrays S_L, S_{Cb} (if available), S_{Cr} (if available) derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.

- Otherwise (separate_colour_plane_flag is equal to 1), the following applies.

- If colour_plane_id is equal to 0, the reference picture sample array refPicLX$_L$ corresponds to the decoded sample array S_L derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.
- Otherwise, if colour_plane_id is equal to 1, the reference picture sample array refPicLX$_L$ corresponds to the decoded sample array S_{Cb} derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.
- Otherwise (colour_plane_id is equal to 2), the reference picture sample array refPicLX$_L$ corresponds to the decoded sample array S_{Cb} derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.

46) Subclause 8.4.2.2 "Fractional sample interpolation process"

In subclause 8.4.2.2, make the following changes.

Replace the paragraphs

- a chroma motion vector mvCLX given in eighth-chroma-sample units, and
- the selected reference picture sample arrays refPicLX$_L$, and refPicLX$_{Cb}$, and refPicLX$_{Cb}$

with the following

- when ChromaArrayType is not equal to 0, a chroma motion vector mvCLX with a precision of (4*SubWidthC) chroma-sample units horizontally and (4*SubHeightC) chroma-sample units vertically, and
- the selected reference picture sample arrays refPicLX$_L$, and when ChromaArrayType is not equal to 0, refPicLX$_{Cb}$, and refPicLX$_{Cb}$

Replace the paragraph starting with "Let (xInt$_C$, yInt$_C$) be a chroma location" *with the following*

Let (xInt$_C$, yInt$_C$) be a chroma location given in full-sample units and (xFrac$_C$, yFrac$_C$) be an offset given in (4*SubWidthC) chroma-sample units horizontally and (4*SubHeightC) chroma-sample units vertically. These variables are used only inside this subclause for specifying general fractional-sample locations inside the reference sample arrays refPicLX$_{Cb}$, and refPicLX$_{Cr}$.

Replace the 4 equations following the paragraph staring with "Otherwise (chroma_format_idc is equal to 3)" *with the following*

$$xIntC = xAC + (mvLX[0] >> 2) + xC \quad (8\text{-}232)$$
$$yIntL = yAC + (mvLX[1] >> 2) + yC \quad (8\text{-}233)$$

$$xFrac_C = mvLX[0] \& 3 \quad (8\text{-}234)$$
$$yFrac_C = mvLX[1] \& 3 \quad (8\text{-}235)$$

Replace the following paragraphs

– The prediction sample value predPartLX$_{Cb}$[x$_C$, y$_C$] is derived by invoking the process specified in subclause 8.4.2.2.2 with (xInt$_C$, yInt$_C$), (xFrac$_C$, yFrac$_C$) and refPicLX$_{Cb}$ given as input.

– The prediction sample value predPartLX$_{Cr}$[x$_C$, y$_C$] is derived by invoking the process specified in subclause 8.4.2.2.2 with (xInt$_C$, yInt$_C$), (xFrac$_C$, yFrac$_C$) and refPicLX$_{Cr}$ given as input.

with the following

– Depedending on ChromaArrayType the following applies.
  – If ChromaArrayType is not equal to 3, the following applies.
    - The prediction sample value predPartLX$_{Cb}$[x$_C$, y$_C$] is derived by invoking the process specified in subclause 8.4.2.2.2 with (xInt$_C$, yInt$_C$), (xFrac$_C$, yFrac$_C$) and refPicLX$_{Cb}$ given as input.
    - The prediction sample value predPartLX$_{Cr}$[x$_C$, y$_C$] is derived by invoking the process specified in subclause 8.4.2.2.2 with (xInt$_C$, yInt$_C$), (xFrac$_C$, yFrac$_C$) and refPicLX$_{Cr}$ given as input.

– Otherwise (ChromaArrayType is equal to 3), the following applies.

- The prediction sample value predPartLX$_{Cb}$[$x_{C,}$ y_C] is derived by invoking the process specified in subclause 8.4.2.2.1 with ($xInt_C$, $yInt_C$), ($xFrac_C$, $yFrac_C$) and refPicLX$_{Cb}$ given as input.
- The prediction sample value predPartLX$_{Cr}$[$x_{C,}$ y_C] is derived by invoking the process specified in subclause 8.4.2.2.1 with ($xInt_C$, $yInt_C$), ($xFrac_C$, $yFrac_C$) and refPicLX$_{Cr}$ given as input.

47) Subclause 8.4.2.2.2 "Chroma sample interpolation process"

In subclause 8.4.2.2.2, replace the first paragraph, which states as follows.

This process shall only be invoked when chroma_format_idc is not equal to 0.

with the following.

This process shall only be invoked when ChromaArrayType is equal to 1 or 2.

48) Subclause 8.5 "Transform coefficient decoding process and picture construction process prior to deblocking filter process"

Replace the content of subclause 8.5 with the following

Inputs to this process are Intra16x16DCLevel (if available), Intra16x16ACLevel (if available), CbIntra16x16DCLevel (if available), CbIntra16x16ACLevel (if available), CrIntra16x16DCLevel (if available), CrIntra16x16ACLevel (if available), LumaLevel (if available), LumaLevel8x8 (if available), ChromaDCLevel (if available), ChromaACLevel (if available), CbLevel (if available), CrLevel (if available), CbLevel8x8 (if available), CrLevel8x8 (if available), and available Inter or Intra prediction sample arrays for the current macroblock for the applicable components $pred_L$, $pred_{Cb}$, or $pred_{Cr}$

NOTE – When decoding a macroblock in Intra_4x4 (or Intra_8x8) prediction mode, the luma component of the macroblock prediction array may not be complete, since for each 4x4 (or 8x8) luma block, the Intra_4x4 (or Intra_8x8) prediction process for luma samples as specified in subclause 8.3.1 (or 8.3.2) and the process specified in this subclause are iterated. For the same reason, the Cb and Cr component of the macroblock prediction array may not be complete when ChromaArrayType is equal to 3.

Outputs of this process are the constructed sample arrays prior to the deblocking filter process for the applicable components S'_L, S'_{Cb}, S'_{Cr}.

NOTE – When decoding a macroblock in Intra_4x4 (or Intra_8x8) prediction mode, the luma component of the macroblock constructed sample arrays prior to the deblocking filter process may not be complete, since for each 4x4 (or 8x8) luma block, the Intra_4x4 (or Intra_8x8) prediction process for luma samples as specified in subclause 8.3.1 (or 8.3.2) and the process specified in this subclause are iterated. For the same reason, the Cb and Cr component of the macroblock constructed sample arrays prior to the deblocking filter process may not be complete when ChromaArrayType is equal to 3.

This subclause specifies transform coefficient decoding and picture construction prior to the deblocking filter process.

When the current macroblock is coded as P_Skip or B_Skip, all values of LumaLevel, LumaLevel8x8, CbLevel, CbLevel8x8, CrLevel, CrLevel8x8, ChromaDCLevel, ChromaACLevel are set equal to 0 for the current macroblock.

49) Subclause 8.5.1 "Specification of transform decoding process for 4x4 luma residual blocks"

*In subclause 8.5.1, replace the paragraph starting with "*When residual_colour_transform_flag*" with the following*

When qpprime_y_zero_transform_bypass_flag is equal to 1, QP'_Y is equal to 0, the macroblock prediction mode is equal to Intra_4x4, and Intra4x4PredMode[luma4x4BlkIdx] is equal to 0 or 1, the intra residual transform-bypass decoding process as specified in subclause 8.5.13 is invoked with nMax equal to 4, horPredFlag equal to

Intra4x4PredMode[luma4x4BlkIdx], and the 4x4 array r as inputs, and the output is a modified version of the 4x4 array r.

50) Subclause 8.5.2 "Specification of transform decoding process for luma samples of Intra_16x16 macroblock prediction mode"

*In subclause 8.5.2, replace the paragraph starting with "*When residual_colour_transform_flag*" with the following*

When qpprime_y_zero_transform_bypass_flag is equal to 1, QP'_Y is equal to 0, the macroblock prediction mode is equal to Intra_16x16, and Intra16x16PredMode is equal to 0 or 1, intra residual transform-bypass decoding process as specified in subclause 8.5.13 is invoked with nMax equal to 4, horPredFlag equal to Intra16x16PredMode, and the 4x4 array r as inputs, and the output is a modified version of the 4x4 array r.

51) Subclause 8.5.3 "Specification of transform decoding process for 8x8 luma residual blocks"

*In subclause 8.5.3, replace the paragraph starting with "*When residual_colour_transform_flag*" with the following*

When qpprime_y_zero_transform_bypass_flag is equal to 1, QP'_Y is equal to 0, the macroblock prediction mode is equal to Intra_8x8, and Intra8x8PredMode[luma8x8BlkIdx] is equal to 0 or 1, the intra residual transform-bypass decoding process as specified in subclause 8.5.13 is invoked with nMax equal to 8, horPredFlag equal to Intra8x8PredMode[luma8x8BlkIdx], and the 8x8 array r as inputs, and the output is a modified version of the 8x8 array r.

52) Subclause 8.5.4 "Specification of transform decoding process for chroma samples"

In subclause 8.5.4, make the following changes.

Replace the first paragraph of the subclause with the following.

This process is invoked for each chroma component Cb and Cr separately when ChromaArrayType is not equal to 0.

Depending on ChromaArrayType, the following applies.

- If ChromaArrayType is equal to 3, the transform decoding process for chroma samples with ChromaArrayType equal to 3 as specified in subclause 8.5.4.1 is invoked.
- Otherwise (ChromaArrayType is not equal to 3), the following text specifies the transform decoding process for chroma samples.

Replace the sentence

Otherwise, if chroma_format_idc is equal to 2, the 2x4 array c is derived using the inverse raster scanning process applied to ChromaDCLevel as follows

with the following.

Otherwise (ChromaArrayType is equal to 2), the 2x4 array c is derived using the inverse raster scanning process applied to ChromaDCLevel as follows

Delete the paragraph starting with "- Otherwise (chroma_format_idc is equal to 3),*".*

Delete the case (c) from Figure 8-7 including the corresponding part of the caption.

Replace the following

Depending on the variable chroma_format_idc, the The position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx inside the macroblock is derived as followsby.

– If chroma_format_idc is equal to 1 or 2, the following applies.

$$xO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 0) \quad (8\text{-}302)$$

$$yO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 1) \quad (8\text{-}303)$$

– Otherwise (chroma_format_idc is equal to 3), the following applies.

xO = InverseRasterScan(chroma4x4BlkIdx / 4, 8, 8, 16, 0) +
InverseRasterScan(chroma4x4BlkIdx % 4, 4, 4, 8, 0) (8-304)

yO =InverseRasterScan(chroma4x4BlkIdx / 4, 8, 8, 16, 1) +
InverseRasterScan(chroma4x4BlkIdx % 4, 4, 4, 8, 1) (8-305)

with the following

The position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx inside the macroblock is derived by.

xO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 0) (8-302)

yO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 1) (8-303)

Update all following equation numbers in clause 8 as necessary.

*Replace the paragraph starting with "*When residual_colour_transform_flag*" with the following*

When qpprime_y_zero_transform_bypass_flag is equal to 1, QP'_Y is equal to 0, the macroblock prediction mode is equal to Intra_4x4, Intra_8x8, or Intra_16x16, and intra_chroma_pred_mode is equal to 1 or 2, the intra residual transform-bypass decoding process as specified in subclause 8.5.13 is invoked with nMax equal to 4, horPredFlag equal to (intra_chroma_pred_mode – 1), and the 4x4 array r as inputs, and the output is a modified version of the 4x4 array r.

53) New subclause 8.5.4.1 "Specification of transform decoding process for chroma samples with ChromaArrayType equal to 3"

Insert a new subclause 8.5.4.1 as follows.

8.5.4.1 Specification of transform decoding process for chroma samples with ChromaArrayType equal to 3

This process is invoked for each chroma component Cb and Cr separately when ChromaArrayType is equal to 3.

Depending on the macroblock prediction mode and transform_size_8x8_flag, the following applies.

– If the macroblock prediction mode is equal to Intra_16x16, the transform decoding process for Cb or Cr residual blocks shall be identical to the process described in subclause 8.5.2 when substituting luma with Cb or Cr, substituting Intra16x16DCLevel with CbIntra16x16DCLevel or CrIntra16x16DCLevel, substituting Intra16x16ACLevel with CbIntra16x16ACLevel or CrIntra16x16ACLevel, and substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$, substituting luma4x4BlkIdx with cb4x4BlkIdx or cr4x4BlkIdx, substituting lumaList with CbList or CrList, and substituting $Clip1_Y$ with $Clip1_C$.

– Otherwise, if transform_size_8x8_flag is equal to 1, the transform decoding process for 8x8 Cb or 8x8 Cr residual blocks shall be identical to the process described in subclause 8.5.3 when substituting luma with Cb or Cr, substituting LumaLevel8x8 with CbLevel8x8 or CrLevel8x8, substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$, substituting luma8x8BlkIdx with cb8x8BlkIdx or cr8x8BlkIdx, and substituting $Clip1_Y$ with $Clip1_C$.

– Otherwise (the macroblock prediction mode is not equal to Intra_16x16 and transform_size_8x8_flag is equal to 0), the transform decoding process for 4x4 Cb or 4x4 Cr residual blocks shall be identical to the process described in subclause 8.5.1 when substituting luma with Cb or Cr, substituting LumaLevel with CbLevel or CrLevel, substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$, substituting luma4x4BlkIdx with cb4x4BlkIdx or cr4x4BlkIdx, and substituting $Clip1_Y$ with $Clip1_C$.

54) Subclause 8.5.6 “Inverse scanning process for 8x8 luma transform coefficients”

Replace the title of subclause 8.5.6 with the following.

8.5.6 Inverse scanning process for 8x8 transform coefficients

55) Subclause 8.5.7 “Derivation process for the chroma quantisation parameters and scaling function”

In subclause 8.5.7, make the following changes.

Delete the following.

The value of $BitDepth'_C$ for the chroma components is derived as

$$BitDepth'_C = BitDepth_C + residual\_colour\_transform\_flag \quad (8\text{-}311)$$

Replace the following

- The variable iYCbCr derived as follows.
  - If the input array c relates to a luma residual block, iYCbCr is set equal to 0.
  - Otherwise, if the input array c relates to a chroma residual block and the chroma component is equal to Cb, iYCbCr is set equal to 1.
  - Otherwise (the input array c relates to a chroma residual block and the chroma component is equal to Cr), iYCbCr is set equal to 2.

with the following.

- The variable iYCbCr derived as follows.
  - If separate_colour_plane_flag is equal to 1, iYCbCr is set equal to colour_plane_id.
  - Otherwise (separate_colour_plane_flag is equal to 0), the following applies.
    - If the input array c relates to a luma residual block, iYCbCr is set equal to 0.
    - Otherwise, if the input array c relates to a chroma residual block and the chroma component is equal to Cb, iYCbCr is set equal to 1.
    - Otherwise (the input array c relates to a chroma residual block and the chroma component is equal to Cr), iYCbCr is set equal to 2.

Replace the paragraph starting with “The inverse scanning process for 8x8 luma transform coefficients” *with the following*

- The variable iYCbCr is derived as follows.
  - If separate_colour_plane_flag is equal to 1, iYCbCr is set equal to colour_plane_id.
  - Otherwise (separate_colour_plane_flag is equal to 0), the following applies.
    - If the input array c relates to a luma residual block, iYCbCr is set equal to 0.
    - Otherwise, if the input array c relates to a chroma residual block and the chroma component is equal to Cb, iYCbCr is set equal to 1.
    - Otherwise (the input array c relates to a chroma residual block and the chroma component is equal to Cr), iYCbCr is set equal to 2.
- The inverse scanning process for 8x8 luma transform coefficients as specified in subclause 8.5.6 is invoked with ScalingList8x8[2 * iYCbCr + mbIsInterFlag] as the input and the output is assigned to the 8x8 matrix weightScale8x8.

56) Subclause 8.5.8 “Scaling and transformation process for luma DC transform coefficients for Intra_16x16 macroblock type”

In subclause 8.5.8, make the following changes.

Change the title of the subclause to

8.5.8 Scaling and transformation process for DC transform coefficients for Intra_16x16 macroblock type

Replace the following

Inputs to this process are transform coefficient level values for luma DC transform coefficients of Intra_16x16 macroblocks as a 4x4 array c with elements c_{ij}, where i and j form a two-dimensional frequency index. The array c is either an array relating to a residual block of the luma component or an array relating to a residual block of a chroma component when chroma_format_idc is equal to 3.

Outputs of this process are 16 scaled DC values for luma 4x4 blocks of Intra_16x16 macroblocks as a 4x4 array dcY with elements dcY_{ij}.

with the following

Inputs to this process are transform coefficient level values for DC transform coefficients of Intra_16x16 macroblocks as a 4x4 array c with elements c_{ij}, where i and j form a two-dimensional frequency index.

Outputs of this process are 16 scaled DC values for 4x4 blocks of Intra_16x16 macroblocks as a 4x4 array dcY with elements dcY_{ij}.

The variables bitDepth and qP are derived as follows.

– If the input array c relates to a luma residual block, bitDepth is set equal to $BitDepth_Y$ and QP is set equal to QP'_Y.

– Otherwise (the input array c relates to a chroma residual block), bitDepth is set equal to $BitDepth_C$ and QP is set equal to QP'_C.

NOTE – When separate_colour_plane_flag is equal to 1, all residual blocks are considered to be associated with the luma component for purposes of the decoding process of each colour component of a picture.

Replace the following

The bitstream shall not contain data that results in any element f_{ij} of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + BitDepth_Y)}$ to $2^{(7 + BitDepth_Y)}-1$, inclusive.

After the inverse transform, scaling is performed as follows.

– If qP is greater than or equal to 36, the scaled result is derived as

$$dcY_{ij} = (f_{ij} * LevelScale(QP'_Y \% 6, 0, 0)) << (QP'_Y / 6 - 6), \quad \text{with} \quad i, j = 0...3. \tag{8-320}$$

– Otherwise (QP'_Y is less than 36), the scaled result is derived as

$$dcY_{ij} = (f_{ij} * LevelScale(QP'_Y \% 6, 0, 0) + (1 << (5 - QP'_Y / 6))) << (qP / 6 - 6), \quad \text{with} \quad i, j = 0...3 \tag{8-321}$$

The bitstream shall not contain data that results in any element dcY_{ij} of dcY with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + BitDepth_Y)}$ to $2^{(7 + BitDepth_Y)}-1$, inclusive.

NOTE – When entropy_coding_mode_flag is equal to 0 and QP'_Y is less than 10 and profile_idc is equal to 66, 77, or 88, the range of values that can be represented for the elements c_{ij} of c is not sufficient to represent the full range of values of the elements dcY_{ij} of dcY that could be necessary to form a close approximation of the content of any possible source picture by use of the Intra_16x16 macroblock type.

with the following

The bitstream shall not contain data that results in any element f_{ij} of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

After the inverse transform, scaling is performed as follows.

– If qP is greater than or equal to 36, the scaled result is derived as

$$dcY_{ij} = (f_{ij} * LevelScale(qP \% 6, 0, 0)) << (qP / 6 – 6), \quad \text{with} \quad i, j = 0...3. \tag{8-320}$$

– Otherwise (qP is less than 36), the scaled result is derived as

$$dcY_{ij} = (f_{ij} * LevelScale(qP \% 6, 0, 0) + (1 << (5 – qP / 6))) << (qP / 6 – 6), \quad \text{with} \quad i, j = 0...3 \tag{8-321}$$

The bitstream shall not contain data that results in any element dcY_{ij} of dcY with i, j = 0..3 that exceeds the range of integer values from $–2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}–1$, inclusive.

NOTE – When entropy_coding_mode_flag is equal to 0 and qP is less than 10 and profile_idc is equal to 66, 77, or 88, the range of values that can be represented for the elements c_{ij} of c is not sufficient to represent the full range of values of the elements dcY_{ij} of dcY that could be necessary to form a close approximation of the content of any possible source picture by use of the Intra_16x16 macroblock type.

57) Subclause 8.5.9 “Scaling and transformation process for chroma DC transform coefficients”

In subclause 8.5.9, make the following changes.

Add the following paragraph to the beginning of this subclause.

This process is only invoked when ChromaArrayType is equal to 1 or 2.

Replace the following

– Otherwise, if chroma_format_idc is equal to 2, the inverse transform for the 2x4 chroma DC transform coefficients is specified as

$$f = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} \\ c_{10} & c_{11} \\ c_{20} & c_{21} \\ c_{30} & c_{31} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \tag{8-324}$$

– Otherwise (chroma_format_idc is equal to 3), the inverse transform for the 4x4 chroma DC transform coefficients is specified as follows.

  – If residual_colour_transform_flag is equal to 1 and the current macroblock prediction mode MbPartPredMode(mb_type, 0) is Intra_4x4 or Intra_8x8, the inverse transform for the 4x4 chroma DC transform coefficients is specified as

$$f_{ij} = c_{ij} << 2 \quad \text{with} \quad i, j = 0..3 \tag{8-325}$$

  – Otherwise, the inverse transform for the 4x4 chroma DC transform coefficients is specified as

$$f = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} & c_{02} & c_{03} \\ c_{10} & c_{11} & c_{12} & c_{13} \\ c_{20} & c_{21} & c_{22} & c_{23} \\ c_{30} & c_{31} & c_{32} & c_{33} \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \tag{8-326}$$

The bitstream shall not contain data that results in any element f_{ij} of f with i, j = 0..3 that exceeds the range of integer values from $–2^{(7 + BitDepth'_C)}$ to $2^{(7 + BitDepth'_C)}–1$, inclusive.

with the following.

– Otherwise (ChromaArrayType is equal to 2), the inverse transform for the 2x4 chroma DC transform coefficients is specified as

$$f = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} \\ c_{10} & c_{11} \\ c_{20} & c_{21} \\ c_{30} & c_{31} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \tag{8-324}$$

The bitstream shall not contain data that results in any element f_{ij} of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth}_C)}$ to $2^{(7 + \text{bitDepth}_C)}-1$, inclusive.

Update all following equation numbers in clause 8 as necessary.

Replace the following

– If chroma_format_idc is equal to 2, the following applies.
  – The variable $QP'_{C,DC}$ is derived as

$$QP'_{C,DC} = QP'_C + 3 \tag{8-328}$$

  – Depending on the value of $QP'_{C,DC}$, the following applies.
    – If $QP'_{C,DC}$ is greater than or equal to 36, the scaled result is derived as

$$dcC_{ij} = (f_{ij} * \text{LevelScale}(QP'_{C,DC} \% 6, 0, 0)) << (QP'_{C,DC} / 6 - 6), \quad \text{with} \quad i = 0..3, j = 0,1 \tag{8-329}$$

    – Otherwise ($QP'_{C,DC}$ is less than 36), the scaled result is derived as

$$dcC_{ij} = (f_{ij} * \text{LevelScale}(QP'_{C,DC} \% 6, 0, 0) + 2^{5 - QP'_{C,DC}/6}) >> (6 - QP'_{C,DC} / 6), \text{ with } i = 0..3, j = 0,1 \tag{8-330}$$

– Otherwise (chroma_format_idc is equal to 3), the following applies.
  – If QP'_C is greater than or equal to 36, the scaled result is derived as

$$dcC_{ij} = (f_{ij} * \text{LevelScale}(QP'_C \% 6, 0, 0)) << (QP'_C / 6 - 6), \quad \text{with} \quad i, j = 0..3. \tag{8-331}$$

  – Otherwise (QP'_C is less than 36), the scaled result is derived as

$$dcC_{ij} = (f_{ij} * \text{LevelScale}(QP'_C \% 6, 0, 0) + 2^{5 - QP'_C/6}) >> (6 - QP'_C / 6), \text{ with } i, j = 0..3. \tag{8-332}$$

The bitstream shall not contain data that results in any element dcC_{ij} of dcC with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{BitDepth}'_C)}$ to $2^{(7 + \text{BitDepth}'_C)}-1$, inclusive.

with the following.

– Otherwise (ChromaArrayType is equal to 2), the following applies.
  – The variable $QP'_{C,DC}$ is derived as

$$QP'_{C,DC} = QP'_C + 3 \tag{8-328}$$

  – Depending on the value of $QP'_{C,DC}$, the following applies.
    – If $QP'_{C,DC}$ is greater than or equal to 36, the scaled result is derived as

$$dcC_{ij} = (f_{ij} * \text{LevelScale}(QP'_{C,DC} \% 6, 0, 0)) << (QP'_{C,DC} / 6 - 6), \quad \text{with} \quad i = 0..3, j = 0,1 \tag{8-329}$$

    – Otherwise ($QP'_{C,DC}$ is less than 36), the scaled result is derived as

$$dcC_{ij} = (f_{ij} * \text{LevelScale}(QP'_{C,DC} \% 6, 0, 0) + 2^{5 - QP'_{C,DC}/6}) >> (6 - QP'_{C,DC} / 6), \text{ with } i = 0..3, j = 0,1 \tag{8-330}$$

The bitstream shall not contain data that results in any element dcC_{ij} of dcC with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth_C)}$ to $2^{(7 + bitDepth_C)}-1$, inclusive.

Update all following equation numbers in clause 8 as necessary.

58) Subclause 8.5.10 "Scaling and transformation process for residual 4x4 blocks"

In subclause 8.5.10, replace the following

– Otherwise (the input array c relates to a chroma residual block), bitDepth is set equal to $BitDepth'_C$.

with

– Otherwise (the input array c relates to a chroma residual block), bitDepth is set equal to $BitDepth_C$.

59) Subclause 8.5.11 "Scaling and transformation process for residual 8x8 luma blocks"

In subclause 8.5.11, make the following changes.

Replace the title of the subclause with the following

8.5.11 Scaling and transformation process for residual 8x8 blocks

Replace the following

Input to this process is an 8x8 array c with elements c_{ij} which is an array relating to an 8x8 residual block of the luma component.

Outputs of this process are residual sample values as 8x8 array r with elements r_{ij}.

with the following.

Input to this process is an 8x8 array c with elements c_{ij} which is either an array relating to a residual block of the luma component or an array relating to a residual block of a chroma component when ChromaArrayType is equal to 3.

NOTE – When separate_colour_plane_flag is equal to 1, all residual blocks are considered to be associated with the luma component for purposes of the decoding process of each coded picture (prior to the final assignment of the decoded picture to a particular luma or chroma picture array according to the value of colour_plane_id).

Outputs of this process are residual sample values as 8x8 array r with elements r_{ij}.

The variables bitDepth and qP are derived as follows.

– If the input array c relates to a luma residual block, bitDepth is set equal to $BitDepth_Y$ and QP is set equal to QP'_Y.

– Otherwise (the input array c relates to a chroma residual block), bitDepth is set equal to $BitDepth_C$ and QP is set equal to QP'_C.

NOTE – When separate_colour_plane_flag is equal to 1, all residual blocks are considered to be associated with the luma component for purposes of the decoding process of each colour component of a picture.

Replace the following.

The bitstream shall not contain data that results in any element c_{ij} of c with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + BitDepth_Y)}$ to $2^{(7 + BitDepth_Y)}-1$, inclusive.

The scaling process for 8x8 block transform coefficient levels c_{ij} proceeds as follows.

– If QP'_Y is greater than or equal to 36, the scaled result is derived as

$$d_{ij} = (c_{ij} * LevelScale8x8(QP'_Y \% 6, i, j)) << (QP'_Y / 6 - 6), \quad \text{with} \quad i, j = 0..7. \tag{8-359}$$

– Otherwise (QP'_Y is less than 36), the scaled result is derived as

$$d_{ij} = (c_{ij} * LevelScale8x8(QP'_Y \% 6, i, j) + 2^{5-QP'_Y/6}) >> (6 - QP'_Y / 6), \text{ with } i, j = 0..7. \quad (8\text{-}360)$$

The bitstream shall not contain data that results in any element d_{ij} of d with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + BitDepth_Y)}$ to $2^{(7 + BitDepth_Y)}-1$, inclusive.

with the following.

The bitstream shall not contain data that results in any element c_{ij} of c with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + BitDepth)}$ to $2^{(7 + BitDepth)}-1$, inclusive.

The scaling process for 8x8 block transform coefficient levels cij proceeds as follows.

– If qP is greater than or equal to 36, the scaled result shall be derived as

$$d_{ij} = (c_{ij} * LevelScale8x8(qP\%6, i, j)) << (qP / 6 - 6), \quad \text{with} \quad i, j = 0..7. \quad (8\text{-}359)$$

– Otherwise (qP is less than 36), the scaled result shall be derived as

$$d_{ij} = (c_{ij} * LevelScale8x8(qP \% 6, i, j) + 2^{5-qP/6}) >> (6 - qP / 6), \text{ with } i, j = 0..7. \quad (8\text{-}360)$$

The bitstream shall not contain data that results in any element d_{ij} of d with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + BitDepth)}$ to $2^{(7 + BitDepth)}-1$, inclusive.

Replace the following paragraphs.

The bitstream shall not contain data that results in any element e_{ij}, f_{ij}, g_{ij}, h_{ij}, or k_{ij} for i and j in the range of 0..7, inclusive, that exceeds the range of integer values from $-2^{(7 + BitDepth_Y)}$ to $2^{(7 + BitDepth_Y)} - 1$, inclusive.

The bitstream shall not contain data that results in any element m_{ij} for i and j in the range of 0..7, inclusive, that exceeds the range of integer values from $-2^{(7 + BitDepth_Y)}$ to $2^{(7 + BitDepth_Y)} - 33$, inclusive.

with the following

The bitstream shall not contain data that results in any element e_{ij}, f_{ij}, g_{ij}, h_{ij}, or k_{ij} for i and j in the range of 0..7, inclusive, that exceeds the range of integer values from $-2^{(7 + BitDepth)}$ to $2^{(7 + BitDepth)} - 1$, inclusive.

The bitstream shall not contain data that results in any element m_{ij} for i and j in the range of 0..7, inclusive, that exceeds the range of integer values from $-2^{(7 + BitDepth)}$ to $2^{(7 + BitDepth)} - 33$, inclusive.

60) Subclause 8.5.12 “Picture construction process prior to deblocking filter process”

In subclause 8.5.12, make the following changes.

Replace the first paragraph with the following.

Inputs to this process are

– luma4x4BlkIdx or chroma4x4BlkIdx or luma8x8BlkIdx or cb4x4BlkIdx or cr4x4BlkIdx or cb8x8BlkIdx or cr8x8BlkIdx

– a sample array u with elements u_{ij} which is either a 4x4 luma block or a 4x4 chroma block or an 8x8 luma block or an 8x8 chroma block when ChromaArrayType is equal to 3.

Replace the paragraph starting with “When u is a chroma block” *and all subparagraphs with the following*

When u is a chroma block, for each sample uij of the chroma block, the following applies.

– The subscript C in the variable S’C is replaced with Cb for the Cb chroma component and with Cr for the Cr chroma component.

– Depending on the size of the block u, the following applies.

  – If u is an 4x4 luma block, the variable nE is set equal to 4 and depending on the variable ChromaArrayType, the position of the upper-left sample of a 4x4 chroma block inside the macroblock is derived as follows.

    – If ChromaArrayType is equal to 1 or 2, the following applies.

      xO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 0) (8-411)

      yO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 1) (8-412)

    – Otherwise (ChromaArrayType is equal to 3), the position of the upper-left sample of the 4x4 Cb block with index cb4x4BlkIdx or the 4x4 Cr block with index cr4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 Cb or Cr block scanning process in subclause 6.4.3.1 with cb4x4BlkIdx or cr4x4BlkIdx as the input and the output being assigned to (xO, yO).

  – Otherwise (u is an 8x8 Cb or Cr block when ChromaArrayType is equal to 3), the position of the upper-left sample of the 8x8 Cb block with index cb8x8BlkIdx or the Cr block with index cr8x8BlkIdx inside the macroblock is derived by invoking the inverse 8x8 Cb or Cr block scanning process in subclause 6.4.4.1 with cb8x8BlkIdx or cr8x8BlkIdx as the input and the output being assigned to (xO, yO), and the variable nE is set equal to 8.

– Depending on the variable MbaffFrameFlag and the current macroblock, the following applies.

  – If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock

    $S'_C[(xP / SubWidthC) + xO + j, ((yP + SubHeightC – 1) / SubHeightC) + 2 * (yO + i)] = u_{ij}$ with i, j = 0..nE – 1 (8-416)

  – Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock),

    $S'_C[(xP/ SubWidthC) + xO + j, (yP / SubHeightC) + yO + i] = u_{ij}$ with i, j = 0..nE – 1 (8-417)

61) Subclause 8.5.13 “Residual colour transform process”

Replace subclause 8.5.13 with the following.

8.5.13 Intra residual transform-bypass decoding process

This process is invoked when qpprime_y_zero_transform_bypass_flag is equal to 1, QP'_Y is equal to 0, the macroblock prediction mode is equal to Intra_4x4, Intra_8x8 or Intra_16x16, and the applicable intra prediction mode is equal to the vertical or horizontal mode. The process for the Cb and Cr components is applied in the same way as for the luma (L or Y) component.

Inputs to this process are

– a variable nMax

– a variable horPredFlag

– an (nMax)x(nMax) array r with elements $r_{i,j}$ which is either an array relating to a residual transform-bypass block of the luma component or an array relating to a residual transform-bypass block of the Cb and Cr component.

Output of this process is a modified version of the (nMax)x(nMax) array r with elements $r_{i,j}$ containing the result of the intra residual transform-bypass decoding process.

Let f be a temporary (nMax)x(nMax) array with elements f_{ij}, which are derived by

$f_{ij} = r_{ij}$ with i, j = 0..nMax – 1 (8-417)

Depending on horPredFlag, the following applies.

– If horPredFlag is equal to 0, the modified array r is derived by.

$$r_{ij} = \sum_{k=0}^{i} f_{kj} \qquad \text{with i, j = 0..nMax – 1} \tag{8-417}$$

– Otherwise (horPredFlag is equal to 1), the modified array r is derived by

$$r_{ij} = \sum_{k=0}^{j} f_{ik} \qquad \text{with i, j = 0..nMax – 1} \tag{8-417}$$

Update all following equation numbers in clause 8 as necessary.

62) Subclause 8.7 “Deblocking filter process”

In subclause 8.7, make the following changes.

Replace the first paragraph, which states as follows.

A conditional filtering process is applied to all NxN (where N = 4 or N = 8 for luma, and N = 4 for chroma) block edges of a picture, except edges at the boundary of the picture and any edges for which the deblocking filter process is disabled by disable_deblocking_filter_idc, as specified below. This filtering process is performed on a macroblock basis after the completion of the picture construction process prior to deblocking filter process (as specified in subclauses 8.5 and 8.6) for the entire decoded picture, with all macroblocks in a picture processed in order of increasing macroblock addresses.

with the following.

A conditional filtering process is specified in this subclause that is an integral part of the decoding process which shall be applied by decoders conforming to the Baseline, Extended, Main, High, High 10, High 4:2:2, and High 4:4:4 Predictive profiles. For decoders conforming to the High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles, the filtering process specified in this subclause, or one similar to it, should be applied but is not required.

The conditional filtering is applied to all NxN (where N = 4 or N = 8 for luma and for chroma when ChromaArrayType is equal to 3, and N = 4 for chroma when ChromaArrayType is equal to 1 or 2) block edges of a picture, except edges at the boundary of the picture and any edges for which the deblocking filter process is disabled by disable_deblocking_filter_idc, as specified below. This filtering process is performed on a macroblock basis after the completion of the picture construction process prior to deblocking filter process (as specified in subclauses 8.5 and 8.6) for the entire decoded picture, with all macroblocks in a picture processed in order of increasing macroblock addresses.

Replace the following

– Otherwise, if chroma_format_idc is equal to 3, both types, the solid bold and dashed bold chroma edges are filtered.

with the following.

– Otherwise, if ChromaArrayType is equal to 3, depending on the transform_size_8x8_flag, the following applies.

  – If transform_size_8x8_flag is equal to 0, both types, the solid bold and dashed bold chroma edges are filtered.

  – Otherwise (transform_size_8x8_flag is equal to 1), only the solid bold chroma edges are filtered.

Replace the paragraph starting with “For the filtering of both chroma components” *with the following*

When ChromaArrayType is not equal to 0, for the filtering of both chroma components with iCbCr = 0 for Cb and iCbCr = 1 for Cr, the following applies.

Replace the paragraph starting with "When filterInternalEdgesFlag is equal to 1, the filtering of the internal vertical chroma edge is specified as follows" with the following.

– When filterInternalEdgesFlag is equal to 1, the filtering of the internal vertical chroma edge is specified as follows.

  – When ChromaArrayType is not equal to 3 or when transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with mbAddr, chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and (xEk, yEk) = (4, k) with k = 0..MbHeightC – 1 as input and S'C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

  – When ChromaArrayType is equal to 3, the process specified in subclause 8.7.1 is invoked with mbAddr, chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and (xEk, yEk) = (8, k) with k = 0..MbHeightC – 1 as input and S'C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

  – When ChromaArrayType is equal to 3 and when transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with mbAddr, chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and (xEk, yEk) = (12, k) with k = 0..MbHeightC – 1 as input and S'C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

Replace the paragraph starting with "filterInternalEdgesFlag is equal to 1, the filtering of the internal horizontal chroma edge is specified as follows" with the following.

– When filterInternalEdgesFlag is equal to 1, the filtering of the internal horizontal chroma edge is specified as follows.

  – When ChromaArrayType is not equal to 3 or when transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with mbAddr, chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 4)$ with k = 0..MbWidthC – 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

  – When ChromaArrayType is not equal to 1, the process specified in subclause 8.7.1 is invoked with mbAddr, chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 8)$ with k = 0..MbWidthC – 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

  – When ChromaArrayType is equal to 2, the process specified in subclause 8.7.1 is invoked with mbAddr, chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 12)$ with k = 0..MbWidthC – 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

  – When ChromaArrayType is equal to 3 and when transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with mbAddr, chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 12)$ with k = 0..MbWidthC – 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

Replace the paragraph that begins with "Finally, the arrays" *with the following*

Depending on separate_colour_plane_flag the following applies.

- If separate_colour_plane_flag is equal to 0, the arrays S'_L, S'_{Cb}, S'_{Cr} are assigned to the arrays S_L, S_{Cb}, S_{Cr} (which represent the decoded picture), respectively.
- Otherwise (separate_colour_plane_flag is equal to 1), the following applies.
  - If colour_plane_id is equal to 0, the arrays S'_L is assigned to the array S_L (which represent the luma component of the decoded picture).

- Otherwise, if colour_plane_id is equal to 1, the arrays S'_L is assigned to the array S_{Cb} (which represents the Cb component of the decoded picture).
- Otherwise (colour_plane_id is equal to 2), the arrays S'_L is assigned to the array S_{Cr} (which represents the Cr component of the decoded picture).

63) Subclause 8.7.2.3 "Filtering process for edges with bS less than 4"

In subclause 8.7.2.3, make the following changes.

Replace the paragraph starting with "The filtered result samples p'0 and q'0 are derived by" *with the following*

The filtered result samples p'0 and q'0 are derived by

$$\Delta = \text{Clip3}(-t_C, t_C, ((((q_0 - p_0) << 2) + (p_1 - q_1) + 4) >> 3)) \quad (8\text{-}469)$$

$$p'_0 = \text{Clip1}(p_0 + \Delta) \quad (8\text{-}470)$$

$$q'_0 = \text{Clip1}(q_0 - \Delta) \quad (8\text{-}471)$$

where the threshold t_C is determined as follows.

– If chromaEdgeFlag is equal to 0,

$$t_C = t_{C0} + ((a_p < \beta) ? 1 : 0) + ((a_q < \beta) ? 1 : 0) \quad (8\text{-}472)$$

– Otherwise (chromaEdgeFlag is equal to 1), the following applies.

  – When ChromaArrayType is equal to 3,

$$t_C = t_{C0} + ((a_p < \beta) ? 1 : 0) + ((a_q < \beta) ? 1 : 0) \quad (8\text{-}472a)$$

– Otherwise

$$t_C = t_{C0} + 1 \quad (8\text{-}473)$$

Update all following equation numbers in clause 8 as necessary.

Replace the paragraph starting with "The filtered result sample p'_1" *with the following.*

The filtered result sample p'_1 is derived as follows

– If chromaEdgeFlag is equal to 0 and a_p is less than β,

$$p'_1 = p_1 + \text{Clip3}(-t_{C0}, t_{C0}, (p_2 + ((p_0 + q_0 + 1) >> 1) - (p_1 << 1)) >> 1) \quad (8\text{-}478)$$

– Otherwise, if chromaEdgeFlag is equal to 1, ChromaArrayType is equal to 3, and a_p is less than β,

$$p'_1 = p_1 + \text{Clip3}(-t_{C0}, t_{C0}, (p_2 + ((p_0 + q_0 + 1) >> 1) - (p_1 << 1)) >> 1) \quad (8\text{-}478a)$$

– Otherwise (chromaEdgeFlag is equal to 1 and ChromaArrayType is not equal to 3, or a_p is greater than or equal to β),

$$p'_1 = p_1 \quad (8\text{-}479)$$

Replace the paragraph starting with "The filtered result sample q'_1" *with the following.*

The filtered result sample q'_1 is derived as follows

– If chromaEdgeFlag is equal to 0 and a_q is less than β,

$$q'_1 = q_1 + \text{Clip3}(-t_{C0}, t_{C0}, (q_2 + ((p_0 + q_0 + 1) >> 1) - (q_1 << 1)) >> 1) \quad (8\text{-}480)$$

– Otherwise, if chromaEdgeFlag is equal to 1, ChromaArrayType is equal to 3, and a_q is less than β,

$$q'_1 = q_1 + \text{Clip3}(-t_{C0}, t_{C0}, (q_2 + ((p_0 + q_0 + 1) >> 1) - (q_1 << 1)) >> 1) \quad (8\text{-}480a)$$

– Otherwise (chromaEdgeFlag is equal to 1 and ChromaArrayType is not equal to 3, or a_q is greater than or equal to β),

$$q'_1 = q_1 \quad (8\text{-}481)$$

Update all following equation numbers in clause 8 as necessary.

64) Subclause 8.7.2.4 "Filtering process for edges for bS equal to 4"

In subclause 8.7.2.4, make the following changes.

Replace the paragraph starting with "The filtered result samples p'_i (i = 0..2) are derived as follows" *with the following.*

The filtered result samples p'i (i = 0..2) are derived as follows.

– If chromaEdgeFlag is equal to 0 and the following condition holds,

$$a_p < \beta \;\&\&\; \text{Abs}(p_0 - q_0) < ((\alpha >> 2) + 2) \quad (8\text{-}484)$$

then the variables p'_0, p'_1, and p'_2 are derived by

$$p'_0 = (p_2 + 2*p_1 + 2*p_0 + 2*q_0 + q_1 + 4) >> 3 \quad (8\text{-}485)$$

$$p'_1 = (p_2 + p_1 + p_0 + q_0 + 2) >> 2 \quad (8\text{-}486)$$

$$p'_2 = (2*p_3 + 3*p_2 + p_1 + p_0 + q_0 + 4) >> 3 \quad (8\text{-}487)$$

– Otherwise, if chromaEdgeFlag is equal to 1, ChromaArrayType is equal to 3, and the condition in Equation 8-484 holds, the variables p'0, p'1, and p'2 are derived by

$$p'_0 = (p_2 + 2*p_1 + 2*p_0 + 2*q_0 + q_1 + 4) >> 3 \quad (8\text{-}485a)$$

$$p'_1 = (p_2 + p_1 + p_0 + q_0 + 2) >> 2 \quad (8\text{-}486a)$$

$$p'_2 = (2*p_3 + 3*p_2 + p_1 + p_0 + q_0 + 4) >> 3 \quad (8\text{-}487a)$$

– Otherwise (chromaEdgeFlag is equal to 1 and ChromaArrayType is not equal to 3, or the condition in Equation 8-484 does not hold), the variables p'0, p'1, and p'2 are derived by

$$p'_0 = (2*p_1 + p_0 + q_1 + 2) >> 2 \quad (8\text{-}488)$$

$$p'_1 = p_1 \quad (8\text{-}489)$$

$$p'_2 = p_2 \quad (8\text{-}490)$$

Update all following equation numbers in clause 8 as necessary.

Replace the paragraph starting with "The filtered result samples q'_i (i = 0..2) are derived as follows" *with the following.*

The filtered result samples q'_i (i = 0..2) are derived as follows.

– If chromaEdgeFlag is equal to 0 and the following condition holds,

$$a_q < \beta \quad \&\& \quad Abs(p_0 - q_0) < ((\alpha >> 2) + 2) \quad (8\text{-}491)$$

then the variables q'_0, q'_1, and q'_2 are derived by

$$q'_0 = (p_1 + 2*p_0 + 2*q_0 + 2*q_1 + q_2 + 4) >> 3 \quad (8\text{-}492)$$

$$q'_1 = (p_0 + q_0 + q_1 + q_2 + 2) >> 2 \quad (8\text{-}493)$$

$$q'_2 = (2*q_3 + 3*q_2 + q_1 + q_0 + p_0 + 4) >> 3 \quad (8\text{-}494)$$

– If chromaEdgeFlag is equal to 1, ChromaArrayType is equal to 3, and the condition in Equation 8-491 holds, the variables q'_0, q'_1, and q'_2 are derived by

$$q'_0 = (p_1 + 2*p_0 + 2*q_0 + 2*q_1 + q_2 + 4) >> 3 \quad (8\text{-}492a)$$

$$q'_1 = (p_0 + q_0 + q_1 + q_2 + 2) >> 2 \quad (8\text{-}493a)$$

$$q'_2 = (2*q_3 + 3*q_2 + q_1 + q_0 + p_0 + 4) >> 3 \quad (8\text{-}494a)$$

– Otherwise (chromaEdgeFlag is equal to 1 and ChromaArrayType is not equal to 3, or the condition in Equation 8-491 does not hold), the variables q'_0, q'_1, and q'_2 are derived by

$$q'_0 = (2*q_1 + q_0 + p_1 + 2) >> 2 \quad (8\text{-}495)$$

$$q'_1 = q_1 \quad (8\text{-}496)$$

$$q'_2 = q_2 \quad (8\text{-}497)$$

Update all following equation numbers in clause 8 as necessary.

65) Clause 9 and all subclauses of clause 9 "Parsing process"

In clause 9 and all subclauses of clause 9, make the following changes.

Replace all occurences of "chroma_format_idc" *with* "ChromaArrayType".

Delete all occurences of "(monochrome)".

66) Subclause 9.1.2 “Mapping process for coded block pattern”

In subclause 9.1.2, make the following changes.

Replace the title of the first part of Table 9-4 “(a) chroma_format_idc is not equal to 0*“ with the following.*

(a) ChromaArrayType is equal to 1, or 2

Replace the title of the second part of Table 9-4 “(b) chroma_format_idc is equal to 0*“ with the following.*

(b) ChromaArrayType is equal to 0, or 3

67) Subclause 9.2 “CAVLC parsing process for transform coefficient levels”

In subclause 9.2, make the following changes.

*Replace the paragraph starting with “*Inputs to this process*” with the following.*

Inputs to this process are bits from slice data, a maximum number of non-zero transform coefficient levels maxNumCoeff, the luma block index luma4x4BlkIdx or the chroma block index chroma4x4BlkIdx or index cb4x4BlkIdx or index cr4x4BlkIdx of the current block of transform coefficient levels.

*Replace the paragraph starting with “*Outputs to this process*” with the following.*

Output of this process is the list coeffLevel containing transform coefficient levels of the luma block with block index luma4x4BlkIdx or the chroma block with block index chroma4x4BlkIdx or index cb4x4BlkIdx or index cr4x4BlkIdx.

68) Subclause 9.2.1 “Parsing process for total number of transform coefficient levels and trailing ones”

In subclause 9.2.1, make the following changes.

Replace the paragraph starting with “ inputs to this process” *with the following.*

Inputs to this process are bits from slice data, a maximum number of non-zero transform coefficient levels maxNumCoeff, the luma block index luma4x4BlkIdx or the chroma block index chroma4x4BlkIdx or index cb4x4BlkIdx or index cr4x4BlkIdx of the current block of transform.

*Delete the paragraph “*Otherwise (chroma_format_idc is equal to 3), nC is set equal to 0.”

*Add two new paragraphs after the paragraph starting with “*When the CAVLC parsing process is invoked for Intra16x16DCLevel*” with the following*

When the CAVLC parsing process is invoked for CbIntra16x16DCLevel, cb4x4BlkIdx is set equal to 0.

When the CAVLC parsing process is invoked for CrIntra16x16DCLevel, cr4x4BlkIdx is set equal to 0.

*Add two new paragraphs after the paragraph starting with “*If the CAVLC parsing process is invoked for Intra16x16DCLevel*” with the following*

Otherwise, if the CAVLC parsing process is invoked for CbIntra16x16DCLevel, CbIntra16x16ACLevel, or CbLevel, the process specified in subclause 6.4.8.4.1 is invoked with cb4x4BlkIdx as the input, and the output is assigned to mbAddrA, mbAddrB, cb4x4BlkIdxA, and cb4x4BlkIdxB. The 4x4 Cb block specified by mbAddrA\cb4x4BlkIdxA is assigned to blkA, and the 4x4 Cb block specified by mbAddrB\cb4x4BlkIdxB is assigned to blkB.

Otherwise, if the CAVLC parsing process is invoked for CrIntra16x16DCLevel, CrIntra16x16ACLevel, or CrLevel, the process specified in subclause 6.4.8.4.1 is invoked with cr4x4BlkIdx as the input, and the output is assigned to mbAddrA, mbAddrB, cr4x4BlkIdxA, and cr4x4BlkIdxB. The 4x4 Cr block specified by mbAddrA\cr4x4BlkIdxA is assigned to blkA, and the 4x4 Cr block specified by mbAddrB\cr4x4BlkIdxB is assigned to blkB.

*Replace the paragraph starting with “*NOTE - When parsing for Intra16x16DCLevel,*” with the following*

NOTE - When parsing for Intra16x16DCLevel, CbIntra16x16DCLevel, or CrIntra16x16DCLevel, the values nA and nB are based on the number of non-zero transform coefficient levels in adjacent 4x4 blocks and not on the number of non-zero DC transform coefficient levels in adjacent 16x16 blocks.

69) Subclause 9.3.1.1 "Initialisation process for context variables"

In subclause 9.3.1.1, make the following changes.

Replace Table 9-11 with the following.

Table 9-11 – Association of ctxIdx and syntax elements for each slice type in the initialisation process

	Syntax element	Table	Slice type			
			SI	I	P, SP	B
slice_data( )	mb_skip_flag	Table 9-13 Table 9-14			11-13	24-26
	mb_field_decoding_flag	Table 9-18	70-72	70-72	70-72	70-72
macroblock_layer( )	mb_type	Table 9-12 Table 9-13 Table 9-14	0-10	3-10	14-20	27-35
	transform_size_8x8_flag	Table 9-16	na	399-401	399-401	399-401
	coded_block_pattern (luma)	Table 9-18	73-76	73-76	73-76	73-76
	coded_block_pattern (chroma)	Table 9-18	77-84	77-84	77-84	77-84
	mb_qp_delta	Table 9-17	60-63	60-63	60-63	60-63
mb_pred( )	prev_intra4x4_pred_mode_flag	Table 9-17	68	68	68	68
	rem_intra4x4_pred_mode	Table 9-17	69	69	69	69
	prev_intra8x8_pred_mode_flag	Table 9-17	na	68	68	68
	rem_intra8x8_pred_mode	Table 9-17	na	69	69	69
	intra_chroma_pred_mode	Table 9-17	64-67	64-67	64-67	64-67
mb_pred( ) and sub_mb_pred( )	ref_idx_l0	Table 9-16			54-59	54-59
	ref_idx_l1	Table 9-16				54-59
	mvd_l0[ ][ ][0]	Table 9-15			40-46	40-46
	mvd_l1[ ][ ][0]	Table 9-15				40-46
	mvd_l0[ ][ ][1]	Table 9-15			47-53	47-53
	mvd_l1[ ][ ][1]	Table 9-15				47-53
sub_mb_pred( )	sub_mb_type	Table 9-13 Table 9-14			21-23	36-39
residual_block_cabac( )	coded_block_flag	Table 9-18 Table 9-24a Table 9-24i	85-104 460-483	85-104 460-483 1012-1023	85-104 460-483 1012-1023	85-104 460-483 1012-1023

	significant_coeff_flag[ ]	Table 9-19 Table 9-22 Table 9-24 Table 9-24 Table 9-24b Table 9-22f Table 9-24d Table 9-24e	105-165 277-337	105-165 277-337 402-416 436-450 484-571 776-863 660-689 718-747	105-165 277-337 402-416 436-450 484-571 776-863 660-689 718-747	105-165 277-337 402-416 436-450 484-571 776-863 660-689 718-747
	last_significant_coeff_flag[ ]	Table 9-20 Table 9-23 Table 9-24 Table 9-24 Table 9-24c Table 9-24g Table 9-24d Table 9-24e	166-226 338-398	166-226 338-398 417-425 451-459 572-659 864-951 690-707 748-765	166-226 338-398 417-425 451-459 572-659 864-951 690-707 748-765	166-226 338-398 417-425 451-459 572-659 864-951 690-707 748-765
	coeff_abs_level_minus1[ ]	Table 9-21 Table 9-24 Table 9-24h Table 9-24d Table 9-24e	227-275	227-275 426-435 952-1011 708-717 766-775	227-275 426-435 952-1011 708-717 766-775	227-275 426-435 952-1011 708-717 766-775

Insert a new Table 9-24a as follows.

Table 9-24a – Values of variables m and n for ctxIdx from 460 to 483

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
460	-17	123	-7	92	0	80	11	80	**472**	-17	123	-7	92	0	80	11	80
461	-12	115	-5	89	-5	89	5	76	**473**	-12	115	-5	89	-5	89	5	76
462	-16	122	-7	96	-7	94	2	84	**474**	-16	122	-7	96	-7	94	2	84
463	-11	115	-13	108	-4	92	5	78	**475**	-11	115	-13	108	-4	92	5	78
464	-12	63	-3	46	0	39	-6	55	**476**	-12	63	-3	46	0	39	-6	55
465	-2	68	-1	65	0	65	4	61	**477**	-2	68	-1	65	0	65	4	61
466	-15	84	-1	57	-15	84	-14	83	**478**	-15	84	-1	57	-15	84	-14	83
467	-13	104	-9	93	-35	127	-37	127	**479**	-13	104	-9	93	-35	127	-37	127
468	-3	70	-3	74	-2	73	-5	79	**480**	-3	70	-3	74	-2	73	-5	79
469	-8	93	-9	92	-12	104	-11	104	**481**	-8	93	-9	92	-12	104	-11	104
470	-10	90	-8	87	-9	91	-11	91	**482**	-10	90	-8	87	-9	91	-11	91
471	-30	127	-23	126	-31	127	-30	127	**483**	-30	127	-23	126	-31	127	-30	127

Insert a new Table 9-24b as follows.

Table 9-24b – Values of variables m and n for ctxIdx from 484 to 571

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
484	-7	93	-2	85	-13	103	-4	86	**528**	-7	93	-2	85	-13	103	-4	86
485	-11	87	-6	78	-13	91	-12	88	**529**	-11	87	-6	78	-13	91	-12	88
486	-3	77	-1	75	-9	89	-5	82	**530**	-3	77	-1	75	-9	89	-5	82
487	-5	71	-7	77	-14	92	-3	72	**531**	-5	71	-7	77	-14	92	-3	72
488	-4	63	2	54	-8	76	-4	67	**532**	-4	63	2	54	-8	76	-4	67
489	-4	68	5	50	-12	87	-8	72	**533**	-4	68	5	50	-12	87	-8	72
490	-12	84	-3	68	-23	110	-16	89	**534**	-12	84	-3	68	-23	110	-16	89
491	-7	62	1	50	-24	105	-9	69	**535**	-7	62	1	50	-24	105	-9	69
492	-7	65	6	42	-10	78	-1	59	**536**	-7	65	6	42	-10	78	-1	59
493	8	61	-4	81	-20	112	5	66	**537**	8	61	-4	81	-20	112	5	66
494	5	56	1	63	-17	99	4	57	**538**	5	56	1	63	-17	99	4	57
495	-2	66	-4	70	-78	127	-4	71	**539**	-2	66	-4	70	-78	127	-4	71
496	1	64	0	67	-70	127	-2	71	**540**	1	64	0	67	-70	127	-2	71
497	0	61	2	57	-50	127	2	58	**641**	0	61	2	57	-50	127	2	58
498	-2	78	-2	76	-46	127	-1	74	**542**	-2	78	-2	76	-46	127	-1	74
499	1	50	11	35	-4	66	-4	44	**543**	1	50	11	35	-4	66	-4	44
500	7	52	4	64	-5	78	-1	69	**544**	7	52	4	64	-5	78	-1	69
501	10	35	1	61	-4	71	0	62	**545**	10	35	1	61	-4	71	0	62
502	0	44	11	35	-8	72	-7	51	**546**	0	44	11	35	-8	72	-7	51
503	11	38	18	25	2	59	-4	47	**547**	11	38	18	25	2	59	-4	47
504	1	45	12	24	-1	55	-6	42	**548**	1	45	12	24	-1	55	-6	42
505	0	46	13	29	-7	70	-3	41	**549**	0	46	13	29	-7	70	-3	41
506	5	44	13	36	-6	75	-6	53	**550**	5	44	13	36	-6	75	-6	53
507	31	17	-10	93	-8	89	8	76	**551**	31	17	-10	93	-8	89	8	76
508	1	51	-7	73	-34	119	-9	78	**552**	1	51	-7	73	-34	119	-9	78
509	7	50	-2	73	-3	75	-11	83	**553**	7	50	-2	73	-3	75	-11	83
510	28	19	13	46	32	20	9	52	**554**	28	19	13	46	32	20	9	52
511	16	33	9	49	30	22	0	67	**555**	16	33	9	49	30	22	0	67
512	14	62	-7	100	-44	127	-5	90	**556**	14	62	-7	100	-44	127	-5	90
513	-13	108	9	53	0	54	1	67	**557**	-13	108	9	53	0	54	1	67

514	-15	100	2	53	-5	61	-15	72	**558**	-15	100	2	53	-5	61	-15	72
515	-13	101	5	53	0	58	-5	75	**559**	-13	101	5	53	0	58	-5	75
516	-13	91	-2	61	-1	60	-8	80	**560**	-13	91	-2	61	-1	60	-8	80
517	-12	94	0	56	-3	61	-21	83	**561**	-12	94	0	56	-3	61	-21	83
518	-10	88	0	56	-8	67	-21	64	**562**	-10	88	0	56	-8	67	-21	64
519	-16	84	-13	63	-25	84	-13	31	**563**	-16	84	-13	63	-25	84	-13	31
520	-10	86	-5	60	-14	74	-25	64	**564**	-10	86	-5	60	-14	74	-25	64
521	-7	83	-1	62	-5	65	-29	94	**565**	-7	83	-1	62	-5	65	-29	94
522	-13	87	4	57	5	52	9	75	**566**	-13	87	4	57	5	52	9	75
523	-19	94	-6	69	2	57	17	63	**567**	-19	94	-6	69	2	57	17	63
524	1	70	4	57	0	61	-8	74	**568**	1	70	4	57	0	61	-8	74
525	0	72	14	39	-9	69	-5	35	**569**	0	72	14	39	-9	69	-5	35
526	-5	74	4	51	-11	70	-2	27	**570**	-5	74	4	51	-11	70	-2	27
527	18	59	13	68	18	55	13	91	**571**	18	59	13	68	18	55	13	91

Insert a new Table 9-24c as follows.

Table 9-24c – Values of variables m and n for ctxIdx from 572 to 659

ctxIdx	**I and SI slices**		**Value of cabac_init_idc**						**ctxIdx**	**I and SI slices**		**Value of cabac_init_idc**					
			0		**1**		**2**					**0**		**1**		**2**	
	m	**n**	**m**	**n**	**m**	**n**	**m**	**n**		**m**	**n**	**m**	**n**	**m**	**n**	**m**	**n**
572	24	0	11	28	4	45	4	39	**616**	24	0	11	28	4	45	4	39
573	15	9	2	40	10	28	0	42	**617**	15	9	2	40	10	28	0	42
574	8	25	3	44	10	31	7	34	**618**	8	25	3	44	10	31	7	34
575	13	18	0	49	33	-11	11	29	**619**	13	18	0	49	33	-11	11	29
576	15	9	0	46	52	-43	8	31	**620**	15	9	0	46	52	-43	8	31
577	13	19	2	44	18	15	6	37	**621**	13	19	2	44	18	15	6	37
578	10	37	2	51	28	0	7	42	**622**	10	37	2	51	28	0	7	42
579	12	18	0	47	35	-22	3	40	**623**	12	18	0	47	35	-22	3	40
580	6	29	4	39	38	-25	8	33	**624**	6	29	4	39	38	-25	8	33
581	20	33	2	62	34	0	13	43	**625**	20	33	2	62	34	0	13	43
582	15	30	6	46	39	-18	13	36	**626**	15	30	6	46	39	-18	13	36
583	4	45	0	54	32	-12	4	47	**627**	4	45	0	54	32	-12	4	47
584	1	58	3	54	102	-94	3	55	**628**	1	58	3	54	102	-94	3	55
585	0	62	2	58	0	0	2	58	**629**	0	62	2	58	0	0	2	58
586	7	61	4	63	56	-15	6	60	**630**	7	61	4	63	56	-15	6	60

587	12	38	6	51	33	-4	8	44	**631**	12	38	6	51	33	-4	8	44
588	11	45	6	57	29	10	11	44	**632**	11	45	6	57	29	10	11	44
589	15	39	7	53	37	-5	14	42	**633**	15	39	7	53	37	-5	14	42
590	11	42	6	52	51	-29	7	48	**634**	11	42	6	52	51	-29	7	48
591	13	44	6	55	39	-9	4	56	**635**	13	44	6	55	39	-9	4	56
592	16	45	11	45	52	-34	4	52	**636**	16	45	11	45	52	-34	4	52
593	12	41	14	36	69	-58	13	37	**637**	12	41	14	36	69	-58	13	37
594	10	49	8	53	67	-63	9	49	**638**	10	49	8	53	67	-63	9	49
595	30	34	-1	82	44	-5	19	58	**639**	30	34	-1	82	44	-5	19	58
596	18	42	7	55	32	7	10	48	**640**	18	42	7	55	32	7	10	48
597	10	55	-3	78	55	-29	12	45	**641**	10	55	-3	78	55	-29	12	45
598	17	51	15	46	32	1	0	69	**642**	17	51	15	46	32	1	0	69
599	17	46	22	31	0	0	20	33	**643**	17	46	22	31	0	0	20	33
600	0	89	-1	84	27	36	8	63	**644**	0	89	-1	84	27	36	8	63
601	26	-19	25	7	33	-25	35	-18	**645**	26	-19	25	7	33	-25	35	-18
602	22	-17	30	-7	34	-30	33	-25	**646**	22	-17	30	-7	34	-30	33	-25
603	26	-17	28	3	36	-28	28	-3	**647**	26	-17	28	3	36	-28	28	-3
604	30	-25	28	4	38	-28	24	10	**648**	30	-25	28	4	38	-28	24	10
605	28	-20	32	0	38	-27	27	0	**649**	28	-20	32	0	38	-27	27	0
606	33	-23	34	-1	34	-18	34	-14	**650**	33	-23	34	-1	34	-18	34	-14
607	37	-27	30	6	35	-16	52	-44	**651**	37	-27	30	6	35	-16	52	-44
608	33	-23	30	6	34	-14	39	-24	**652**	33	-23	30	6	34	-14	39	-24
609	40	-28	32	9	32	-8	19	17	**653**	40	-28	32	9	32	-8	19	17
610	38	-17	31	19	37	-6	31	25	**654**	38	-17	31	19	37	-6	31	25
611	33	-11	26	27	35	0	36	29	**655**	33	-11	26	27	35	0	36	29
612	40	-15	26	30	30	10	24	33	**656**	40	-15	26	30	30	10	24	33
613	41	-6	37	20	28	18	34	15	**657**	41	-6	37	20	28	18	34	15
614	38	1	28	34	26	25	30	20	**658**	38	1	28	34	26	25	30	20
615	41	17	17	70	29	41	22	73	**659**	41	17	17	70	29	41	22	73

Insert a new Table 9-24d as follows.

Table 9-24d– Values of variables m and n for ctxIdx from 660 to 717

ctxIdx	I slices		Value of cabac_init_idc						ctxIdx	I slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		**m**	**n**	**m**	**n**	**m**	**n**	**m**	**n**
660	-17	120	-4	79	-5	85	-3	78	**689**	2	59	2	59	2	58	-11	68
661	-20	112	-7	71	-6	81	-8	74	**690**	23	-13	9	-2	17	-10	9	-2
662	-18	114	-5	69	-10	77	-9	72	**691**	26	-13	26	-9	32	-13	30	-10
663	-11	85	-9	70	-7	81	-10	72	**692**	40	-15	33	-9	42	-9	31	-4
664	-15	92	-8	66	-17	80	-18	75	**693**	49	-14	39	-7	49	-5	33	-1
665	-14	89	-10	68	-18	73	-12	71	**694**	44	3	41	-2	53	0	33	7
666	-26	71	-19	73	-4	74	-11	63	**695**	45	6	45	3	64	3	31	12
667	-15	81	-12	69	-10	83	-5	70	**696**	44	34	49	9	68	10	37	23
668	-14	80	-16	70	-9	71	-17	75	**697**	33	54	45	27	66	27	31	38
669	0	68	-15	67	-9	67	-14	72	**698**	19	82	36	59	47	57	20	64
670	-14	70	-20	62	-1	61	-16	67	**699**	21	-10	21	-13	17	-10	9	-2
671	-24	56	-19	70	-8	66	-8	53	**700**	24	-11	33	-14	32	-13	30	-10
672	-23	68	-16	66	-14	66	-14	59	**701**	28	-8	39	-7	42	-9	31	-4
673	-24	50	-22	65	0	59	-9	52	**702**	28	-1	46	-2	49	-5	33	-1
674	-11	74	-20	63	2	59	-11	68	**703**	29	3	51	2	53	0	33	7
675	-14	106	-5	85	-3	81	-3	78	**704**	29	9	60	6	64	3	31	12
676	-13	97	-6	81	-3	76	-8	74	**705**	35	20	61	17	68	10	37	23
677	-15	90	-10	77	-7	72	-9	72	**706**	29	36	55	34	66	27	31	38
678	-12	90	-7	81	-6	78	-10	72	**707**	14	67	42	62	47	57	20	64
679	-18	88	-17	80	-12	72	-18	75	**708**	-3	75	-6	66	-5	71	-9	71
680	-10	73	-18	73	-14	68	-12	71	**709**	-1	23	-7	35	0	24	-7	37
681	-9	79	-4	74	-3	70	-11	63	**710**	1	34	-7	42	-1	36	-8	44
682	-14	86	-10	83	-6	76	-5	70	**711**	1	43	-8	45	-2	42	-11	49
683	-10	73	-9	71	-5	66	-17	75	**712**	0	54	-5	48	-2	52	-10	56
684	-10	70	-9	67	-5	62	-14	72	**713**	-2	55	-12	56	-9	57	-12	59
685	-10	69	-1	61	0	57	-16	67	**714**	0	61	-6	60	-6	63	-8	63
686	-5	66	-8	66	-4	61	-8	53	**715**	1	64	-5	62	-4	65	-9	67
687	-9	64	-14	66	-9	60	-14	59	**716**	0	68	-8	66	-4	67	-6	68
688	-5	58	0	59	1	54	-9	52	**717**	-9	92	-8	76	-7	82	-10	79

Insert a new Table 9-24e as follows.

Table 9-24e– Values of variables m and n for ctxIdx from 718 to 775

ctxIdx	I slices		Value of cabac_init_idc						ctxIdx	I slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		**m**	**n**	**m**	**n**	**m**	**n**	**m**	**n**
718	-17	120	-4	79	-5	85	-3	78	**747**	2	59	2	59	2	58	-11	68
719	-20	112	-7	71	-6	81	-8	74	**748**	23	-13	9	-2	17	-10	9	-2
720	-18	114	-5	69	-10	77	-9	72	**749**	26	-13	26	-9	32	-13	30	-10
721	-11	85	-9	70	-7	81	-10	72	**750**	40	-15	33	-9	42	-9	31	-4
722	-15	92	-8	66	-17	80	-18	75	**751**	49	-14	39	-7	49	-5	33	-1
723	-14	89	-10	68	-18	73	-12	71	**752**	44	3	41	-2	53	0	33	7
724	-26	71	-19	73	-4	74	-11	63	**753**	45	6	45	3	64	3	31	12
725	-15	81	-12	69	-10	83	-5	70	**754**	44	34	49	9	68	10	37	23
726	-14	80	-16	70	-9	71	-17	75	**755**	33	54	45	27	66	27	31	38
727	0	68	-15	67	-9	67	-14	72	**756**	19	82	36	59	47	57	20	64
728	-14	70	-20	62	-1	61	-16	67	**757**	21	-10	21	-13	17	-10	9	-2
729	-24	56	-19	70	-8	66	-8	53	**758**	24	-11	33	-14	32	-13	30	-10
730	-23	68	-16	66	-14	66	-14	59	**759**	28	-8	39	-7	42	-9	31	-4
731	-24	50	-22	65	0	59	-9	52	**760**	28	-1	46	-2	49	-5	33	-1
732	-11	74	-20	63	2	59	-11	68	**761**	29	3	51	2	53	0	33	7
733	-14	106	-5	85	-3	81	-3	78	**762**	29	9	60	6	64	3	31	12
734	-13	97	-6	81	-3	76	-8	74	**763**	35	20	61	17	68	10	37	23
735	-15	90	-10	77	-7	72	-9	72	**764**	29	36	55	34	66	27	31	38
736	-12	90	-7	81	-6	78	-10	72	**765**	14	67	42	62	47	57	20	64
737	-18	88	-17	80	-12	72	-18	75	**766**	-3	75	-6	66	-5	71	-9	71
738	-10	73	-18	73	-14	68	-12	71	**767**	-1	23	-7	35	0	24	-7	37
739	-9	79	-4	74	-3	70	-11	63	**768**	1	34	-7	42	-1	36	-8	44
740	-14	86	-10	83	-6	76	-5	70	**769**	1	43	-8	45	-2	42	-11	49
741	-10	73	-9	71	-5	66	-17	75	**770**	0	54	-5	48	-2	52	-10	56
742	-10	70	-9	67	-5	62	-14	72	**771**	-2	55	-12	56	-9	57	-12	59
743	-10	69	-1	61	0	57	-16	67	**772**	0	61	-6	60	-6	63	-8	63
744	-5	66	-8	66	-4	61	-8	53	**773**	1	64	-5	62	-4	65	-9	67
745	-9	64	-14	66	-9	60	-14	59	**774**	0	68	-8	66	-4	67	-6	68
746	-5	58	0	59	1	54	-9	52	**775**	-9	92	-8	76	-7	82	-10	79

Insert a new Table 9-24f as follows.

Table 9-24f – Values of variables m and n for ctxIdx from 776 to 863

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
776	-6	93	-13	106	-21	126	-22	127	**820**	-6	93	-13	106	-21	126	-22	127
777	-6	84	-16	106	-23	124	-25	127	**821**	-6	84	-16	106	-23	124	-25	127
778	-8	79	-10	87	-20	110	-25	120	**822**	-8	79	-10	87	-20	110	-25	120
779	0	66	-21	114	-26	126	-27	127	**823**	0	66	-21	114	-26	126	-27	127
780	-1	71	-18	110	-25	124	-19	114	**824**	-1	71	-18	110	-25	124	-19	114
781	0	62	-14	98	-17	105	-23	117	**825**	0	62	-14	98	-17	105	-23	117
782	-2	60	-22	110	-27	121	-25	118	**826**	-2	60	-22	110	-27	121	-25	118
783	-2	59	-21	106	-27	117	-26	117	**827**	-2	59	-21	106	-27	117	-26	117
784	-5	75	-18	103	-17	102	-24	113	**828**	-5	75	-18	103	-17	102	-24	113
785	-3	62	-21	107	-26	117	-28	118	**829**	-3	62	-21	107	-26	117	-28	118
786	-4	58	-23	108	-27	116	-31	120	**830**	-4	58	-23	108	-27	116	-31	120
787	-9	66	-26	112	-33	122	-37	124	**831**	-9	66	-26	112	-33	122	-37	124
788	-1	79	-10	96	-10	95	-10	94	**832**	-1	79	-10	96	-10	95	-10	94
789	0	71	-12	95	-14	100	-15	102	**833**	0	71	-12	95	-14	100	-15	102
790	3	68	-5	91	-8	95	-10	99	**834**	3	68	-5	91	-8	95	-10	99
791	10	44	-9	93	-17	111	-13	106	**835**	10	44	-9	93	-17	111	-13	106
792	-7	62	-22	94	-28	114	-50	127	**836**	-7	62	-22	94	-28	114	-50	127
793	15	36	-5	86	-6	89	-5	92	**837**	15	36	-5	86	-6	89	-5	92
794	14	40	9	67	-2	80	17	57	**838**	14	40	9	67	-2	80	17	57
795	16	27	-4	80	-4	82	-5	86	**839**	16	27	-4	80	-4	82	-5	86
796	12	29	-10	85	-9	85	-13	94	**840**	12	29	-10	85	-9	85	-13	94
797	1	44	-1	70	-8	81	-12	91	**841**	1	44	-1	70	-8	81	-12	91
798	20	36	7	60	-1	72	-2	77	**842**	20	36	7	60	-1	72	-2	77
799	18	32	9	58	5	64	0	71	**843**	18	32	9	58	5	64	0	71
800	5	42	5	61	1	67	-1	73	**844**	5	42	5	61	1	67	-1	73
801	1	48	12	50	9	56	4	64	**845**	1	48	12	50	9	56	4	64
802	10	62	15	50	0	69	-7	81	**846**	10	62	15	50	0	69	-7	81
803	17	46	18	49	1	69	5	64	**847**	17	46	18	49	1	69	5	64
804	9	64	17	54	7	69	15	57	**848**	9	64	17	54	7	69	15	57
805	-12	104	10	41	-7	69	1	67	**849**	-12	104	10	41	-7	69	1	67

806	-11	97	7	46	-6	67	0	68	**850**	-11	97	7	46	-6	67	0	68
807	-16	96	-1	51	-16	77	-10	67	**851**	-16	96	-1	51	-16	77	-10	67
808	-7	88	7	49	-2	64	1	68	**852**	-7	88	7	49	-2	64	1	68
809	-8	85	8	52	2	61	0	77	**853**	-8	85	8	52	2	61	0	77
810	-7	85	9	41	-6	67	2	64	**854**	-7	85	9	41	-6	67	2	64
811	-9	85	6	47	-3	64	0	68	**855**	-9	85	6	47	-3	64	0	68
812	-13	88	2	55	2	57	-5	78	**856**	-13	88	2	55	2	57	-5	78
813	4	66	13	41	-3	65	7	55	**857**	4	66	13	41	-3	65	7	55
814	-3	77	10	44	-3	66	5	59	**858**	-3	77	10	44	-3	66	5	59
815	-3	76	6	50	0	62	2	65	**859**	-3	76	6	50	0	62	2	65
816	-6	76	5	53	9	51	14	54	**860**	-6	76	5	53	9	51	14	54
817	10	58	13	49	-1	66	15	44	**861**	10	58	13	49	-1	66	15	44
818	-1	76	4	63	-2	71	5	60	**862**	-1	76	4	63	-2	71	5	60
819	-1	83	6	64	-2	75	2	70	**863**	-1	83	6	64	-2	75	2	70

Insert a new Table 9-24g as follows.

Table 9-24g – Values of variables m and n for ctxIdx from 864 to 951

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
864	15	6	14	11	19	-6	17	-13	**908**	15	6	14	11	19	-6	17	-13
865	6	19	11	14	18	-6	16	-9	**909**	6	19	11	14	18	-6	16	-9
866	7	16	9	11	14	0	17	-12	**910**	7	16	9	11	14	0	17	-12
867	12	14	18	11	26	-12	27	-21	**911**	12	14	18	11	26	-12	27	-21
868	18	13	21	9	31	-16	37	-30	**912**	18	13	21	9	31	-16	37	-30
869	13	11	23	-2	33	-25	41	-40	**913**	13	11	23	-2	33	-25	41	-40
870	13	15	32	-15	33	-22	42	-41	**914**	13	15	32	-15	33	-22	42	-41
871	15	16	32	-15	37	-28	48	-47	**915**	15	16	32	-15	37	-28	48	-47
872	12	23	34	-21	39	-30	39	-32	**916**	12	23	34	-21	39	-30	39	-32
873	13	23	39	-23	42	-30	46	-40	**917**	13	23	39	-23	42	-30	46	-40
874	15	20	42	-33	47	-42	52	-51	**918**	15	20	42	-33	47	-42	52	-51
875	14	26	41	-31	45	-36	46	-41	**919**	14	26	41	-31	45	-36	46	-41
876	14	44	46	-28	49	-34	52	-39	**920**	14	44	46	-28	49	-34	52	-39
877	17	40	38	-12	41	-17	43	-19	**921**	17	40	38	-12	41	-17	43	-19
878	17	47	21	29	32	9	32	11	**922**	17	47	21	29	32	9	32	11

879	24	17	45	-24	69	-71	61	-55	**923**	24	17	45	-24	69	-71	61	-55
880	21	21	53	-45	63	-63	56	-46	**924**	21	21	53	-45	63	-63	56	-46
881	25	22	48	-26	66	-64	62	-50	**925**	25	22	48	-26	66	-64	62	-50
882	31	27	65	-43	77	-74	81	-67	**926**	31	27	65	-43	77	-74	81	-67
883	22	29	43	-19	54	-39	45	-20	**927**	22	29	43	-19	54	-39	45	-20
884	19	35	39	-10	52	-35	35	-2	**928**	19	35	39	-10	52	-35	35	-2
885	14	50	30	9	41	-10	28	15	**929**	14	50	30	9	41	-10	28	15
886	10	57	18	26	36	0	34	1	**930**	10	57	18	26	36	0	34	1
887	7	63	20	27	40	-1	39	1	**931**	7	63	20	27	40	-1	39	1
888	-2	77	0	57	30	14	30	17	**932**	-2	77	0	57	30	14	30	17
889	-4	82	-14	82	28	26	20	38	**933**	-4	82	-14	82	28	26	20	38
890	-3	94	-5	75	23	37	18	45	**934**	-3	94	-5	75	23	37	18	45
891	9	69	-19	97	12	55	15	54	**935**	9	69	-19	97	12	55	15	54
892	-12	109	-35	125	11	65	0	79	**936**	-12	109	-35	125	11	65	0	79
893	36	-35	27	0	37	-33	36	-16	**937**	36	-35	27	0	37	-33	36	-16
894	36	-34	28	0	39	-36	37	-14	**938**	36	-34	28	0	39	-36	37	-14
895	32	-26	31	-4	40	-37	37	-17	**939**	32	-26	31	-4	40	-37	37	-17
896	37	-30	27	6	38	-30	32	1	**940**	37	-30	27	6	38	-30	32	1
897	44	-32	34	8	46	-33	34	15	**941**	44	-32	34	8	46	-33	34	15
898	34	-18	30	10	42	-30	29	15	**942**	34	-18	30	10	42	-30	29	15
899	34	-15	24	22	40	-24	24	25	**943**	34	-15	24	22	40	-24	24	25
900	40	-15	33	19	49	-29	34	22	**944**	40	-15	33	19	49	-29	34	22
901	33	-7	22	32	38	-12	31	16	**945**	33	-7	22	32	38	-12	31	16
902	35	-5	26	31	40	-10	35	18	**946**	35	-5	26	31	40	-10	35	18
903	33	0	21	41	38	-3	31	28	**947**	33	0	21	41	38	-3	31	28
904	38	2	26	44	46	-5	33	41	**948**	38	2	26	44	46	-5	33	41
905	33	13	23	47	31	20	36	28	**949**	33	13	23	47	31	20	36	28
906	23	35	16	65	29	30	27	47	**950**	23	35	16	65	29	30	27	47
907	13	58	14	71	25	44	21	62	**951**	13	58	14	71	25	44	21	62

Insert a new Table 9-24h as follows.

Table 9-24h – Values of variables m and n for ctxIdx from 952 to 1011

ctxIdx	I and SI	Value of cabac_init_idc	ctxIdx	I and SI	Value of cabac_init_idc

	slices		0		1		2			slices		0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
952	-3	71	-6	76	-23	112	-24	115	**982**	-3	71	-6	76	-23	112	-24	115
953	-6	42	-2	44	-15	71	-22	82	**983**	-6	42	-2	44	-15	71	-22	82
954	-5	50	0	45	-7	61	-9	62	**984**	-5	50	0	45	-7	61	-9	62
955	-3	54	0	52	0	53	0	53	**985**	-3	54	0	52	0	53	0	53
956	-2	62	-3	64	-5	66	0	59	**986**	-2	62	-3	64	-5	66	0	59
957	0	58	-2	59	-11	77	-14	85	**987**	0	58	-2	59	-11	77	-14	85
958	1	63	-4	70	-9	80	-13	89	**988**	1	63	-4	70	-9	80	-13	89
959	-2	72	-4	75	-9	84	-13	94	**989**	-2	72	-4	75	-9	84	-13	94
960	-1	74	-8	82	-10	87	-11	92	**990**	-1	74	-8	82	-10	87	-11	92
961	-9	91	-17	102	-34	127	-29	127	**991**	-9	91	-17	102	-34	127	-29	127
962	-5	67	-9	77	-21	101	-21	100	**992**	-5	67	-9	77	-21	101	-21	100
963	-5	27	3	24	-3	39	-14	57	**993**	-5	27	3	24	-3	39	-14	57
964	-3	39	0	42	-5	53	-12	67	**994**	-3	39	0	42	-5	53	-12	67
965	-2	44	0	48	-7	61	-11	71	**995**	-2	44	0	48	-7	61	-11	71
966	0	46	0	55	-11	75	-10	77	**996**	0	46	0	55	-11	75	-10	77
967	-16	64	-6	59	-15	77	-21	85	**997**	-16	64	-6	59	-15	77	-21	85
968	-8	68	-7	71	-17	91	-16	88	**998**	-8	68	-7	71	-17	91	-16	88
969	-10	78	-12	83	-25	107	-23	104	**999**	-10	78	-12	83	-25	107	-23	104
970	-6	77	-11	87	-25	111	-15	98	**1000**	-6	77	-11	87	-25	111	-15	98
971	-10	86	-30	119	-28	122	-37	127	**1001**	-10	86	-30	119	-28	122	-37	127
972	-12	92	1	58	-11	76	-10	82	**1002**	-12	92	1	58	-11	76	-10	82
973	-15	55	-3	29	-10	44	-8	48	**1003**	-15	55	-3	29	-10	44	-8	48
974	-10	60	-1	36	-10	52	-8	61	**1004**	-10	60	-1	36	-10	52	-8	61
975	-6	62	1	38	-10	57	-8	66	**1005**	-6	62	1	38	-10	57	-8	66
976	-4	65	2	43	-9	58	-7	70	**1006**	-4	65	2	43	-9	58	-7	70
977	-12	73	-6	55	-16	72	-14	75	**1007**	-12	73	-6	55	-16	72	-14	75
978	-8	76	0	58	-7	69	-10	79	**1008**	-8	76	0	58	-7	69	-10	79
979	-7	80	0	64	-4	69	-9	83	**1009**	-7	80	0	64	-4	69	-9	83
980	-9	88	-3	74	-5	74	-12	92	**1010**	-9	88	-3	74	-5	74	-12	92
981	-17	110	-10	90	-9	86	-18	108	**1011**	-17	110	-10	90	-9	86	-18	108

Insert a new Table 9-24i as follows.

Table 9-24i – Values of variables m and n for ctxIdx from 1012 to 1023

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	N	m	n
1012	-3	70	-3	74	-2	73	-5	79	**1018**	-10	90	-8	87	-9	91	-11	91
1013	-8	93	-9	92	-12	104	-11	104	**1019**	-30	127	-23	126	-31	127	-30	127
1014	-10	90	-8	87	-9	91	-11	91	**1020**	-3	70	-3	74	-2	73	-5	79
1015	-30	127	-23	126	-31	127	-30	127	**1021**	-8	93	-9	92	-12	104	-11	104
1016	-3	70	-3	74	-2	73	-5	79	**1022**	-10	90	-8	87	-9	91	-11	91
1017	-8	93	-9	92	-12	104	-11	104	**1023**	-30	127	-23	126	-31	127	-30	127

70) Subclause 9.3.2 "Binarization process"

In subclause 9.3.2, make the following changes.

*Replace the paragraph starting with "*The possible values of the context index ctxIdx*" with the following.*

The possible values of the context index ctxIdx are in the range 0 to 1023, inclusive. The value assigned to ctxIdxOffset specifies the lower value of the range of ctxIdx assigned to the corresponding binarization or binarization part of a syntax element.

Replace Table 9-25 with the following.

Table 9-25 – Syntax elements and associated types of binarization, maxBinIdxCtx, and ctxIdxOffset

Syntax element	Type of binarization	maxBinIdxCtx	ctxIdxOffset
mb_type (SI slices only)	prefix and suffix as specified in subclause 9.3.2.5	prefix: 0 suffix: 6	prefix: 0 suffix: 3
mb_type (I slices only)	as specified in subclause 9.3.2.5	6	3
mb_skip_flag (P, SP slices only)	FL, cMax=1	0	11
mb_type (P, SP slices only)	prefix and suffix as specified in subclause 9.3.2.5	prefix: 2 suffix: 5	prefix: 14 suffix: 17
sub_mb_type (P, SP slices only)	as specified in subclause 9.3.2.5	2	21
mb_skip_flag (B slices only)	FL, cMax=1	0	24
mb_type (B slices only)	prefix and suffix as specified in subclause 9.3.2.5	prefix: 3 suffix: 5	prefix: 27 suffix: 32
sub_mb_type (B slices only)	as specified in subclause 9.3.2.5	3	36
mvd_l0[ ][ ][0], mvd_l1[ ][ ][0]	prefix and suffix as given by UEG3 with signedValFlag=1, uCoff=9	prefix: 4 suffix: na	prefix: 40 suffix: na (uses DecodeBypass)

mvd_l0[ ][ ][1], mvd_l1[ ][ ][1]		prefix: 4 suffix: na	prefix: 47 suffix: na (uses DecodeBypass)
ref_idx_l0, ref_idx_l1	U	2	54
mb_qp_delta	as specified in subclause 9.3.2.7	2	60
intra_chroma_pred_mode	TU, cMax=3	1	64
prev_intra4x4_pred_mode_flag, prev_intra8x8_pred_mode_flag	FL, cMax=1	0	68
rem_intra4x4_pred_mode, rem_intra8x8_pred_mode	FL, cMax=7	0	69
mb_field_decoding_flag	FL, cMax=1	0	70
coded_block_pattern	prefix and suffix as specified in subclause 9.3.2.6	prefix: 3 suffix: 1	prefix: 73 suffix: 77
coded_block_flag (ctxBlockCat < 5)	FL, cMax=1	0	85
significant_coeff_flag (frame coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	105
last_significant_coeff_flag (frame coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	166
coeff_abs_level_minus1 (blocks with ctxBlockCat < 5)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 227 suffix: na, (uses DecodeBypass)
coeff_sign_flag	FL, cMax=1	0	na, (uses DecodeBypass)
end_of_slice_flag	FL, cMax=1	0	276
significant_coeff_flag (field coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	277
last_significant_coeff_flag (field coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	338
transform_size_8x8_flag	FL, cMax=1	0	399
significant_coeff_flag (frame coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	402
last_significant_coeff_flag (frame coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	417
coeff_abs_level_minus1 (blocks with ctxBlockCat = = 5)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 426 suffix: na, (uses DecodeBypass)
significant_coeff_flag (field coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	436
last_significant_coeff_flag (field coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	451
coded_block_flag (5 < ctxBlockCat < 9)	FL, cMax=1	0	460
coded_block_flag (9 < ctxBlockCat < 13)	FL, cMax=1	0	472
coded_block_flag (ctxBlockCat = = 5, 9, or 13)	FL, cMax=1	0	1012

significant_coeff_flag (frame coded blocks with 5<ctxBlockCat<9)	FL, cMax=1	0	484
significant_coeff_flag (frame coded blocks with 9<ctxBlockCat<13)	FL, cMax=1	0	528
last_significant_coeff_flag (frame coded blocks with 5<ctxBlockCat<9)	FL, cMax=1	0	572
last_significant_coeff_flag (frame coded blocks with 9<ctxBlockCat<13)	FL, cMax=1	0	616
coeff_abs_level_minus1 (blocks with 5<ctxBlockCat<9)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 952 suffix: na, (uses DecodeBypass)
coeff_abs_level_minus1 (blocks with 9<ctxBlockCat<13)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 982 suffix: na, (uses DecodeBypass)
significant_coeff_flag (field coded blocks with 5<ctxBlockCat< 9)	FL, cMax=1	0	776
significant_coeff_flag (field coded blocks with 9<ctxBlockCat<13)	FL, cMax=1	0	820
last_significant_coeff_flag (field coded blocks with 5<ctxBlockCat<9)	FL, cMax=1	0	864
last_significant_coeff_flag (field coded blocks with 9<ctxBlockCat<13)	FL, cMax=1	0	908
significant_coeff_flag (frame coded blocks with ctxBlockCat = = 9)	FL, cMax=1	0	660
significant_coeff_flag (frame coded blocks with ctxBlockCat = = 13)	FL, cMax=1	0	718
last_significant_coeff_flag (frame coded blocks with ctxBlockCat = = 9)	FL, cMax=1	0	690
last_significant_coeff_flag (frame coded blocks with ctxBlockCat = = 13)	FL, cMax=1	0	748
coeff_abs_level_minus1 (blocks with ctxBlockCat = = 9)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 708 suffix: na, (uses DecodeBypass)
coeff_abs_level_minus1 (blocks with ctxBlockCat = = 13)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 766 suffix: na, (uses DecodeBypass)
significant_coeff_flag (field coded blocks with ctxBlockCat = = 9)	FL, cMax=1	0	675
significant_coeff_flag (field coded blocks with ctxBlockCat = = 13)	FL, cMax=1	0	733
last_significant_coeff_flag (field coded blocks with ctxBlockCat = = 9)	FL, cMax=1	0	699
last_significant_coeff_flag (field coded blocks with ctxBlockCat = = 13)	FL, cMax=1	0	757

71) Subclause 9.3.2.6 "Binarization process for coded block pattern"

In subclause 9.3.2.6, replace the paragraph starting with " The binarization of coded_block_pattern consists of…" *with the following.*

The binarization of coded_block_pattern consists of a prefix part and (when present) a suffix part. The prefix part of the binarization is given by the FL binarization of CodedBlockPatternLuma with cMax = 15. When ChromaArrayType is not equal to 0 or 3, the suffix part is present and consists of the TU binarization of CodedBlockPatternChroma with cMax = 2. The relationship between the value of the syntax element coded_block_pattern and the values of CodedBlockPatternLuma and CodedBlockPatternChroma is given as specified in subclause 7.4.5.

72) Subclause 9.3.3.1 "Derivation process for ctxIdx"

In subclause 9.3.3.1, replace Table 9-31 with the following.

Table 9-31 – Assignment of ctxIdxBlockCatOffset to ctxBlockCat for syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1

Syntax element	ctxBlockCat (as specified in Table 9-33)													
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
coded_block_flag	0	4	8	12	16	0	0	4	8	4	0	4	8	8
significant_coeff_flag	0	15	29	44	47	0	0	15	29	0	0	15	29	0
last_significant_coeff_flag	0	15	29	44	47	0	0	15	29	0	0	15	29	0
coeff_abs_level_minus1	0	10	20	30	39	0	0	10	20	0	0	10	20	0

73) Subclause 9.3.3.1.1.9 "Derivation process of ctxIdxInc for the syntax element coded_block_flag"

In subclause 9.3.3.1.1.9, make the following changes.

Replace the first paragraph with the following.

Input to this process is ctxBlockCat and additional input is specified as follows.

- If ctxBlockCat is equal to 0, 6, or 10, no additional input
- Otherwise, if ctxBlockCat is equal to 1 or 2, luma4x4BlkIdx
- Otherwise, if ctxBlockCat is equal to 3, the chroma component index iCbCr
- Otherwise, if ctxBlockCat is equal to 4, chroma4x4BlkIdx and the chroma component index iCbCr
- Otherwise, if ctxBlockCat is equal to 5, luma8x8BlkIdx
- Otherwise, if ctxBlockCat is equal to 7 or 8, cb4x4BlkIdx
- Otherwise, if ctxBlockCat is equal to 9, cb8x8BlkIdx
- Otherwise, if ctxBlockCat is equal to 11 or 12, cr4x4BlkIdx
- Otherwise, (ctxBlockCat is equal to 13), cr8x8BlkIdx

Replace the paragraph starting with "If ctxBlockCat is equal to 0*" with the following.*

- If ctxBlockCat is equal to 0, 6, or 10, the following applies.
  - The derivation process for neighbouring macroblocks specified in subclause 6.4.8.1 is invoked and the output is assigned to mbAddrN (with N being either A or B).

– The variable transBlockN is derived as follows.

  – If mbAddrN is available and the macroblock mbAddrN is coded in Intra_16x16 prediction mode, the following applies.

    – When ctxBlockCat is equal to 0, the luma DC block of macroblock mbAddrN is assigned to transBlockN

    – When ctxBlockCat is equal to 6, the Cb DC block of macroblock mbAddrN is assigned to transBlockN

    – When ctxBlockCat is equal to 10, the Cr DC block of macroblock mbAddrN is assigned to transBlockN

  – Otherwise, transBlockN is marked as not available.

Replace the sentence "Otherwise (ctxBlockCat is equal to 4), the following applies*" with the following.*

Otherwise, if ctxBlockCat is equal to 4, the following applies

Insert the following paragraphs before the paragraph starting with "Let the variable condTermFlagN (with N being either A or B) be derived as follows".

- Otherwise, if ctxBlockCat is equal to 5, the following applies.

  - The derivation process for neighbouring 8x8 luma blocks specified in subclause 6.4.8.2 is invoked with luma8x8BlkIdx as input and the output is assigned to mbAddrN, luma8x8BlkIdxN (with N being either A or B).

  - The variable transBlockN is derived as follows.

    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ((CodedBlockPatternLuma >>luma8x8BlkIdx) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 luma block with index luma8x8BlkIdxN of macroblock mbAddrN is assigned to transBlockN.

    - Otherwise, transBlockN is marked as not available.

- Otherwise, if ctxBlockCat is equal to7 or 8, the following applies.

  - The derivation process for neighbouring 4x4 Cb blocks specified in subclause 6.4.8.4.1 is invoked with cb4x4BlkIdx as input and the output is assigned to mbAddrN, cb4x4BlkIdxN (with N being either A or B).

  - The variable transBlockN is derived as follows.

    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ((CodedBlockPatternLuma >> (cb4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 0 for the macroblock mbAddrN, the 4x4 Cb block with index cb4x4BlkIdxN of macroblock mbAddrN is assigned to transBlockN.

    - Otherwise, if mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, ((CodedBlockPatternLuma >> (cb4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cb block with index (cb4x4BlkIdxN >> 2) of macroblock mbAddrN is assigned to transBlockN.

    - Otherwise, transBlockN is marked as not available.

- Otherwise, if ctxBlockCat is equal to 9, the following applies.

  - The derivation process for neighbouring 8x8 Cb blocks specified in subclause 6.4.8.2.1 is invoked with cb8x8BlkIdx as input and the output is assigned to mbAddrN, cb8x8BlkIdxN (with N being either A or B).

  - The variable transBlockN is derived as follows.

    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ((CodedBlockPatternLuma >>cb8x8BlkIdx) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cb block with index cb8x8BlkIdxN of macroblock mbAddrN is assigned to transBlockN.

    - Otherwise, transBlockN is marked as not available.

- Otherwise, if ctxBlockCat is equal to 11 or 12, the following applies.
  - The derivation process for neighbouring 4x4 Cr blocks specified in subclause 6.4.8.4.1 is invoked with cr4x4BlkIdx as input and the output is assigned to mbAddrN, cr4x4BlkIdxN (with N being either A or B).
  - The variable transBlockN is derived as follows.
    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ((CodedBlockPatternLuma >> (cr4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 0 for the macroblock mbAddrN, the 4x4 Cr block with index cr4x4BlkIdxN of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, if mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, ((CodedBlockPatternLuma >> (cr4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cr block with index (cr4x4BlkIdxN >> 2) of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, transBlockN is marked as not available.
- Otherwise (ctxBlockCat is equal to 13), the following applies.
  - The derivation process for neighbouring 8x8 Cr blocks specified in subclause 6.4.8.2.1 is invoked with cr8x8BlkIdx as input and the output is assigned to mbAddrN, cr8x8BlkIdxN (with N being either A or B).
  - The variable transBlockN is derived as follows.
    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM,, ((CodedBlockPatternLuma >>cr8x8BlkIdx) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cr block with index cr8x8BlkIdxN of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, transBlockN is marked as not available.

74) Subclause 9.3.3.1.3 “Assignment process of ctxIdxInc for syntax elements significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1”

In subclause 9.3.3.1.1, make the following changes.

Replace Table 9-33 with the following

Table 9-33 – Specification of ctxBlockCat for the different blocks

Block description	maxNumCoeff	ctxBlockCat
block of luma DC transform coefficient levels (i.e., list Intra16x16DCLevel as described in subclause 7.4.5.3)	16	0
block of luma AC transform coefficient levels (i.e., list Intra16x16ACLevel[i] as described in subclause 7.4.5.3)	15	1
block of 16 luma transform coefficient levels (i.e., list LumaLevel[i] as described in subclause 7.4.5.3)	16	2
block of chroma DC transform coefficient levels when ChromaArrayType is equal to 1 or 2 (i.e., list ChromaDCLevel as described in subclause 7.4.5.3)	4 * NumC8x8	3
block of chroma AC transform coefficient levels when ChromaArrayType is equal to 1 or 2 (i.e., list ChromaACLevel as described in subclause 7.4.5.3)	15	4
block of 64 luma transform coefficient levels (i.e., list LumaLevel8x8[i] as described in subclause 7.4.5.3)	64	5

block of Cb DC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbIntra16x16DCLevel as described in subclause 7.4.5.3)	16	6
block of Cb AC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbIntra16x16ACLevel[i] as described in subclause 7.4.5.3)	15	7
block of 16 Cb transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbLevel[i] as described in subclause 7.4.5.3)	16	8
block of 64 Cb transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbLevel8x8[i] as described in subclause 7.4.5.3)	64	9
block of Cr DC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrIntra16x16DCLevel as described in subclause 7.4.5.3)	16	10
block of Cr AC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrIntra16x16ACLevel[i] as described in subclause 7.4.5.3)	15	11
block of 16 Cr transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrLevel[i] as described in subclause 7.4.5.3)	16	12
block of 64 Cr transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrLevel8x8[i] as described in subclause 7.4.5.3)	64	13

Replace the sentence starting with "For the syntax elements significant_coeff_flag and last_significant_coeff_flag in blocks with ctxBlockCat < 5" *with the following*

For the syntax elements significant_coeff_flag and last_significant_coeff_flag in blocks with ctxBlockCat not equal to 3, 5, 9, and 13, the variable ctxIdxInc is derived by

Replace the paragraph starting with "For the syntax elements significant_coeff_flag and last_significant_coeff_flag in 8x8 luma blocks" *with the following.*

For the syntax elements significant_coeff_flag and last_significant_coeff_flag in 8x8 luma, Cb, or Cr blocks with ctxBlockCat = = 5, 9, or 13, Table 9-34 contains the specification of ctxIdxInc for the given values of levelListIdx, where levelListIdx ranges from 0 to 62, inclusive.

Change the title of Table 9-34 to "Mapping of scanning position to ctxIdxInc for ctxBlockCat = = 5, 9, or 13".

75) Subclause A.2.4 "High profile"

In subclause A.2.4, replace the following.

Conformance of a bitstream to the High profile is specified by profile_idc being equal to 100. Decoders conforming to the High profile at a specific level shall be capable of decoding all bitstreams in which level_idc and constraint_set3_flag represents a level less than or equal to the specified level and either or both of the following conditions are true:

– profile_idc is equal to 77 or 100, or

– constraint_set1_flag is equal to 1.

with

Conformance of a bitstream to the High profile is specified by profile_idc being equal to 100. Decoders conforming to the High profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

– profile_idc is equal to 100 and level_idc represents a level less than or equal to the specified level.

NOTE – The value 100 for profile_idc indicates that the bitstream conforms to the High profile as specified in this subclause. When profile_idc is equal to 100 and constraint_set3_flag is equal to 1, this indicates that the bitstream conforms to the High

profile and additionally conforms to the constraints specified for the High 10 Intra profile in subclause A.2.8. For example, such a bitstream must have bit_depth_luma_minus8 equal to 0, have bit_depth_chroma_minus8 equal to 0, obey the MinCr, MaxBR and MaxCPB constraints of the High profile, contain only IDR pictures, have num_ref_frames equal to 0, have dpb_output_delay equal to 0, and obey the maximum slice size constraint of the High 10 Intra profile.

76) Subclause A.2.5 "High 10 profile"

In subclause A.2.5, replace the following.

Conformance of a bitstream to the High 10 profile is specified by profile_idc being equal to 110. Decoders conforming to the High 10 profile at a specific level shall be capable of decoding all bitstreams in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level and either or both of the following conditions are true:

– profile_idc is equal to 77, 100, or 110, or

– constraint_set1_flag is equal to 1.

with

Conformance of a bitstream to the High 10 profile is specified by profile_idc being equal to 110. Decoders conforming to the High 10 profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

– profile_idc is equal to 100 or 110 and level_idc represents a level less than or equal to the specified level.

77) Subclause A.2.6 "High 4:2:2 profile"

In subclause A.2.6, replace the following.

Conformance of a bitstream to the High 4:2:2 profile is specified by profile_idc being equal to 122. Decoders conforming to the High 4:2:2 profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77, 100, 110, or 122, or

– constraint_set1_flag is equal to 1.

with

Conformance of a bitstream to the High 4:2:2 profile is specified by profile_idc being equal to 122. Decoders conforming to the High 4:2:2 profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

– profile_idc is equal to 100, 110, or 122 and level_idc represents a level less than or equal to the specified level.

78) New subclause A.2.7 "High 4:4:4 Predictive profile"

Add a new subclause A.2.7 as follows.

A.2.7 High 4:4:4 Predictive profile

Bitstreams conforming to the High 4:4:4 Predictive profile shall obey the following constraints:

– Only I, P, B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.
– Sequence parameter sets shall have bit_depth_luma_minus8 in the range of 0 to 6 inclusive.
– Sequence parameter sets shall have bit_depth_chroma_minus8 in the range of 0 to 6 inclusive.
– The level constraints specified for the High 4:4:4 Predictive profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 4:4:4 Predictive profile is specified by profile_idc being equal to 244. Decoders conforming to the High 4:4:4 Predictive profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level
– profile_idc is equal to 44, 100, 110, 122, or 244 and the value of level_idc represents a level less than or equal to the specified level

79) New subclause A.2.8 "High 10 Intra profile"

Add a new subclause A.2.8 as follows.

A.2.8 High 10 Intra profile

Bitstreams conforming to the High 10 Intra profile shall obey the following constraints:

– All constraints specified in subclause A.2.5 for the High 10 profile shall be obeyed.
– All pictures shall be IDR pictures.
– Sequence parameter sets shall have num_ref_frames equal to 0.
– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have num_reorder_frames equal to 0.
– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have max_dec_frame_buffering equal to 0.
– Picture timing SEI messages, whether present in the bitstream (by non-VCL NAL units) or conveyed equivalently by other means not specified in this Recommendation | International Standard, shall have dpb_output_delay equal to 0.
– The level constraints specified for the High 10 Intra profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 10 Intra profile is specified by constraint_set3_flag being equal to 1 with profile_idc equal to 110. Decoders conforming to the High 10 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true.

– profile_idc is equal to 100 or 110.
– constraint_set3_flag is equal to 1.
– level_idc represents a level less than or equal to the specified level.

NOTE – The value 100 for profile_idc indicates that the bitstream conforms to the High profile as specified in subclause A.2.4. When profile_idc is equal to 100 and constraint_set3_flag is equal to 1, this indicates that the bitstream conforms to the High profile and additionally conforms to the constraints specified for the High 10 Intra profile in this subclause. For example, such a bitstream must have bit_depth_luma_minus8 equal to 0, have bit_depth_chroma_minus8 equal to 0, obey the MinCr, MaxBR and MaxCPB constraints of the High profile, contain only IDR pictures, have num_ref_frames equal to 0, have dpb_output_delay equal to 0, and obey the maximum slice size constraint of the High 10 Intra profile.

The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the High 10 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 10 Intra profile. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 10 Intra profile. However, the application of the deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 10, High 4:2:2, and High 4:4:4 Predictive profiles when decoding bitstreams that conform to the High 10 Intra profile.

80) New subclause A.2.9 “High 4:2:2 Intra profile”

Add a new subclause A.2.9 as follows.

A.2.9 High 4:2:2 Intra profile

Bitstreams conforming to the High 4:2:2 Intra profile shall obey the following constraints:

– All constraints specified in subclause A.2.6 for the High 4:2:2 profile shall be obeyed.

– All pictures shall be IDR pictures.

– Sequence parameter sets shall have num_ref_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have num_reorder_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have max_dec_frame_buffering equal to 0.

– Picture timing SEI messages, whether present in the bitstream (by non-VCL NAL units) or conveyed equivalently by other means not specified in this Recommendation | International Standard, shall have dpb_output_delay equal to 0.

– The level constraints specified for the High 4:2:2 Intra profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 4:2:2 Intra profile is specified by constraint_set3_flag being equal to 1 with profile_idc equal to 122. Decoders conforming to the High 4:2:2 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true:

– profile_idc is equal to 100, 110, or 122.

– constraint_set3_flag is equal to 1.

– level_idc represents a level less than or equal to the specified level.

The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the High 4:2:2 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 4:2:2 Intra profile. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 4:2:2 Intra profile. However, the application of the deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 4:2:2, and High 4:4:4 Predictive profiles when decoding bitstreams that conform to the High 4:2:2 Intra profile.

81) Subclause A.2.10 “High 4:4:4 Intra profile”

Add a new subclause A.2.10 as follows.

A.2.10 High 4:4:4 Intra profile

Bitstreams conforming to the High 4:4:4 Intra profile shall obey the following constraints:

– All constraints specified in subclause A.2.7 for the High 4:4:4 Predictive profile shall be obeyed.

– All pictures shall be IDR pictures.

– Sequence parameter sets shall have num_ref_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have num_reorder_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have max_dec_frame_buffering equal to 0.

– Picture timing SEI messages, whether present in the bitstream (by non-VCL NAL units) or conveyed equivalently by other means not specified in this Recommendation | International Standard, shall have dpb_output_delay equal to 0.

– The level constraints specified for the High 4:4:4 Intra profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 4:4:4 Intra profile is specified by constraint_set3_flag being equal to 1 with profile_idc equal to 244. Decoders conforming to the High 4:4:4 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true:

– profile_idc is equal to 44, 100, 110, 122, or 244.

– constraint_set3_flag is equal to 1.

– level_idc represents a level less than or equal to the specified level.

The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the High 4:4:4 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. However, the application of the deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 4:4:4 Predictive profile when decoding bitstreams that conform to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles.

82) Subclause A.2.11 “CAVLC 4:4:4 Intra profile”

Add a new subclause A.2.11 as follows.

A.2.11 CAVLC 4:4:4 Intra profile

Bitstreams conforming to the CAVLC 4:4:4 Intra profile shall obey the following constraints:

– All constraints specified in subclause A.2.10 for the High 4:4:4 Intra profile shall be obeyed.

– Picture parameter sets shall have entropy_coding_mode_flag equal to 0.

– The level constraints specified for the CAVLC 4:4:4 Intra profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the CAVLC 4:4:4 Intra profile is specified by profile_idc being equal to 44. Decoders conforming to the CAVLC 4:4:4 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true:

– profile_idc is equal to 44.

– level_idc represents a level less than or equal to the specified level.

The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the CAVLC 4:4:4 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. However, the application of the deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 4:4:4 Predictive profile when decoding bitstreams that conform to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles.

83) Subclause A.3.2 “Level limits common to the High, High 10, High 4:2:2, and High 4:4:4 profiles”

In the title and text of subclause A.3.2, make the following changes.

Replace the title of the subclause with “Level limits common to the High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles”.

Replace all occurrences of the phrase “High, High 10, High 4:2:2, or High 4:4:4 profiles” *with* “High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles”.

Replace the paragraph which states as follows.

Table A-1 specifies the limits for each level. Entries marked "-" in Table A-1 denote the absence of a corresponding limit.

with the following.

Table A-1 specifies the limits for each level. Entries marked "-" in Table A-1 denote the absence of a corresponding limit. The use of the MinCR parameter column of Table A-1 for these profiles is specified in subclause A.3.3.

84) Subclause A.3.3 "Profile-specific level limits"

In subclause A.3.3, make the following changes.

Replace all occurrences of the phrase "Main, High, High 10, High 4:2:2, or High 4:4:4 profiles" *with* "Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles".

Replace all occurrences of the phrase "Main, High, High 10, High 4:2:2, and High 4:4:4 profiles" *with* "Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles".

Insert the following paragraphs.

i) In bitstreams conforming to the High profile, the sum of the NumBytesInNALunit variables for access unit 0 is less than or equal to $384 * (PicSizeInMbs + MaxMBPS * (t_r(0) - t_{r,n}(0))) \div MinCR$, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture 0 and PicSizeInMbs is the number of macroblocks in picture 0.

> NOTE – Such a limit involving MinCR is not imposed for bitstream conformance to the High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles.

j) In bitstreams conforming to the High profile, the sum of the NumBytesInNALunit variables for access unit n (with $n > 0$) is less than or equal to $384 * MaxMBPS * (t_r(n) - t_r(n - 1)) \div MinCR$, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture n.

> NOTE – Such a limit involving MinCR is not imposed for bitstream conformance to the High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles.

k) In bitstreams conforming to the High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, when PicSizeInMbs is greater than 1620, the number of macroblocks in any coded slice shall not exceed MaxFS / 4, where MaxFS is specified in Table A-1.

> NOTE – Items i), j), and k) above are included herein for purposes of specification of the High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles. The aspects of these items as they relate to the High, High 10, and High 4:2:2 profiles are included herein for completeness, and reflect corrections of the intended specification of these profiles.

Replace Table A-2 with the following.

Table A-2 – Specification of cpbBrVclFactor and cpbBrNalFactor

Profile	cpbBrVclFactor	cpbBrNalFactor
High	1 250	1 500
High 10 or High 10 Intra	3 000	3 600
High 4:2:2 or High 4:2:2 Intra	4 000	4 800
High 4:4:4 Predictive, High 4:4:4 Intra, or CAVLC 4:4:4 Intra	4 000	4 800

85) Subclause D.1 “SEI payload syntax”

Replace the content of subclause D.1 with the following.

sei_payload(payloadType, payloadSize) {	C	Descriptor
if(payloadType = = 0)		
buffering_period(payloadSize)	5	
else if(payloadType = = 1)		
pic_timing(payloadSize)	5	
else if(payloadType = = 2)		
pan_scan_rect(payloadSize)	5	
else if(payloadType = = 3)		
filler_payload(payloadSize)	5	
else if(payloadType = = 4)		
user_data_registered_itu_t_t35(payloadSize)	5	
else if(payloadType = = 5)		
user_data_unregistered(payloadSize)	5	
else if(payloadType = = 6)		
recovery_point(payloadSize)	5	
else if(payloadType = = 7)		
dec_ref_pic_marking_repetition(payloadSize)	5	
else if(payloadType = = 8)		
spare_pic(payloadSize)	5	
else if(payloadType = = 9)		
scene_info(payloadSize)	5	
else if(payloadType = = 10)		
sub_seq_info(payloadSize)	5	
else if(payloadType = = 11)		
sub_seq_layer_characteristics(payloadSize)	5	
else if(payloadType = = 12)		
sub_seq_characteristics(payloadSize)	5	
else if(payloadType = = 13)		
full_frame_freeze(payloadSize)	5	
else if(payloadType = = 14)		
full_frame_freeze_release(payloadSize)	5	
else if(payloadType = = 15)		
full_frame_snapshot(payloadSize)	5	
else if(payloadType = = 16)		
progressive_refinement_segment_start(payloadSize)	5	
else if(payloadType = = 17)		
progressive_refinement_segment_end(payloadSize)	5	
else if(payloadType = = 18)		
motion_constrained_slice_group_set(payloadSize)	5	
else if(payloadType = = 19)		
film_grain_characteristics(payloadSize)	5	
else if(payloadType = = 20)		
deblocking_filter_display_preference(payloadSize)	5	
else if(payloadType = = 21)		

stereo_video_info(payloadSize)	5	
else if(payloadType = = 22)		
post_filter_hint(payloadSize)	5	
else if(payloadType = = 23)		
tone_mapping_info(payloadSize)	5	
else		
reserved_sei_message(payloadSize)	5	
if(!byte_aligned( )) {		
bit_equal_to_one /* equal to 1 */	5	f(1)
while(!byte_aligned( ))		
bit_equal_to_zero /* equal to 0 */	5	f(1)
}		
}		

86) New subclause D.1.22.1 "Post-filter hint SEI message syntax"

Add a new subclause D.1.22.1 "Post-filter hint SEI message syntax" *as follows.*

D.1.22.1 Post-filter hint SEI message syntax

post_filter_hint(payloadSize) {	**C**	**Descriptor**
filter_hint_size_y	5	ue(v)
filter_hint_size_x	5	ue(v)
filter_hint_type	5	u(2)
for(colour_component = 0; colour_component < 3; colour_component ++)		
for(cy = 0; cy < filter_hint_size_y; cy ++)		
for(cx = 0; cx < filter_hint_size_x; cx ++)		
filter_hint[colour_component][cy][cx]	5	se(v)
additional_extension_flag	5	u(1)
}		

87) New subclause D.1.22.2 "Tone mapping information SEI message syntax"

Add a new subclause D.1.22.2 "Tone mapping information SEI message syntax" *as follows.*

D.1.22.2 Tone mapping information SEI message syntax

tone_mapping_info(payloadSize) {	**C**	**Descriptor**
tone_map_id	5	ue(v)
tone_map_cancel_flag	5	u(1)
if(!tone_map_cancel_flag) {		
tone_map_repetition_period	5	ue(v)
coded_data_bit_depth	5	u(8)
target_bit_depth	5	u(8)
model_id	5	ue(v)
if(model_id = = 0) {		

min_value	5	u(32)
max_value	5	u(32)
}		
if(model_id = = 1) {		
sigmoid_midpoint	5	u(32)
sigmoid_width	5	u(32)
}		
if(model_id = = 2)		
for(i = 0; i < (1 << target_bit_depth); i++)		
start_of_coded_interval[i]	5	u(v)
if(model_id = = 3) {		
num_pivots	5	u(16)
for(i=0; i < num_pivots; i++) {		
coded_pivot_value[i]	5	u(v)
target_pivot_value[i]	5	u(v)
}		
}		
}		
}		

88) Subclause D.2.19 "Motion-constrained slice group set SEI message semantics"

In subclause D.2.19, replace the paragraph starting with "The target picture set for*" with the following.*

The target picture set for this SEI message contains all consecutive primary coded pictures in decoding order starting with the associated primary coded IDR picture (inclusive) and ending with the following primary coded IDR picture (exclusive) or with the very last primary coded picture in the bitstream (inclusive) in decoding order when there is no following primary coded IDR picture. The slice group set is a collection of one or more slice groups, identified by the slice_group_id[i] syntax element. When separate_colour_plane_flag is equal to 1, the term "primary coded pictures" represents the parts of the corresponding primary coded pictures that correspond to the NAL units having the same colour_plane_id.

89) New subclause D.2.22.1 "Post-filter hint SEI message semantics"

Add a new subclause D.2.22.1 as follows.

D.2.22.1 Post-filter hint SEI message semantics

This SEI message provides the coefficients of a post-filter or correlation information for the design of a post-filter for potential use in post-processing of the output decoded pictures to obtain improved displayed quality.

filter_hint_size_y specifies the vertical size of the filter coefficient or correlation array. The value of filter_hint_size_y shall be in the range of 1 to 15, inclusive.

filter_hint_size_x specifies the horizontal size of the filter coefficient or correlation array. The value of filter_hint_size_x shall be in the range of 1 to 15, inclusive.

filter_hint_type identifies the type of the transmitted filter hints as specified in Table D-7. The value of filter_hint_type shall be in the range of 0 to 2, inclusive.

Table D-7 – filter_hint_type values

Value	Description
0	coefficients of a 2D FIRfilter
1	coefficients of two 1D FIR filters
2	cross-correlation matrix
3	Reserved

filter_hint[colour_component][cy][cx] specifies a filter coefficient or an element of a cross-correlation matrix between original and decoded signal with 16-bit precision. colour_component specifies the related colour component. cy represents a counter in vertical direction, cx represents a counter in horizontal direction. Depending on filter_hint_type, the following applies.

– If filter_hint_type is equal to 0, the coefficients of a 2-dimensional FIR filter with the size of filter_hint_size_y * filter_hint_size_x are transmitted.

– Otherwise, if filter_hint_type is equal to 1, the filter coefficients of two 1-dimensional FIR filters are transmitted. In this case, filter_hint_size_y shall be equal to 2. The index cy = 0 specifies the filter coefficients of the horizontal filter and cy = 1 specifies the filter coefficients of the vertical filter. In the filtering process, the horizontal filter shall be applied first and the result shall be filtered by the vertical filter.

– Otherwise (filter_hint_type is equal to 2), the transmitted hints specify a cross-correlation matrix between the original signal s and the decoded signal s'.

NOTE 1 - The cross-correlation matrix for a related colour component with the size of filter_hint_size_y * filter_hint_size_x is defined as follows:

$$\text{filter\_hint}\,(\text{cy},\text{cx}) = \frac{1}{h \cdot w} \sum_{m=0}^{h-1} \sum_{n=0}^{w-1} s(m,n) \cdot s'(m + \text{cy} - \mathit{offset\_y}, n + \text{cx} - \mathit{offset\_x}) \tag{D-26}$$

where *s* denotes the original frame, *s'* denotes the decoded frame, *h* denotes the vertical height of the related colour component, *w* denotes the horizontal width of the related colour component, *offset_y* is equal to (filter_hint_size_y >> 1), *offset_x* is equal to (filter_hint_size_x >> 1), 0 <= cy < filter_hint_size_y and 0 <= cx < filter_hint_size_x.

NOTE 2 - A decoder can derive a Wiener post-filter from the cross-correlation matrix of original and decoded signal and the auto-correlation matrix of the decoded signal.

additional_extension_flag equal to 0 indicates that no additional data follows within the post-filter hint SEI message. The value of additional_extension_flag shall be equal to 0. The value of 1 for additional_extension_flag is reserved for future use by ITU-T | ISO/IEC. Decoders that conform to this Recommendation | International Standard shall ignore all data that follows the value of 1 for additional_extension_flag in a post-filter hint SEI message.

90) New subclause D.2.22.2 "Tone mapping information SEI message semantics"

Add a new subclause D.2.22.2 "Tone mapping information SEI message semantics" as follows.

D.2.22.2 Tone mapping information SEI message semantics

This SEI message provides information to enable remapping of the colour samples of the output decoded pictures for customization to particular display environments. The remapping process maps coded sample values in the RGB colour space (specified in Annex E) to target sample values. All mappings are expressed in the RGB colour space and should be applied to each RGB component separately.

tone_map_id contains an identifying number that may be used to identify the purpose of the tone mapping model. The value of tone_map_id shall be in the range of 0 to $2^{32} - 1$, inclusive.

Values of tone_map_id from 0 to 255 and from 512 to $2^{31} - 1$ may be used as determined by the application. Values of tone_map_id from 256 to 511 and from 2^{31} to $2^{32} - 1$ are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping information SEI messages containing a value of tone_map_id in the range of 256 to 511 or in the range of 2^{31} to $2^{32} - 1$, and bitstreams shall not contain such values.

NOTE – The tone_map_id can be used to support tone mapping operations that are suitable for different display scenarios. For example, different values of tone_map_id may correspond to different display bit depths.

tone_map_cancel_flag equal to 1 indicates that the tone mapping information SEI message cancels the persistence of any previous tone mapping information SEI message in output order. tone_map_cancel_flag equal to 0 indicates that tone mapping information follows.

tone_map_repetition_period specifies the persistence of the tone mapping information SEI message and may specify a picture order count interval within which another tone mapping information SEI message with the same value of tone_map _id or the end of the coded video sequence shall be present in the bitstream. The value of tone_map_repetition_period shall be in the range of 0 to 16 384, inclusive.

tone_map_repetition_period equal to 0 specifies that the tone map information applies to the current decoded picture only.

tone_map_repetition_period equal to 1 specifies that the tone map information persists in output order until any of the following conditions are true.

– A new coded video sequence begins

– A picture in an access unit containing a tone mapping information SEI message with the same value of tone_map_id is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic).

tone_map_repetition_period equal to 0 or equal to 1 indicates that another tone mapping information SEI message with the same value of tone_map_id may or may not be present.

tone_map_repetition_period greater than 1 specifies that the tone map information persists until any of the following conditions are true.

– A new coded video sequence begins

– A picture in an access unit containing a tone mapping information SEI message with the same value of tone_map_id is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + tone_map_repetition_period.

tone_map_repetition_period greater than 1 indicates that another tone mapping information SEI message with the same value of tone_map_id shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + tone_map_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

coded_data_bit_depth specifies the BitDepth_Y of the luma component of the coded video sequence. It is used to identify the tone mapping information SEI message that is intended for use with the coded video sequence. If tone mapping information SEI messages are present that have coded_data_bit_depth that is not equal to BitDepth_Y, these refer to the hypothetical result of a transcoding operation performed to convert the coded video to the BitDepth_Y corresponding to the value of coded_data_bit_depth.

The value of coded_data_bit_depth shall be in the range of 8 to 14, inclusive. Values of coded_data_bit_depth from 0 to 7 and from 15 to 255 are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping SEI messages that contain a coded_data_bit_depth in the range of 0 to 7 or in the range of 15 to 255, and bitstreams shall not contain such values.

target_bit_depth specifies the bit depth of the output of the dynamic range mapping function (or tone mapping function) described by the tone mapping information SEI message. The tone mapping function specified with a particular target_bit_depth is suggested to be reasonable for all display bit depths that are equal to or less than the target_bit_depth.

The value of target_bit_depth shall be in the range of 1 to 16, inclusive. Values of target_bit_depth equal to 0 and in the range of 17 to 255 are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping SEI messages that contain a value of target_bit_depth equal to 0 or in the range of 17 to 255, and bitstreams shall not contain such values.

model_id specifies the model utilized for mapping the coded data into the target_bit_depth range. Values greater than 3 are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping SEI messages that contain a value of model_id greater than 3, and bitstreams shall not contain such values.

NOTE – A model_id of 0 corresponds to a linear mapping with clipping; a model_id of 1 corresponds to a sigmoidal mapping; a model_id of 2 corresponds to a user-defined table mapping, and a model_id of 3 corresponds to a piece-wise linear mapping.

min_value specfies the RGB sample value in the coded data that maps to the minimum value in the signaled target_bit_depth. It is used in combination with the max_value parameter. All values in the coded data that are less than or equal to min_value are mapped to this minimum value in the target_bit_depth representation.

max_value specifies the RGB sample value in the coded data that maps to the maximum value in the signaled target_bit_depth. It is used in combination with the min_value parameter. All values in the coded data that are larger than or equal to max_value are mapped to this maximum value in the target_bit_depth representation.

sigmoid_midpoint specifies the RGB sample value of the coded data that is mapped to the center point of the target_bit_depth representation. It is used in combination with the sigmoid_width parameter.

sigmoid_width specifies the distance between two coded data values that approximately correspond to the 5% and 95% values of the target_bit_depth representation, respectively. It is used in combination with the sigmoid_midpoint parameter and is interpreted according to the following function:

$$f(i) = Round\left(\frac{2^{target\_bit\_depth} - 1}{1 + \exp\left(\frac{-6 * (i - sigmoid\_midpoint)}{sigmoid\_width} \right)} \right) \qquad for\ i = 0, \cdots, (2^{coded\_bit\_depth} - 1) \tag{D-27}$$

where *f*(i) denotes the function that maps an RGB sample value from the coded data to a resulting RGB sample value in the target_bit_depth representation.

start_of_coded_interval[i] specifies the beginning point of an interval in the coded data such that all RGB sample values that are greater than or equal to start_of_coded_interval[i] and less than start_of_coded_interval[i + 1] are mapped to i in the target bit depth representation. The value of start_of_coded_interval[$2^{target\_bit\_depth}$] is equal to $2^{coded\_bit\_depth}$. The number of bits used for the representation of the start_of_coded_interval is ((coded_data_bit_depth + 7) >> 3) << 3.

num_pivots specifies the number of pivot points in the piece-wise linear mapping function without counting the two default end points, (0, 0) and ($2^{coded\_data\_bit\_depth} - 1$, $2^{target\_bit\_depth} - 1$) .

coded_pivot_value[i] specifies the value in the coded_bit_depth corresponding to the i-th pivot point. The number of bits used for the representation of the coded_pivot_value is ((coded_data_bit_depth + 7) >> 3) << 3.

target_pivot_value[i] specifies the value in the reference target_bit_depth corresponding to the i-th pivot point. The number of bits used for the representation of the target_pivot_value is ((target_bit_depth + 7) >> 3) << 3.

91) Subclause E.2.1 “VUI parameters semantics”

In subclause E.2.1, replace the following paragraphs.

num_reorder_frames indicates the maximum number of frames, complementary field pairs, or non-paired fields that precede any frame, complementary field pair, or non-paired field in the coded video sequence in decoding order and follow it in output order. The value of num_reorder_frames shall be in the range of 0 to max_dec_frame_buffering, inclusive. When the num_reorder_frames syntax element is not present, the value of num_reorder_frames value shall be inferred to be equal to max_dec_frame_buffering.

max_dec_frame_buffering specifies the required size of the HRD decoded picture buffer (DPB) in units of frame buffers. The coded video sequence shall not require a decoded picture buffer with size of more than Max(1, max_dec_frame_buffering) frame buffers to enable the output of decoded pictures at the output times specified by dpb_output_delay of the picture timing SEI messages. The value of max_dec_frame_buffering shall be in the range of num_ref_frames to MaxDpbSize (as specified in subclause A.3.1 or A.3.2), inclusive. When the

max_dec_frame_buffering syntax element is not present, the value of max_dec_frame_buffering shall be inferred to be equal to MaxDpbSize.

with

num_reorder_frames indicates the maximum number of frames, complementary field pairs, or non-paired fields that precede any frame, complementary field pair, or non-paired field in the coded video sequence in decoding order and follow it in output order. The value of num_reorder_frames shall be in the range of 0 to max_dec_frame_buffering, inclusive. When the num_reorder_frames syntax element is not present, the value of num_reorder_frames value shall be inferred as follows.

– If profile_idc is equal to 44, 100, 110, 122, or 244 and constraint_set3_flag is equal to 1, the value of num_reorder_frames shall be inferred to be equal to 0.

– Otherwise (profile_idc is not equal to 44, 100, 110, 122, or 244 or constraint_set3_flag is equal to 0), the value of num_reorder_frames shall be inferred to be equal to MaxDpbSize.

max_dec_frame_buffering specifies the required size of the HRD decoded picture buffer (DPB) in units of frame buffers. The coded video sequence shall not require a decoded picture buffer with size of more than Max(1, max_dec_frame_buffering) frame buffers to enable the output of decoded pictures at the output times specified by dpb_output_delay of the picture timing SEI messages. The value of max_dec_frame_buffering shall be in the range of num_ref_frames to MaxDpbSize (as specified in subclause A.3.1 or A.3.2), inclusive. When the max_dec_frame_buffering syntax element is not present, the value of max_dec_frame_buffering shall be inferred as follows.

– If profile_idc is equal to 44 or 244 and constraint_set3_flag is equal to 1, the value of max_dec_frame_buffering shall be inferred to be equal to 0.

– Otherwise (profile_idc is not equal to 44 or 244 or constraint_set3_flag is equal to 0), the value of max_dec_frame_buffering shall be inferred to be equal to MaxDpbSize.

APPENDIX H26404

Series A : Organization of the work of ITU-T

Number	*Approval Date*	*Recommendation Title*	*Status*
A.1	07-2006	Work methods for study groups of the ITU Telecommunication Standardization Sector (ITU-T)	
A.2	10-2004	Presentation of contributions relative to the study of Questions assigned to ITU-T	
A.2 (2004) Amendment 1	07-2006	Single type of input contribution	
A.3	10-1996	Elaboration and presentation of texts and development of terminology and other means of expression for Recommendations of the ITU Telecommunication Standardization Sector	
A.4	06-2002	Communication process between ITU-T and Forums and Consortia	
A.4 (2004) Amendment 1	07-2006	Procedures for preparation of liaison statements between scheduled meetings	
A.5	11-2001	Generic procedures for including references to documents of other organizations in ITU-T Recommendations	
A.6	06-2002	Cooperation and exchange of information between ITU-T and national and regional standards development organizations	
A.6 (2004) Amendment 1	07-2006	Procedures for preparation of liaison statements between scheduled meetings	
A.7	10-2004	Focus groups: Working methods and procedures	
A.7 (2004) Amendment 1	07-2006	Single type of input contribution	
A.8	07-2006	Alternative approval process for new and revised ITU-T Recommendations	
A.9	11-2003	Working procedures for the Special Study Group on IMT-2000 and Beyond	
A.11	10-2004	Publication of ITU-T Recommendations and WTSA proceedings	
A.12	10-2004	Identification and layout of ITU-T Recommendations	
A.13	10-2000	Supplements to ITU-T Recommendations	
A.23	10-2000	Collaboration with the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) on information technology	
A.23 Annex A	11-2001	Guide to ITU-T and ISO/IEC JTC1 cooperation	
A.30	03-1993	Major degradation or disruption of service	
A.Sup2	06-2000	Guidelines on interoperability experiments	
A.Sup3	11-2001	IETF and ITU-T collaboration guidelines	

Recommendation count: 24

Series B :

Number	*Approval Date*	*Recommendation Title*	*Status*
B.1	11-1988	Letter symbols for telecommunications	
B.3	11-1988	Use of the international system of units (SI)	
B.10	11-1988	Graphical symbols and rules for the preparation of documentation in telecommunications	
B.11	11-1988	Legal time – Use of the term UTC	
B.12	11-1988	Use of the decibel and the neper in telecommunications	
B.13	11-1988	Terms and definitions	
B.14	11-1988	Terms and symbols for information quantities in telecommunications	
B.15	10-1996	Nomenclature of the frequency and wavelength bands used in telecommunications	
B.16	11-1988	Use of certain terms linked with physical quantities	
B.17	11-1988	Adoption of the CCITT Specification and Description Language (SDL)	
B.18	03-1993	Traffic intensity unit	
B.19	10-1996	Abbreviations and initials used in telecommunications	

Recommendation count: 11

Series C :

Number	*Approval Date*	*Recommendation Title*	*Status*
C.1	03-1993	ITU statistical yearbook	
C.3	03-1993	Instructions for international telecommunication services	

Recommendation count: 1

Series D : General tariff principles

Number	*Approval Date*	*Recommendation Title*	*Status*
D.000	06-2002	Terms and definitions for the D-series Recommendations	
D.1	07-1991	General principles for the lease of international (continental and intercontinental) private telecommunication circuits and networks	
D.3	06-1992	Principles for the lease of analogue international circuits for private service	
D.4	09-2005	Special conditions for the lease of international (continental and intercontinental) sound- and television-programme circuits for private service	
D.5	11-1988	Costs and value of services rendered as factors in the fixing of rates	
D.6	11-1988	General principles for the provision of international telecommunications facilities to organizations formed to meet the specialized international communication needs of their members	
D.7	01-1992	Concept and implementation of "one-stop shopping" for international private leased telecommunication circuits	
D.8	11-1988	Special conditions for the lease of international end-to-end digital circuits for private service	
D.9	11-1988	Private leasing of transmitters or receivers	
D.10	07-1991	General tariff principles for international public data communication services	
D.11	03-1991	Special tariff principles for international packet-switched public data communication services by means of the virtual call facility	
D.12	11-1988	Measurement unit for charging by volume in the international packet-switched data communication service	
D.13	11-1988	Guiding principles to govern the apportionment of accounting rates in international packet-switched public data communication relations	
D.15	11-1988	General charging and accounting principles for non-voice services provided by interworking between public data networks	
D.20	11-1988	Special tariff principles for the international circuit-switched public data communication services	
D.21	11-1988	Special tariff principles for short transaction transmissions on the international packet-switched public data networks using the fast select facility with restriction	
D.30	11-1988	Implementation of reverse charging on international public data communication services	
D.35	01-1992	General charging principles in the international public message handling services and associated applications	
D.36	03-1995	General accounting principles applicable to message handling services and associated applications	
D.37	07-1996	Accounting and settlement principles applicable to the provision of public directory services between interconnected Directory Management Domains	

D.40	06-1992	General tariff principles applicable to telegrams exchanged in the international public telegram service	
D.41	11-1988	Introduction of accounting rates by zones in the international public telegram service	
D.42	11-1988	Accounting in the international public telegram service	
D.43	11-1988	Partial and total refund of charges in the international public telegram service	
D.43 (1988) Corrigendum 1	11-1989		Available only in PDF.
D.45	06-1992	Charging and accounting principles for the international telemessage service	
D.50	11-1988	Tariff and international accounting principles for the international teletex service	
D.50	10-2000	International Internet connection	
D.50 (2000) Amendment 1	06-2004	New Appendix I – General considerations for charging criteria and options for international Internet connectivity	
D.60	07-1991	Guiding principles to govern the apportionment of accounting rates in intercontinental telex relations	
D.61	11-1988	Charging and accounting provisions relating to the measurement of the chargeable duration of a telex call	
D.65	11-1988	General charging and accounting principles in the international telex service for multi-address messages via store-and-forward units	
D.67	03-1995	Charging and accounting in the international telex service	
D.70	06-1992	General tariff principles for the international public facsimile service between public bureaux (bureaufax service)	
D.71	06-1992	General tariff principles for the public facsimile service between subscriber stations (telefax service)	
D.73	06-1992	General tariff and international accounting principles for interworking between the international bureaufax and telefax services	
D.79	07-1991	Charging and accounting principles for the international videotex service	
D.80	11-1988	Accounting and refunds for phototelegrams	
D.81	11-1988	Accounting and refunds for private phototelegraph calls	
D.83	11-1988	Rates for phototelegrams and private phototelegraph calls	
D.85	11-1988	Charging for international phototelegraph calls to multiple destinations	
D.90	03-1995	Charging, billing, international accounting and settlement in the maritime mobile service	

D.91	07-1996	Transmission in encoded form of maritime telecommunications accounting information
D.91 (1996) Amendment 1	06-1998	Year 2000 issue and its impact on ITU-T D.91 application
D.93	11-2003	Charging and accounting in the international land mobile telephone service (provided via cellular radio systems)
D.94	01-1992	Charging, billing and accounting principles for international aeronautical mobile service, and international aeronautical mobile-satellite service
D.95	10-1992	Charging, billing, accounting and refunds in the data messaging land/maritime mobile-satellite service
D.96	12-1999	Charging, billing, accounting and settlement principles for Global Mobile Personal Communications by Satellite (GMPCS) for the international telephone service
D.98	03-1993	Charging and accounting provisions relating to the transferred account telegraph and telematic services
D.100	11-1988	Charging for international calls in manual or semi-automatic operating
D.101	11-1988	Charging in automatic international telephone service
D.103	06-1992	Charging in automatic service for calls terminating on a recorded announcement stating the reason for the call not being completed
D.104	11-1988	Charging for calls to subscriber's station connected either to the absent subscriber's service or to a device substituting a subscriber in his absence
D.105	11-1988	Charging for calls from or to a public call office
D.106	11-1988	Introduction of reduced rates during periods of light traffic in the international telephone service
D.110	06-1992	Charging and accounting for conference calls
D.115	06-2004	Tariff principles and accounting for the International Freephone Service (IFS)
D.116	06-2004	Charging and accounting principles relating to the home country direct telephone service
D.117	06-1999	Charging and accounting principles for the international premium rate service (IPRS)
D.120	07-1996	Charging and accounting principles for the international telecommunication charge card service
D.140	06-2002	Accounting rate principles for the international telephone service
D.140 (2002) Amendment 1	12-2002	New Appendix to Annex C: Guidelines
D.140 (2002) Amendment 2	06-2003	Revision to Annex E
D.140 (2002) Amendment 3	11-2003	Revised Annex A – Guidelines for the cost elements to be taken into account when determining accounting rates and accounting rate shares for the international telephone service
D.140 Supplement 1	06-2002	Updated teledensities and indicative target settlement rates
D.140 Supplement 2	06-2003	Updated teledensities and indicative target settlement rates (1 January 2003)
D.140 Supplement 3	06-2004	Updated teledensities and indicative target settlement rates (1 January 2004)

D.150	06-1999	New system for accounting in international telephony	
D.150 (1999) Amendment 1	09-2005	Optional transit share arrangement	
D.151	11-1988	Old system for accounting in international telephony	
D.151/E.251 (1988) Corrigendum 1	11-1989		Available only in PDF.
D.155	07-1996	Guiding principles governing the apportionment of accounting rates in intercontinental telephone relations	
D.160	11-1988	Mode of application of the flat-rate price procedure set forth in Recommendation D.67 and Recommendation D.150 for remuneration of facilities made available to the Administrations of other countries	
D.170	06-2006	Monthly telephone and telex accounts	
D.171	11-1988	Adjustments and refunds in the international telephone service	
D.172	11-1988	Accounting for calls circulated over international routes for which accounting rates have not been established	
D.173	11-1988	Defaulting subscribers	
D.174	11-1988	Conventional transmission of information necessary for billing and accounting regarding collect and credit card calls	
D.176	12-1997	Transmission in encoded form of telephone reversed charge billing and accounting information	
D.176 (1997) Amendment 1	06-1998	Year 2000 issue and its impact on ITU-T D.176 application	
D.177	11-1988	Adjustment of charges and refunds in the international telex service	
D.178	03-1993	Monthly accounts for semi-automatic telephone calls (ordinary and urgent calls, with or without special facilities)	
D.180	09-2005	Occasional provision of circuits for international sound- and television-programme transmissions	
D.185	11-1988	General tariff and accounting principles for international one-way point-to-multipoint satellite services	
D.186	10-1996	General tariff and accounting principles for international two-way multipoint telecommunication service via satellite	
D.188	10-1992	General charging and accounting principles applicable to an international videoconferencing service	
D.190	06-2002	Exchange of international traffic accounting data between Administrations using electronic data interchange (EDI) techniques	
D.192	06-1992	Principles for charging and accounting of service telecommunications	
D.193	11-1988	Special tariff principles for privilege telecommunications	
D.195	11-1988	Settlement of international telecommunication balances of accounts	
D.195	06-2006	Time-scale for settlement of accounts for international telecommunication services	

D.196	06-1992	Clearing of international telecommunication balances of accounts
D.197	07-1991	Notification of change of address(es) for accounting and settlement purposes
D.201	12-2002	General principles regarding call-back practices
D.210	09-1994	General charging and accounting principles for international telecommunication services provided over the Integrated Services Digital Network (ISDN)
D.211	12-1998	International accounting for the use of the signal transfer point and/or signalling point for relay in Signalling System No. 7
D.212	10-1996	Charging and accounting principles for the use of Signalling System No. 7
D.220	03-1991	Charging and accounting principles to be applied to international circuit-mode demand bearer services provided over the integrated services digital network (ISDN)
D.224	12-1999	Charging and accounting principles for ATM/B-ISDN
D.225	12-1997	Charging and accounting principles to be applied to frame relay data transmission service
D.230	03-1995	General charging and accounting principles for supplementary services associated with international telecommunication services provided over the Integrated Services Digital Network (ISDN)
D.231	11-1988	Charging and accounting principles relating to the User-to-User Information (UUI) supplementary service
D.232	05-1997	Specific tariff and accounting principles applicable to ISDN supplementary services
D.233	07-1996	Charging and accounting principles to be applied to the reversed charge supplementary service
D.240	03-1991	Charging and accounting principles for teleservices supported by the ISDN
D.250	07-1991	General charging and accounting principles for non-voice services provided by interworking between the ISDN and existing public data networks
D.251	11-1988	General charging and accounting principles for the basic telephone service provided over the ISDN or by interconnection between the ISDN and the public switched telephone network
D.260	03-1991	Charging and accounting capabilities to be applied on the ISDN
D.280	03-1995	Principles for charging and billing, accounting and reimbursements for universal personal telecommunication
D.285	07-1996	Guiding principles for charging and accounting for intelligent network supported services
D.286	07-1996	Charging and accounting principles for the global virtual network service
D.300R	03-1995	Determination of accounting rate shares in telephone relations between countries in Europe and the Mediterranean Basin

D.300R (1995) Amendment 1	06-1998	Applicability of 1992 values of standard accounting rate shares components
D.301R	03-1995	Determination of accounting rate shares and collection charges in telex relations between countries in Europe and the Mediterranean Basin
D.301R (1995) Amendment 1	06-1998	Applicability of 1984 values of standard accounting rate shares components
D.302R	03-1995	Determination of the accounting rate shares and collection charges for the international public telegram service applicable to telegrams exchanged between countries in Europe and the Mediterranean Basin
D.302R (1995) Amendment 1	06-1998	Applicability of 1984 values of standard transition and terminal rate shares components
D.303R	03-1995	Determination of accounting rate shares and collection charges applicable by countries in Europe and the Mediterranean Basin to the occasional provision of circuits for sound- and television-programme transmissions
D.303R (1995) Amendment 1	06-1998	Applicability of 1984 values of standard accounting rate shares components
D.305 R	11-1988	Remuneration for facilities used for the switched-transit handling of intercontinental telephone traffic in a country in Europe or the Mediterranean Basin
D.306R	07-1991	Remuneration of public packet-switched data transmission networks between the countries of Europe and the Mediterranean Basin
D.307R	03-1995	Remuneration of digital systems and channels used in telecommunication relations between the countries of Europe and the Mediterranean Basin
D.307R (1995) Amendment 1	06-1998	Applicability of 1984 values of flat-rate remuneration
D.310R	03-1995	Determination of rentals for the lease of international programme (sound- and television-) circuits and associated control circuits for private service in relations between countries in Europe and the Mediterranean Basin
D.310R (1995) Amendment 1	06-1998	Applicability of 1984 values of the annual rental
D.390 R	11-1988	Accounting system in the international automatic telephone service
D.400R	12-1999	Accounting rates applicable to direct traffic relations in voice telephony between countries in Latin America and the Caribbean
D.401 R	11-1988	Accounting rates applicable to telex relations between countries in Latin America
D.500R	06-1998	Accounting rates applicable to telephone relations between countries in Asia and Oceania
D.501R	10-1993	Accounting rates applicable to telex relations between countries in Asia and Oceania
D.600R	10-2000	Cost methodology for the regional tariff group for Africa applicable to the international automatic telephone service
D.601R	10-1993	Determination of accounting rate shares and collection charges in telex relations between countries in Africa
D.602R	12-2002	Application of the “sender pays transit” principle in transit relation
D.603R	12-2002	Minimizing collection charges on inter-African calls

D.604R	01-2005	The last international transit center pays the traffic	
D.606R	11-1988	Preferential rates in telecommunication relations between countries in Africa	
D.Sup1	11-1988	Cost and tariff study method	Available only in PDF.
D.Sup2	11-1988	Method for carrying out a cost price study by regional tariff groups	
D.Sup3	03-1993	Handbook on the methodology for determining costs and establishing national tariffs	

Recommendation count: 272

Series E : General tariff principles

Number	*Approval Date*	*Recommendation Title*	*Status*
E.100	11-1988	Definitions of terms used in international telephone operation	
E.104	02-1995	International telephone directory assistance service and public access	
E.105	08-1992	International telephone service	
E.106	10-2003	International Emergency Preference Scheme (IEPS) for disaster relief operations	
E.107	02-2007	Emergency Telecommunications Service (ETS) and interconnection framework for national implementations of ETS	
E.109	02-1995	International billed number screening procedures for collect and third-party calling	
E.110	11-1988	Organization of the international telephone network	
E.111	11-1988	Extension of international telephone services	
E.112	11-1988	Arrangements to be made for controlling the telephone services between two countries	
E.113	05-1997	Validation procedures for the international telecommunications charge card service	
E.114	11-1988	Supply of lists of subscribers (directories and other means)	
E.115	05-2007	Computerized directory assistance	Pre-published.
E.116	05-1997	International telecommunication charge card service	
E.117	06-1994	Terminal devices used in connection with the public telephone service (other than telephones)	
E.118	05-2006	The international telecommunication charge card	
E.120	11-1988	Instructions for users of the international telephone service	
E.121	06-2004	Pictograms, symbols and icons to assist users of the telephone and telefax services	
E.121 (2004) Erratum 1	10-2004		
E.122	11-1988	Measures to reduce customer difficulties in the international telephone service	
E.123	02-2001	Notation for national and international telephone numbers, e-mail addresses and Web addresses	
E.124	11-1988	Discouragement of frivolous international calling to unassigned or vacant numbers answered by recorded announcements without charge	
E.125	10-1984	Inquiries among users of the international telephone service	
E.126	11-1988	Harmonization of the general information pages of the telephone directories published by Administrations	
E.127	11-1988	Pages in the telephone directory intended for foreign visitors	

E.128	11-1988	Leaflet to be distributed to foreign visitors
E.129	09-2002	Presentation of national numbering plans
E.130	11-1988	Choice of the most useful and desirable supplementary telephone services
E.131	11-1988	Subscriber control procedures for supplementary telephone services
E.132	11-1988	Standardization of elements of control procedures for supplementary telephone services
E.133	11-1988	Operating procedures for cardphones
E.134	03-1993	Human factors aspects of public terminals: Generic operating procedures
E.135	10-1995	Human factors aspects of public telecommunication terminals for people with disabilities
E.136	05-1997	Specification of a tactile identifier for use with telecommunication cards
E.137	05-1997	User instructions for payphones
E.138	06-2002	Human factors aspects of public telephones to improve their usability for older people
E.138 Erratum 1	02-2003	
E.140	08-1992	Operator-assisted telephone service
E.141	03-1993	Instructions for operators on the operator-assisted international telephone service
E.148	11-1988	Routing of traffic by automatic transit exchanges
E.149	11-1988	Presentation of routing data
E.150	11-1988	Publication of a "list of international telephone routes"
E.151	08-1992	Telephone conference calls
E.152	05-2006	International freephone service
E.153	10-1996	Home country direct
E.154	03-1998	International Shared Cost Service
E.155	03-1998	International Premium Rate Service
E.155 (1998) Amendment 1	02-2001	
E.156	05-2006	Guidelines for ITU-T action on reported misuse of E.164 number resources
E.160	03-1993	Definitions relating to national and international numbering plans
E.161	02-2001	Arrangement of digits, letters and symbols on telephones and other devices that can be used for gaining access to a telephone network
E.162	04-1995	Capability for seven digit analysis of international E.164 numbers at Time T
E.164	02-2005	The international public telecommunication numbering plan
E.164 Supplement 1	03-1998	Alternatives for carrier selection and network identification

E.164 Supplement 2	11-1998	Number Portability
E.164 Supplement 3	05-2004	Operational and administrative issues associated with national implementations of the ENUM functions
E.164 Supplement 4	05-2004	Operational and administrative issues associated with the implementation of ENUM for non-geographic country codes
E.164.1	05-2006	Criteria and procedures for the reservation, assignment and reclamation of E.164 country codes and associated identification codes (ICs)
E.164.2	02-2001	E.164 numbering resources for trials
E.164.3	09-2001	Principles, criteria and procedures for the assignment and reclamation of E.164 country codes and associated identification codes for groups of countries
E.165	11-1988	Timetable for coordinated implementation of the full capability of the numbering plan for the ISDN era (Recommendation E.164)
E.165.1	10-1996	Use of escape code "0" within the E.164 numbering plan during the transition period to implementation of NPI mechanism
E.166/X.122	03-1998	Numbering plan interworking for the E.164 and X.121 numbering plans
E.167	11-1988	ISDN Network Identification Codes
E.168	05-2002	Application of E.164 numbering plan for UPT
E.168 (2002) Amendment 1	05-2004	New Appendix I
E.168.1	02-2005	Assignment procedures for universal personal telecommunications (UPT) numbers in the provisioning of the international UPT service
E.169	05-2002	Application of Recommendation E.164 numbering plan for universal international numbers for international telecommunications services using country codes for global services
E.169.1	09-2001	Application of Recommendation E.164 numbering plan for universal international freephone numbers for international freephone service
E.169.2	10-2000	Application of Recommendation E.164 numbering plan for universal international premium rate numbers for the international premium rate service
E.169.3	10-2000	Application of Recommendation E.164 numbering plan for universal international shared cost numbers for international shared cost service
E.170	10-1992	Traffic routing
E.171/Q.13	11-1988	International telephone routing plan
E.172	10-1992	ISDN routing plan
E.173	08-1991	Routing plan for interconnection between public land mobile networks and fixed terminal networks
E.174	04-1995	Routing principles and guidance for Universal Personal Telecommunications (UPT)
E.175	11-1988	Models for international network planning
E.177	10-1996	B-ISDN routing
E.180/Q.35	03-1998	Technical characteristics of tones for the telephone service
E.181	11-1988	Customer recognition of foreign tones

E.182	03-1998	Application of tones and recorded announcements in telephone services
E.183	03-1998	Guiding principles for telephone announcements
E.184	11-1988	Indications to users of ISDN terminals
E.190	05-1997	Principles and responsibilities for the management, assignment and reclamation of E-series international numbering resources
E.191	03-2000	B-ISDN addressing
E.191 (2000) Corrigendum 1	02-2002	
E.191.1	02-2001	Criteria and procedures for the allocation of ITU-T International Network Designator addresses
E.193	03-2000	E.164 country code expansion
E.195	10-2000	ITU-T International numbering resource administration
E.201	08-1991	Reference recommendation for mobile services
E.202	10-1992	Network operational principles for future public mobile systems and services
E.210	11-1988	Ship station identification for VHF/UHF and maritime mobile-satellite services
E.211	11-1988	Selection procedures for VHF/UHF maritime mobile services
E.212	05-2004	The international identification plan for mobile terminals and mobile users
E.212 (2004) Erratum 1	10-2004	
E.212 (2004) Amendment 1	02-2007	Annexes to the international identification plan for mobile terminals and mobile users
E.213	11-1988	Telephone and ISDN numbering plan for land mobile stations in public land mobile networks (PLMN)
E.214	02-2005	Structure of the land mobile global title for the signalling connection control part (SCCP)
E.215	05-1997	Telephone/ISDN numbering plan for the mobile-satellite services of Inmarsat
E.216	03-1993	Selection procedures for the INMARSAT mobile-satellite telephone and ISDN services
E.217	05-2002	Maritime communications – Ship station identity
E.218	05-2004	Management of the allocation of terrestrial trunk radio Mobile Country Codes
E.220	02-1996	Interconnection of public land mobile networks (PLMN)
E.230	08-1992	Chargeable duration of calls
D.103	06-1992	Charging in automatic service for calls terminating on a recorded announcement stating the reason for the call not being completed

D.104	11-1988	Charging for calls to subscriber's station connected either to the absent subscriber's service or to a device substituting a subscriber in his absence
E.260	11-1988	Basic technical problems concerning the measurement and recording of call durations
E.261	11-1988	Devices for measuring and recording call durations
D.170	06-2006	Monthly telephone and telex accounts
E.300	11-1988	Special uses of circuits normally employed for automatic telephone traffic
E.301	03-1993	Impact of non-voice applications on the telephone network
E.320	11-1988	Speeding up the establishment and clearing of phototelegraph calls
F.107	11-1988	Rules for phototelegraph calls established over circuits normally used for telephone traffic
E.330	11-1988	User control of ISDN-supported services
E.331	10-1991	Minimum user-terminal interface for a human user entering address information into an ISDN terminal
Z.323	11-1988	Man-machine interaction
E.350	03-2000	Dynamic routing interworking
E.351	03-2000	Routing of multimedia connections across TDM-, ATM- and IP-based networks
E.352	03-2000	Routing guidelines for efficient routing methods
E.353	02-2001	Routing of calls when using international network routing addresses
E.360.1	05-2002	Framework for QoS routing and related traffic engineering methods for IP-, ATM-, and TDM-based multiservice networks
E.360.2	05-2002	QoS routing and related traffic engineering methods – Call routing and connection routing methods
E.360.3	05-2002	QoS routing and related traffic engineering methods – QoS resource management methods
E.360.4	05-2002	QoS routing and related traffic engineering methods – Routing table management methods and requirements
E.360.5	05-2002	QoS routing and related traffic engineering methods – Transport routing methods
E.360.6	05-2002	QoS routing and related traffic engineering methods – Capacity management methods
E.360.7	05-2002	QoS routing and related traffic engineering methods – Traffic engineering operational requirements
E.361	05-2003	QoS routing support for interworking of QoS service classes across routing technologies
E.370	02-2001	Service principles when public circuit-switched international telecommunication networks interwork with IP-based networks

E.401	11-1988	Statistics for the international telephone service (number of circuits in operation and volume of traffic)
E.408	05-2004	Telecommunication networks security requirements
E.409	05-2004	Incident organization and security incident handling: Guidelines for telecommunication organizations
E.410	03-1998	International network management – General information
E.411	03-2000	International network management – Operational guidance
E.411 (2000) Amendment 1	03-2001	
E.412	01-2003	Network management controls
E.413	11-1988	International network management – Planning
E.414	11-1988	International network management – Organization
E.415	08-1991	International network management guidance for common channel signalling system No. 7
E.416	03-2000	Network management principles and functions for B-ISDN traffic
E.417	02-2005	Framework for the network management of IP-based networks
E.418	05-2003	Framework for network management of IMT-2000 networks
E.419	02-2006	Business oriented Key Performance Indicators for management of networks and services
E.420	11-1988	Checking the quality of the international telephone service – General considerations
E.421	11-1988	Service quality observations on a statistical basis
E.422	02-1996	Observations on international outgoing telephone calls for quality of service
E.423	11-1988	Observations on traffic set up by operators
E.424	10-1992	Test calls
E.425	03-2002	Internal automatic observations
E.426	10-1992	General guide to the percentage of effective attempts which should be observed for international telephone calls
E.427	11-1988	Collection and statistical analysis of special quality of service observation data for measurements of customer difficulties in the international automatic service
E.428	10-1992	Connection retention
E.430	06-1992	Quality of service framework
E.431	06-1992	Service quality assessment for connection set-up and release delays
E.432	06-1992	Connection quality
E.433	06-1992	Billing integrity

E.434	06-1992	Subscriber-to-subscriber measurement of the public switched telephone network
E.436	03-1998	Customer Affecting Incidents and blocking Defects Per Million
E.437	05-1999	Comparative metrics for network performance management
E.438	03-2000	Performance parameters and measurement methods to assess N-ISDN 64 kbit/s circuit-switched bearer service UDI in operation
E.439	03-2000	Test call measurement to assess N-ISDN 64 kbit/s circuit-switched bearer service UDI in operation
E.440	02-1996	Customer satisfaction point
E.450	03-1998	Facsimile quality of service on public networks – General aspects
E.451	02-2001	Facsimile call cut-off performance
E.452	03-1993	Facsimile modem speed reductions and transaction time
E.453	08-1994	Facsimile image quality as corrupted by transmission-induced scan line errors
E.454	10-1996	Transmission performance metrics based on Error Correction Mode (ECM) facsimile
E.456	03-1998	Test transaction for facsimile transmission performance
E.457	02-1996	Facsimile measurement methodologies
E.458	02-1996	Figure of merit for facsimile transmission performance
E.459	03-1998	Measurements and metrics for characterizing facsimile transmission performance using non-intrusive techniques
E.460	03-2000	Measurements and metrics for monitoring the performance of V.34 Group 3 Facsimile
E.470	02-2005	Operational considerations for QoS of voice over IP-based networks with PSTN-IP-PSTN architecture
E.480	09-2006	Framework for service management operational requirements – Service management
E.490	06-1992	Traffic measurement and evaluation – General survey
E.490.1	01-2003	Overview of Recommendations on traffic engineering
E.491	05-1997	Traffic measurement by destination
E.492	02-1996	Traffic reference period
E.493	02-1996	Grade of service (GOS) monitoring
E.500	11-1998	Traffic intensity measurement principles
E.501	05-1997	Estimation of traffic offered in the network
E.502	02-2001	Traffic measurement requirements for digital telecommunication exchanges
E.503	06-1992	Traffic measurement data analysis
E.504	11-1988	Traffic measurement administration
E.505	06-1992	Measurements of the performance of common channel signalling network

E.506	06-1992	Forecasting international traffic
E.507	11-1988	Models for forecasting international traffic
E.508	10-1992	Forecasting new telecommunication services
E.510	11-1988	Determination of the number of circuits in manual operation
E.520	11-1988	Number of circuits to be provided in automatic and/or semiautomatic operation, without overflow facilities
E.521	11-1988	Calculation of the number of circuits in a group carrying overflow traffic
E.522	11-1988	Number of circuits in a high-usage group
E.523	11-1988	Standard traffic profiles for international traffic streams
E.524	05-1999	Overflow approximations for non-random inputs
E.525	06-1992	Designing networks to control grade of service
E.526	03-1993	Dimensioning a circuit group with multi-slot bearer services and no overflow inputs
E.527	03-2000	Dimensioning at a circuit group with multi-slot bearer services and overflow traffic
E.528	02-1996	Dimensioning of digital circuit multiplication equipment (DCME) systems
E.529	05-1997	Network dimensioning using end-to-end GOS objectives
E.540	11-1988	Overall grade of service of the international part of an international connection
E.541	11-1988	Overall grade of service for international connections (subscriber-to-subscriber)
E.543	11-1988	Grades of service in digital international telephone exchanges
E.550	03-1993	Grade-of-service and new performance criteria under failure conditions in international telephone exchanges
E.600	03-1993	Terms and definitions of traffic engineering
E.651	03-2000	Reference connections for traffic engineering of IP access networks
E.671	03-2000	Post-selection delay in PSTN/ISDN networks using Internet telephony for a portion of the connection
E.681	10-2001	Traffic engineering methods for IP acess networks based on hybrid fiber/coax system
E.700	10-1992	Framework of the E.700-Series Recommendations
E.701	10-1992	Reference connections for traffic engineering
E.710	10-1992	ISDN traffic modelling overview
E.711	10-1992	User demand modelling

E.712	10-1992	User plane traffic modelling
E.713	10-1992	Control plane traffic modelling
E.716	10-1996	User demand modelling in Broadband-ISDN
E.720	11-1988	ISDN grade of service concept
E.721	05-1999	Network grade of service parameters and target values for circuit-switched services in the evolving ISDN
E.723	06-1992	Grade-of-service parameters for Signalling System No. 7 networks
E.724	02-1996	GOS parameters and target GOS objectives for IN services
E.726	03-2000	Network grade of service parameters and target values for B-ISDN
E.728	03-1998	Grade-of-service parameters for B-ISDN signalling
E.730	10-1992	ISDN dimensioning methods overview
E.731	10-1992	Methods for dimensioning resources operating in circuit-switched mode
E.733	11-1998	Methods for dimensioning resources in Signalling System No. 7 networks
E.734	10-1996	Methods for allocating and dimensioning Intelligent Network (IN) resources
E.735	05-1997	Framework for traffic control and dimensioning in B-ISDN
E.736	03-2000	Methods for cell level traffic control in B-ISDN
E.737	02-2001	Dimensioning methods for B-ISDN
E.743	04-1995	Traffic measurements for SS No. 7 dimensioning and planning
E.744	10-1996	Traffic and congestion control requirements for SS No. 7 and IN-structured networks
E.745	03-2000	Cell level measurement requirements for the B-ISDN
E.750	03-2000	Introduction to the E.750 series of Recommendations on traffic engineering aspects of networks supporting personnal communications services
E.751	02-1996	Reference connections for traffic engineering of land mobile networks
E.752	10-1996	Reference connections for traffic engineering of maritime and aeronautical systems
E.755	02-1996	Reference connections for UPT traffic performance and GOS
E.760	03-2000	Terminal mobility traffic modelling
E.770	03-1993	Land mobile and fixed network interconnection traffic grade of service concept
E.771	10-1996	Network grade of service parameters and target values for circuit-switched public land mobile services
E.773	10-1996	Maritime and aeronautical mobile grade of service concept
E.774	10-1996	Network grade of service parameters and target values for maritime and aeronautical mobile services
E.775	02-1996	UPT grade of service concept
E.776	10-1996	Network grade of service parameters for UPT

E.800	08-1994	Terms and definitions related to quality of service and network performance including dependability	
E.801	10-1996	Framework for Service Quality Agreement	
E.802	02-2007	Framework and methodologies for the determination and application of QoS parameters	Pre-published.
E.810	10-1992	Framework of the Recommendations on the serveability performance and service integrity for telecommunication services	
E.820	10-1992	Call models for serveability and service integrity performance	
E.830	10-1992	Models for the specification, evaluation and allocation of serveability and service integrity	
E.845	11-1988	Connection accessibility objective for the international telephone service	
E.846	03-1993	Accessibility for 64 kbit/s circuit-switched international end-to-end ISDN connection types	
E.850	10-1992	Connection retainability objective for the international telephone service	
E.855	11-1988	Connection integrity objective for the international telephone service	
E.860	06-2002	Framework of a service level agreement	
E.861	02-2006	Defining operations competency metrics	
E.862	06-1992	Dependability planning of telecommunication networks	
E.880	11-1988	Field data collection and evaluation on the performance of equipment, networks and services	
E.910	12-2005	Procedures for registration within the domain ".int"	
E.300 Series Supplement 1	11-1988	List of possible supplementary telephone services which may be offered to subscribers	
E.300 Series Supplement 3	11-1988	North american precise audible tone plan	
E.300 Series Supplement 4	11-1988	Treatment of calls considered as terminating abnormally	
E.300 Series Supplement 5	10-1984	Modelling of an experimental test design for the determination of inexperienced user difficulties in setting up international calls using nationally available instructions, or to compare different sets of instructions	
E.300 Series Supplement 6	11-1988	Preparation of information to customers travelling abroad	
E.300 Series Supplement 7	11-1988	Description of INMARSAT existing and planned systems	

E.800 Series Supplement 1	11-1988	Table of the Erlang formula
E.800 Series Supplement 2	11-1988	Curves showing the relation between the traffic offered and the number of circuits required
E.800 Series Supplement 5	11-1988	Teletraffic implications for international switching and operational procedures resulting from a failure of a transmission facility
E.800 Series Supplement 7	11-1988	Guide for evaluating and implementing alternate routing networks

Recommendation count: 499

Series F : Non-telephone telecommunication services

Number	*Approval Date*	*Recommendation Title*	*Status*
F.1	03-1998	Operational provisions for the international public telegram service	
F.2	11-1988	Operational provisions for the collection of telegram charges	
F.4	11-1988	Plain and secret language	
F.10	11-1988	Character error rate objective for telegraph communication using 5-unit start-stop equipment	
F.11	10-1991	Continued availability of traditional services	
F.13	11-1988	Operational provisions for participation in the transferred account telegraph and telematic service	
F.14	08-1992	General provisions for one-stop-shopping arrangements	
F.15	08-1992	Evaluating the success of new services	
F.16	02-1995	Global virtual network service	
F.17	08-1992	Operational aspects of service telecommunications	
F.18	03-1998	Guidelines on harmonization of international public bureau services	
F.19	10-1996	Collection and dissemination of official service information	
F.20	11-1988	The international gentex service	
F.21	11-1988	Composition of answer-back codes for the international gentex service	
F.23	11-1988	Grade of service for long-distance international gentex circuits	
F.24	11-1988	Average grade of service from country to country in the gentex service	
F.30	03-1993	Use of various sequences of combinations for special purposes	
F.31	11-1988	Telegram retransmission system	
F.32	10-1995	Telegram destination indicators	
F.35	11-1988	Provisions applying to the operation of an international public automatic message switching service for equipments utilizing the International Telegraph Alphabet No. 2	
F.40	03-1991	International public telemessage service	
F.41	03-1991	Interworking between the telemessage service and the international public telegram service	
F.59	10-1996	General characteristics of the international telex service	
F.60	08-1992	Operational provisions for the international telex service	

F.61	11-1988	Operational provisions relating to the chargeable duration of a telex call
F.63	03-1993	Additional facilities in the international telex service
F.64	11-1988	Determination of the number of international telex circuits required to carry a given volume of traffic
F.65	11-1988	Time-to-answer by operators at international telex positions
F.68	11-1988	Establishment of the automatic intercontinental telex network
F.69	06-1994	The international telex service – Service and operational provisions of telex destination codes and telex network identification codes
F.70	11-1988	Evaluating the quality of the international telex service
F.71	11-1988	Interconnection of private teleprinter networks with the telex network
F.72	10-1996	The international telex service – General principles and operational aspects of a store and forward facility
F.74	08-1992	Intermediate storage devices accessed from the international telex service using single stage selection – Answerback format
F.80	10-1991	Basic requirements for interworking relations between the international telex service and other services
F.82	10-1991	Operational provisions to permit interworking between the international telex service and the intex service
F.83	07-1990	Operational principles for communication between terminals of the international telex service and data terminal equipment on packet-switched public data networks
F.421	11-1988	Message handling services: Intercommunication between the IPM service and the telex service
F.421 Errata	12-1999	
F.86	10-1991	Interworking between the international telex service and the videotex service
F.87	03-1991	Operational principles for the transfer of messages from terminals on the telex network to Group 3 facsimile terminals connected to the public switched telephone network
F.89	08-1992	Status enquiry function in the international telex service
F.91	11-1988	General statistics for the telegraph services
F.92	11-1988	Service codes
F.93	11-1988	Routing table for offices connected to the gentex service
F.95	11-1988	Table of international telex relations and traffic
F.100	11-1988	Scheduled radiocommunication service
F.104	10-1991	International leased circuit services – Customer circuit designations
F.105	11-1988	Operational provisions for phototelegrams
F.106	11-1988	Operational provisions for private phototelegraph calls
F.107	11-1988	Rules for phototelegraph calls established over circuits normally used for telephone traffic

F.108	11-1988	Operating rules for international phototelegraph calls to multiple destinations
F.110	07-1996	Operational provisions for the maritime mobile service
F.111	03-1991	Principles of service for mobile systems
F.112	11-1988	Quality objectives for 50-baud start-stop telegraph transmission in the maritime mobile-satellite service
F.113	08-1992	Service provisions for aeronautical passenger communications supported by mobile-satellite systems
F.115	02-1995	Service objectives and principles for future public land mobile telecommunication systems
F.116	03-2000	Service features and operational provisions in IMT-2000
E.210	11-1988	Ship station identification for VHF/UHF and maritime mobile-satellite services
F.122	11-1988	Operational procedures for the maritime satellite data transmission service
F.125	08-1993	Numbering plan for access to the mobile-satellite services of INMARSAT from the international telex service
F.127	10-1996	Operational procedures for interworking between the international telex service and the service offered by the INMARSAT-C system
F.130	11-1988	Maritime answer-back codes
F.131	11-1988	Radiotelex service codes
F.140	03-1993	Point-to-multipoint telecommunication service via satellite
F.141	06-1994	International two-way multipoint telecommunication service via satellite
F.150	10-1991	Service and operational provisions for the Intex service
F.160	03-1993	General operational provisions for the international public facsimile services
F.162	07-1996	Service and operational requirements of store-and-forward facsimile service
F.163	07-1996	Operational requirements of the interconnection of facsimile store-and-forward units
F.166	07-1996	Service and operational requirements for a fax database service
F.170	03-1998	Operational provisions for the international public facsimile service between public bureaux (Bureaufax)
F.171	11-1988	Operational provisions relating to the use of store-and-forward switching nodes within the bureaufax service
F.180	10-1996	General operational provisions for the international public facsimile service between subscribers' terminals (Telefax)
F.182	10-1996	Operational provisions for the international public facsimile service between subscribers with Group 3 facsimile terminals (Telefax 3)
F.182bis	10-1996	Guidelines for the support of the communication of documents using Group 3 facsimile between user terminals via public networks

F.184	07-1996	Operational provisions for the international public facsimile service between subscriber stations with group 4 facsimile terminals (Telefax 4)
F.185	06-1998	Internet facsimile: Guidelines for the support of the communication of facsimile documents
F.190	08-1992	Operational provisions for the international facsimile service between public bureaux and subscriber stations and vice versa (bureaufax-telefax and vice versa)
F.200	08-1992	Teletex service
F.201	03-1993	Interworking between teletex service and telex service – General principles
F.202	11-1988	Interworking between the telex service and the teletex service – General procedures and operational requirements for the international interconnection of telex/teletex conversion facilities
F.203	11-1988	Network based storage for the teletex service
F.220	03-1993	Service requirements unique to the processable mode number eleven (PM11) used within the teletex service
F.230	11-1988	Service requirements unique to the mixed mode (MM) used within the teletex service
F.300	03-1993	Videotex service
F.301	10-1995	Fast speed PSTN videotex
F.350	11-1988	Application of Series T Recommendations
F.351	11-1988	General principles on the presentation of terminal identification to users of the telematic services
F.353	11-1988	Provision of telematic and data transmission services on integrated services digital network (ISDN)
F.400/X.400	06-1999	Message handling system and service overview
F.401	08-1992	Message handling services: Naming and addressing for public message handling services
F.410	08-1992	Message handling services: The public message transfer service
F.415	11-1988	Message handling services: Intercommunication with public physical delivery services
F.420	08-1992	Message handling services: The public interpersonal messaging service
F.421	11-1988	Message handling services: Intercommunication between the IPM service and the telex service
F.421 Errata	12-1999	
F.422	11-1988	Message handling services: Intercommunication between the IPM service and the teletex service
F.423	08-1992	Message handling services: Intercommunication between the interpersonal messaging service and the telefax service
F.435	06-1999	Message handling services: Electronic Data Interchange messaging service
F.440	08-1992	Message handling services: The voice messaging service

F.471	08-1997	Operational requirements for the interconnection of voice-mail store-and-forward units
F.471 (1997) Corrigendum 1	09-1998	
F.472	08-1997	Service and operational requirements of the voice-mail store-and-forward service
F.500	08-1992	International public directory services
F.510	02-2003	Automated directory assistance – White pages service definition
F.515	04-2003	Unified Directory specification
F.551	03-1993	Service Recommendation for the telematic file transfer within Telefax 3, Telefax 4, Teletex services and message handling services
F.581	03-1993	Guidelines for programming communication interfaces (PCIs) definition: Service Recommendation
F.600	04-2004	Service and operational principles for public data transmission service
F.700	11-2000	Framework Recommendation for multimedia services
F.701	11-1988	Teleconference service
F.701	11-2000	Guideline Recommendation for identifying multimedia service requirements
F.702	07-1996	Multimedia conference services
F.703	11-2000	Multimedia conversational services
F.710	03-1991	General principles for audiographic conference service
F.711	08-1993	Audiographic conference teleservice for ISDN
F.720	08-1992	Videotelephony services – General
F.721	08-1992	Videotelephony teleservice for ISDN
F.723	07-1996	Videophone service in the Public Switched Telephone Network (PSTN)
F.724	09-2005	Service description and requirements for videotelephony services over IP networks
F.730	08-1992	Videoconference service – General
F.731	07-1997	Multimedia Conference Services in the ISDN
F.732	10-1996	Multimedia conference services in the B-ISDN
F.733	09-2005	Service description and requirements for multimedia conference services over IP networks
F.740	08-1993	Audiovisual interactive services
F.741	09-2005	Service description and requirements for audiovisual on-demand services

F.742	09-2005	Service description and requirements for distance learning services
F.750	02-2005	Metadata framework
F.761	11-1988	Service-oriented requirements for telewriting applications
F.790	01-2007	Telecommunications accessibility guidelines for older persons and persons with disabilities
F.811	07-1996	Broadband connection-oriented bearer service
F.812	08-1992	Broadband connectionless data bearer service
F.813	02-1995	Virtual path service for reserved and permanent communications
F.850	03-1993	Principles of Universal Personal Telecommunication (UPT)
F.851	02-1995	Universal Personal Telecommunication (UPT) – Service description (service set 1)
F.852	03-2000	Universal Personal Telecommunication (UPT) – Service description (service set 2)
F.853	11-1998	Supplementary services in the Universal Personal Telecommunication (UPT) environment
F.901	03-1993	Usability evaluation of telecommunication services
F.902	02-1995	Interactive services design guidelines
F.910	02-1995	Procedures for designing, evaluating and selecting symbols, pictograms and icons
F.Sup1	11-1988	Definitions relating to telegraph, telematic and data transmission services
F.Sup2	11-1988	Terms and definitions for telex

Recommendation count: 279

Series G : Telephone transmission quality, telephone installations, local line networks

Number	*Approval Date*	*Recommendation Title*	*Status*
G.100	02-2001	Definitions used in Recommendations on general characteristics of international telephone connections and circuits	
P.10/G.100	07-2006	Vocabulary for performance and quality of service	
P.10/G.100 (2006) Amendment 1	01-2007	New Appendix I – Definition of Quality of Experience (QoE)	
G.100.1	11-2001	The use of the decibel and of relative levels in speechband telecommunications	
G.101	11-2003	The transmission plan	
G.102	11-1988	Transmission performance objectives and Recommendations	
G.103	12-1998	Hypothetical reference connections	
G.105	11-1988	Hypothetical reference connection for crosstalk studies	
G.107	03-2005	The E-model, a computational model for use in transmission planning	
G.107 (2005) Amendment 1	06-2006	New Appendix II – Provisional impairment factor framework for wideband speech transmission	
G.108	09-1999	Application of the E-model: A planning guide	
G.108 Erratum 1	12-2000		
G.108 (1999) Amendment 1	09-2003	New Appendix I – The relationship between and interaction of talker echo and absolute delay	
G.108 (1999) Amendment 2	03-2004	New Appendix II – Planning examples regarding delay in packet-based networks	
G.108.1	05-2000	Guidance for assessing conversational speech transmission quality effects not covered by the E-model	
G.108.2	03-2007	Transmission planning aspects of echo cancellers	Pre-published.
G.109	09-1999	Definition of categories of speech transmission quality	
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G.111	03-1993	Loudness ratings (LRs) in an international connection	
G.113	02-2001	Transmission impairments due to speech processing	
G.113 (2001) Amendment 1	06-2006	New Appendix IV – Provisional planning values for the wideband equipment impairment factor Ie,wb	
G.113 (2001) Amendment 2	01-2007	Revised Appendix I – Provisional planning values for the equipment impairment factor Ie and packet-loss robustness factor Bpl	
G.114	05-2003	One-way transmission time	
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G.115	02-1996	Mean active speech level for announcement and speech synthesis systems
G.116	09-1999	Transmission performance objectives applicable to end-to-end international connections
G.117	02-1996	Transmission aspects of unbalance about earth
G.120	12-1998	Transmission characteristics of national networks
G.121	03-1993	Loudness ratings (LRs) of national systems
G.122	03-1993	Influence of national systems on stability and talker echo in international connections
G.123	11-1988	Circuit noise in national networks
G.125	11-1988	Characteristics of national circuits on carrier systems
G.126	03-1993	Listener echo in telephone networks
G.131	11-2003	Talker echo and its control
G.132	11-1988	Attenuation distortion
G.133	11-1988	Group-delay distortion
G.134	11-1988	Linear crosstalk
G.135	11-1988	Error on the reconstituted frequency
G.136	09-1999	Application rules for Automatic Level Control Devices
G.136 Erratum 1	12-2000	
G.141	11-1988	Attenuation distortion
G.142	12-1998	Transmission characteristics of exchanges
G.143	11-1988	Circuit noise and the use of compandors
G.151	11-1988	General performance objectives applicable to all modern international circuits and national extension circuits
G.152	11-1988	Characteristics appropriate to long-distance circuits of a length not exceeding 2500 km
G.153	11-1988	Characteristics appropriate to international circuits more than 2500 km in length
G.161	10-1976	Echo-suppressors suitable for circuits having either short or long propagation times
G.161	06-2004	Interaction aspects of signal processing network equipment
G.162	11-1988	Characteristics of compandors for telephony
G.163	11-1988	Call concentrating systems
G.164	11-1988	Echo suppressors
G.165	03-1993	Echo cancellers

G.166	11-1988	Characteristics of syllabic compandors for telephony on high capacity long distance systems	
G.167	03-1993	Acoustic echo controllers	
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G.169	07-1999	Automatic level control devices	
G.171	11-1988	Transmission plan aspects of privately operated networks	
G.172	11-1988	Transmission plan aspects of international conference calls	
G.173	03-1993	Transmission planning aspects of the speech service in digital public land mobile networks	
G.174	06-1994	Transmission performance objectives for terrestrial digital wireless systems using portable terminals to access the PSTN	
G.175	05-2000	Transmission planning for private/public network interconnection of voice traffic	
G.176	04-1997	Planning guidelines for the integration of ATM technology into networks supporting voiceband services	
G.177	09-1999	Transmission planning for voiceband services over hybrid Internet/PSTN connections	
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G.211	11-1988	Make-up of a carrier link	
G.212	11-1988	Hypothetical reference circuits for analogue systems	
G.213	11-1988	Interconnection of systems in a main repeater station	
G.214	11-1988	Line stability of cable systems	
G.215	11-1988	Hypothetical reference circuit of 5000 km for analogue systems	
G.221	11-1988	Overall recommendations relating to carrier-transmission systems	
G.222	11-1988	Noise objectives for design of carrier-transmission systems of 2500 km	
G.223	11-1988	Assumptions for the calculation of noise on hypothetical reference circuits for telephony	
G.224	11-1988	Maximum permissible value for the absolute power level (power referred to one milliwatt) of a signalling pulse	
G.225	11-1988	Recommendations relating to the accuracy of carrier frequencies	
G.226	11-1988	Noise on a real link	

G.227	11-1988	Conventional telephone signal
G.228	11-1988	Measurement of circuit noise in cable systems using a uniform-spectrum random noise loading
G.229	11-1988	Unwanted modulation and phase jitter
G.230	11-1988	Measuring methods for noise produced by modulating equipment and through-connection filters
G.231	11-1988	Arrangement of carrier equipment
G.232	11-1988	12-channel terminal equipments
G.233	11-1988	Recommendations concerning translating equipments
G.234	10-1976	8-channel terminal equipments
G.235	11-1988	16-channel terminal equipments
G.241	11-1988	Pilots on groups, supergroups, etc.
G.242	11-1988	Through-connection of groups, supergroups, etc.
G.243	11-1988	Protection of pilots and additional measuring frequencies at points where there is a through-connection
G.311	11-1988	General characteristics of systems providing 12 carrier telephone circuits on an open-wire pair
G.312	11-1988	Intermediate repeaters for open-wire carrier systems conforming to Recommendation G.311
G.313	11-1988	Open-wire lines for use with 12-channel carrier systems
G.314	10-1976	General characteristics of systems providing eight carrier telephone circuits on an open-wire pair
G.322	11-1988	General characteristics recommended for systems on symmetric pair cables
G.323	11-1988	A typical transistorized system on symmetric cable pairs
G.324	10-1976	General characteristics for valve-type systems on symmetric cable pairs
G.325	11-1988	General characteristics recommended for systems providing 12 telephone carrier circuits on a symmetric cable pair [(12 + 12) systems]
G.326	11-1988	Typical systems on symmetric cable pairs [(12 + 12) systems]
G.327	10-1976	Valve-type systems offering 12 carrier telephone circuits on a symmetric cable pair [(12 + 12) systems]
G.332	11-1988	12 MHz systems on standardized 2.6/9.5 mm coaxial cable pairs
G.333	11-1988	60 MHz systems on standardized 2.6/9.5 mm coaxial cable pairs
G.334	11-1988	18 MHz systems on standardized 2.6/9.5 mm coaxial cable pairs
G.337	10-1976	General characteristics of systems on 2.6/9.5 mm coaxial cable pairs
G.338	10-1976	4 MHz valve-type systems on standardized 2.6/9.5 mm coaxial cable pairs

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G.341	11-1988	1.3 MHz systems on standardized 1.2/4.4 mm coaxial cable pairs
G.343	11-1988	4 MHz systems on standardized 1.2/4.4 mm coaxial cable pairs
G.344	11-1988	6 MHz systems on standardized 1.2/4.4 mm coaxial cable pairs
G.345	11-1988	12 MHz systems on standardized 1.2/4.4 mm coaxial cable pairs
G.346	11-1988	18 MHz systems on standardized 1.2/4.4 mm coaxial cable pairs
G.352	11-1988	Interconnection of coaxial carrier systems of different designs
G.356	11-1980	(120 + 120) channel systems on a single coaxial pair
G.361	11-1988	Systems providing three carrier telephone circuits on a pair of open-wire lines
G.371	11-1988	FDM carrier systems for submarine cable
G.411	11-1988	Use of radio-relay systems for international telephone circuits
G.412	11-1988	Terminal equipments of radio-relay systems forming part of a general telecommunication network
G.421	11-1988	Methods of interconnection
G.422	11-1988	Interconnection at audio-frequencies
G.423	11-1988	Interconnection at the baseband frequencies of frequency-division multiplex radio-relay systems
G.431	11-1988	Hypothetical reference circuits for frequency-division multiplex radio-relay systems
G.433	11-1988	Hypothetical reference circuit for trans-horizon radio-relay systems for telephony using frequency-division multiplex
G.434	11-1988	Hypothetical reference circuit for systems using analogue transmission in the fixed-satellite service
G.441	11-1988	Permissible circuit noise on frequency-division multiplex radio-relay systems
G.442	11-1988	Radio-relay system design objectives for noise at the far end of a hypothetical reference circuit with reference to telegraphy transmission
G.444	11-1988	Allowable noise power in the hypothetical reference circuit of trans-horizon radio-relay systems for telephony using frequency-division multiplex
G.445	11-1988	Allowable noise power in the hypothetical reference circuit for frequency-division multiplex telephony in the fixed-satellite service

G.451	11-1988	Use of radio links in international telephone circuits	
G.453	11-1988	Improved transmission system for HF radio-telephone circuits	
G.464	11-1988	Principles of the devices used to achieve privacy in radiotelephone conversations	
G.473	11-1988	Interconnection of a maritime mobile satellite system with the international automatic switched telephone service; transmission aspects	
G.541	10-1976	Specification of factory lengths of loaded telecommunication cable	
G.542	10-1976	Specification of loading coils for loaded telecommunication cables	
G.543	10-1976	Specification for repeater sections of loaded telecommunication cable	
G.544	10-1976	Specifications for terminal equipment and intermediate repeater stations	
G.601	11-1988	Terminology for cables	
G.602	11-1988	Reliability and availability of analogue cable transmission systems and associated equipments	
G.611	11-1988	Characteristics of symmetric cable pairs for analogue transmission	
G.612	11-1988	Characteristics of symmetric cable pairs designed for the transmission of systems with bit rates of the order of 6 to 34 Mbit/s	
G.613	11-1988	Characteristics of symmetric cable pairs usable wholly for the transmission of digital systems with a bit rate of up to 2 Mbit/s	
G.614	11-1988	Characteristics of symmetric pair star-quad cables designed earlier for analogue transmission systems and being used now for digital system transmission at bit rates of 6 to 34 Mbit/s	
G.621	11-1988	Characteristics of 0.7/2.9 mm coaxial cable pairs	
G.622	11-1988	Characteristics of 1.2/4.4 mm coaxial cable pairs	
G.623	11-1988	Characteristics of 2.6/9.5 mm coaxial cable pairs	
G.631	11-1988	Types of submarine cable to be used for systems with line frequencies of less than about 45 MHz	
G.640	03-2006	Co-location longitudinally compatible interfaces for free space optical systems	
G.641	11-1988	Waveguide diameters	
G.650.1	06-2004	Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable	
G.650.2	07-2007	Definitions and test methods for statistical and non-linear related attributes of single mode fibre and cable	Pre-published.
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G.653	12-2006	Characteristics of a dispersion-shifted single-mode optical fibre and cable	
G.654	12-2006	Characteristics of a cut-off shifted single-mode optical fibre and cable	
G.655	03-2006	Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable	
G.656	12-2006	Characteristics of a fibre and cable with non-zero dispersion for wideband optical transport	
G.657	12-2006	Characteristics of a bending loss insensitive single mode optical fibre and cable for the access network	
G.661	07-2007	Definitions and test methods for the relevant generic parameters of optical amplifier devices and subsystems	Not available, contact sales@itu.int.
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G.663	04-2000	Application related aspects of optical amplifier devices and subsystems	
G.663 (2000) Amendment 1	01-2003	Amendements to Appendix II	
G.664	03-2006	Optical safety procedures and requirements for optical transport systems	
G.665	01-2005	Generic characteristics of Raman amplifiers and Raman amplified subsystems	
G.666	07-2005	Characteristics of PMD compensators and PMD compensating receivers	
G.667	12-2006	Characteristics of Adaptive Chromatic Dispersion Compensators	Pre-published.
G.671	01-2005	Transmission characteristics of optical components and subsystems	
G.671 (2005) Amendment 1	03-2006		
G.671 (2005) Amendment 1 Erratum 1	11-2006		
G.671 (2005) Amendment 2	12-2006		
G.680	07-2007	Physical transfer functions of optical networks elements	Pre-published.
G.681	10-1996	Functional characteristics of interoffice and long-haul line systems using optical amplifiers, including optical multiplexing	
G.691	03-2006	Optical interfaces for single channel STM-64 and other SDH systems with optical amplifiers	
G.692	10-1998	Optical interfaces for multichannel systems with optical amplifiers	
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G.692 (1998) Corrigendum 2	06-2002		
G.692 (1998) Amendment 1	01-2005		
G.693	05-2006	Optical interfaces for intra-office systems	
G.694.1	06-2002	Spectral grids for WDM applications: DWDM frequency grid	
G.694.2	12-2003	Spectral grids for WDM applications: CWDM wavelength grid	
G.695	12-2006	Optical interfaces for coarse wavelength division multiplexing applications	
G.696.1	07-2005	Longitudinally compatible intra-domain DWDM applications	
G.696.1 (2005) Erratum 1	03-2006		
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G.698.1	12-2006	Multichannel DWDM applications with single-channel optical interfaces	Pre-published.
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G.703	11-2001	Physical/electrical characteristics of hierarchical digital interfaces	
G.703 (2001) Erratum 1	07-2005		
G.704	10-1998	Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels	
G.705	11-1988	Characteristics required to terminate digital links on a digital exchange	
G.705	10-2000	Characteristics of plesiochronous digital hierarchy (PDH) equipment functional blocks	
G.706	04-1991	Frame alignment and cyclic redundancy check (CRC) procedures relating to basic frame structures defined in Recommendation G.704	
G.707/Y.1322	01-2007	Network node interface for the synchronous digital hierarchy (SDH)	Pre-published.
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G.709	03-1993	Synchronous multiplexing structure	
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G.711 Appendix II	02-2000	A comfort noise payload definition for ITU-T G.711 use in packet-based multimedia communication systems	
G.712	11-2001	Transmission performance characteristics of pulse code modulation channels	
G.713	11-1988	Performance characteristics of PCM channels between 2-wire interfaces at voice frequencies	
G.714	11-1988	Separate performance characteristics for the encoding and decoding sides of PCM channels applicable to 4-wire voice-frequency interfaces	
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G.720	07-1995	Characterization of low-rate digital voice coder performance with non-voice signals	
G.722	11-1988	7 kHz audio-coding within 64 kbit/s	
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G.722 Annex A	03-1993	Testing signal-to-total distortion ratio for 7 kHz audio-codecs at 64 kbit/s Recommendation G.722 connected back-to-back	
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G.722.1	05-2005	Low-complexity coding at 24 and 32 kbit/s for hands-free operation in systems with low frame loss	
G.722.2	07-2003	Wideband coding of speech at around 16 kbit/s using Adaptive Multi-Rate Wideband (AMR-WB)	
G.722.2 (2003) Erratum 1	06-2004		
G.722.2 (2003) Cor.1	09-2005		Available only in MS Word.
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G.722.2 Annex A	01-2002	Comfort noise aspects	
G.722.2 Annex B	01-2002	Source Controlled Rate operation	
G.722.2 Annex B (2002) Erratum 1	07-2003		
G.722.2 Annex C	03-2004	Fixed-point C-code	

G.722.2 Annex C (2004) Erratum 1	06-2004		
G.722.2 Annex D	07-2003	Digital test sequences	
G.722.2 Annex E	01-2002	Frame structure	
G.722.2 Annex E (2002) Corrigendum 1	07-2003		
G.722.2 Annex F	11-2002	AMR-WB usage in H.245	
G.722.2 Appendix I	01-2002	Error concealment of erroneous or lost frames	
G.722.2 Appendix I (2002) Amendment 1	07-2003		
G.723	11-1988	Extensions of Recommendation G.721 adaptive differential pulse code modulation to 24 and 40 kbit/s for digital circuit multiplication equipment application	
G.723.1	05-2006	Dual rate speech coder for multimedia communications transmitting at 5.3 and 6.3 kbit/s	Available only in MS Word.
G.724	11-1988	Characteristics of a 48-channel low bit rate encoding primary multiplex operating at 1544 kbit/s	
G.725	11-1988	System aspects for the use of the 7 kHz audio codec within 64 kbit/s	
G.726	12-1990	40, 32, 24, 16 kbit/s Adaptive Differential Pulse Code Modulation (ADPCM)	
G.726 (1990) Corrigendum 1	05-2005	Correction to Annex A: Extensions of Recommendation G.726 for use with uniform-quantized input and output	
G.726 Annex A	11-1994	Extensions of Recommendation G.726 for use with uniform-quantized input and output	
G.726 Annex B	07-2003	Packet format, capability identifier and capability parameters for H.245 signalling	
G.726 App II test vectors	03-1991	Digital test sequences for the verification of the G.726 40, 32, 24 and 16 kbit/s ADPCM algorithm	Available only in MS Word.
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G.8011/Y.1307	08-2004	Ethernet over Transport – Ethernet services framework	
G.8011/Y.1307 (2004) Corrigendum 1	06-2005		
G.8011/Y.1307 (2004) Amendment 1	08-2005		
G.8011.1/Y.1307.1	08-2004	Ethernet private line service	
G.8011.1/Y.1307.1 (2004) Corrigendum 1	06-2005		
G.8011.2/Y.1307.2	09-2005	Ethernet virtual private line service	
G.8012/Y.1308	08-2004	Ethernet UNI and Ethernet NNI	
G.8012/Y.1308 (2004) Amendment 1	05-2006		
G.8021/Y.1341	08-2004	Characteristics of Ethernet transport network equipment functional blocks	
G.8021/Y.1341 (2004) Amendment 1	06-2006		Pre-published.
G.8031/Y.1342	06-2006	Ethernet Protection Switching	
G.8040/Y.1340	09-2005	GFP frame mapping into Plesiochronous Digital Hierarchy (PDH)	
G.8080/Y.1304	06-2006	Architecture for the automatically switched optical network (ASON)	
G.8080/Y.1304 (2006) Erratum 1	04-2007		
G.8081/Y.1353	06-2004	Terms and definitions for Automatically Switched Optical Networks (ASON)	
G.8081/Y.1353 (2004) Amendment 1	06-2006		
G.8081/Y.1353 (2004) Amend.2	07-2007		Not available, contact sales@itu.int.
G.8101	12-2006	Terms and definitions for transport MPLS	
G.8110/Y.1370	01-2005	MPLS layer network architecture	

G.8110.1/Y.1370.1	11-2006	Architecture of Transport MPLS (T-MPLS) layer network	
G.8110.1/Y.1370.1 (2006) Amend.1	07-2007		Not available, contact sales@itu.int.
G.8112/Y.1371	10-2006	Interfaces for the Transport MPLS (T-MPLS) hierarchy	
G.8112/Y.1371 (2006) Cor.1	01-2007		Not available, contact sales@itu.int.
G.8121/Y.1381	03-2006	Characteristics of Transport MPLS equipment functional blocks	
G.8121/Y.1361 (2006) Corrigendum 1	12-2006		
G.8131/Y.1382	02-2007	Linear protection switching for Transport MPLS (T-MPLS) networks	Pre-published.
G.8201	09-2003	Error performance parameters and objectives for multi-operator international paths within the Optical Transport Network (OTN)	
G.8251	11-2001	The control of jitter and wander within the optical transport network (OTN)	
G.8251 (2001) Corrigendum 1	06-2002		
G.8251 (2001) Amendment 1	06-2002		
G.8261/Y.1361	05-2006	Timing and synchronization aspects in packet networks	
G.8261/Y.1361 (2006) Corrigendum 1	12-2006		Pre-published.
G.8601/Y.1391	06-2006	Architecture of service management in multi-bearer, multi-carrier environment	
G.9951	02-2001	Phoneline networking transceivers – Foundation	
G.9952/G.989.2	11-2001	Phoneline networking transceivers – Payload format and link layer requirements	
G.9953	03-2003	Phoneline networking transceivers – Isolation function	
G.9954	01-2007	Home networking transceivers – Enhanced physical, media access, and link layer specifications	Pre-published.
G.100 Series Supplement 29	03-1993	Planning of mixed analogue-digital circuits (chains, connections)	
G.100 Series Supplement 31	03-1993	Principles of determining an impedance strategy for the local network	
G.100 Series Supplement 32	03-1993	Transmission aspects of digital mobile radio systems	

G Suppl. 4	12-1972	Certain methods of avoiding the transmission of excessive noise between interconnected systems	Not available, contact sales@itu.int.
G.Sup5	10-1984	Measurement of the load of telephone circuits under field conditions	Available only in PDF.
G Suppl. 7	12-1972	Loss-frequency response of channel-translating equipment used in some countries for international circuits	Not available, contact sales@itu.int.
G Suppl. 8	12-1972	Method proposed by the Belgian telephone administration for interconnection between coaxial and symmetric pair systems	Not available, contact sales@itu.int.
G.Sup17	10-1984	Group-delay distortion performance of terminal equipment	Available only in PDF.
G.Sup19	10-1984	Digital crosstalk measurement (method used by the Administrations of France, the Netherlands and Spain)	Available only in PDF.
G.Sup22	10-1984	Mathematical models of multiplex signals	Available only in PDF.
G.Sup26	10-1984	Estimating the signal load margin of FDM wideband amplifier equipment and transmission systems	Available only in PDF.
G.Sup27	10-1984	Interference from external sources	Available only in PDF.
G.Sup28	10-1984	Application of transmultiplexers, FDM codecs, data-in-voice (DIV) systems and data-over-voice (DOV) systems during the transition from an analogue to a digital network	Available only in PDF.
G Suppl. 32	11-1988	Transfer of alarm information on 60-channel transmultiplexing equipment	Not available, contact sales@itu.int.
G.Sup34	11-1988	Temperature in underground containers for the installation of repeaters	Available only in PDF.
G.Sup35	11-1988	Guidelines concerning the measurement of wander	Available only in PDF.
G.Sup36	11-1988	Jitter and wander accumulation in digital networks	Available only in PDF.
G.Sup37	10-1998	ITU-T Recommendation G.763 digital circuit multiplication equipment (DCME) tutorial and dimensioning	
G.Sup38	10-1998	Variable bit rate calculations for the ITU-T Recommendation G.767 Digital Circuit Multiplication Equipment (DCME)	
G.Sup39	02-2006	Optical system design and engineering considerations	
G.Sup39 (2006) Erratum 1	08-2006		

Recommendation count: 1026

Number	*Approval Date*	*Recommendation Title*	*Status*
H.11	10-1984	Characteristics of circuits in the switched telephone network	
H.12	10-1984	Characteristics of telephone-type leased circuits	
H.14	10-1984	Characteristics of group links for the transmission of wide-spectrum signals	
H.15	10-1984	Characteristics of supergroup links for the transmission of wide-spectrum signals	
O.72	10-1984	Characteristics of an impulsive-noise measuring instrument for wideband data transmission	
H.21	10-1984	Composition and terminology of international voice-frequency telegraph systems	
H.22	10-1984	Transmission requirements of international voice-frequency telegraph links (at 50, 100 and 200 bauds)	
H.23	10-1984	Basic characteristics of telegraph equipments used in international voice-frequency telegraph systems	
H.34	10-1984	Subdivision of the frequency band of a telephone-type circuit between telegraphy and other services	
H.52	10-1984	Transmission of wide-spectrum signals (data, facsimile, etc.) on wideband group links	
H.53	10-1984	Transmission of wide-spectrum signals (data, etc.) over wideband supergroup links	
H.100	11-1988	Visual telephone systems	
H.110	11-1988	Hypothetical reference connections for videoconferencing using primary digital group transmission	
H.120	03-1993	Codecs for videoconferencing using primary digital group transmission	
H.130	11-1988	Frame structures for use in the international interconnection of digital codecs for videoconferencing or visual telephony	
H.140	11-1988	A multipoint international videoconference system	
H.200	03-1993	Framework for Recommendations for audiovisual services	
H.221	03-2004	Frame structure for a 64 to 1920 kbit/s channel in audiovisual teleservices	
H.221 (2004) Amendment 1	09-2005	Support for 14 kHz audio bandwidth extension of G.722.1 Annex C in H.221	
H.222.0	05-2006	Information technology – Generic coding of moving pictures and associated audio information: Systems	
H.222.0 (2006) Amendment 1	01-2007	Transport of MPEG-4 streaming text and MPEG-4 lossless audio over MPEG-2 systems	Pre-published.
H.222.1	03-1996	Multimedia multiplex and synchronization for audiovisual communication in ATM environments	

H.223	07-2001	Multiplexing protocol for low bit rate multimedia communication
H.224	01-2005	A real time control protocol for simplex applications using the H.221 LSD/HSD/MLP channels
H.225.0	05-2006	Call signalling protocols and media stream packetization for packet-based multimedia communication systems
H.225.0 (2006) Amendment 1	01-2007	Updating connected party information after third party pause and re-routing and procedures related to echo control
H.226	09-1998	Channel aggregation protocol for multilink operation on circuit-switched networks
H.230	03-2004	Frame-synchronous control and indication signals for audiovisual systems
H.230 (2004) Amendment 1	10-2005	Support of Unicode in H.320 systems and new Annex A for H.230 generic capabilities and messages in H.245
H.231	07-1997	Multipoint control units for audiovisual systems using digital channels up to 1920 kbit/s
H.233	11-2002	Confidentiality system for audiovisual services
H.234	11-2002	Encryption key management and authentication system for audiovisual services
H.235	08-2003	Security and encryption for H-series (H.323 and other H.245-based) multimedia terminals
H.235.0	09-2005	H.323 security: Framework for security in H-series (H.323 and other H.245-based) multimedia systems
H.235.1	09-2005	H.323 security: Baseline security profile
H.235.2	09-2005	H.323 security: Signature security profile
H.235.3	09-2005	H.323 security: Hybrid security profile
H.235.4	09-2005	H.323 security: Direct and selective routed call security
H.235.5	09-2005	H.323 security: Framework for secure authentication in RAS using weak shared secrets
H.235.6	09-2005	H.323 security: Voice encryption profile with native H.235/H.245 key management
H.235.7	09-2005	H.323 security: Usage of the MIKEY key management protocol for the Secure Real Time Transport Protocol (SRTP) within H.235
H.235.7 (2005) Erratum 1	10-2006	
H.235.8	09-2005	H.323 security: Key exchange for SRTP using secure signalling channels
H.235.9	09-2005	H.323 security: Security gateway support for H.323
H.239	09-2005	Role management and additional media channels for H.300-series terminals
H.239 (2005) Erratum 1	01-2006	
H.241	05-2006	Extended video procedures and control signals for H.300-series terminals
H.242	03-2004	System for establishing communication between audiovisual terminals using digital channels up to 2 Mbit/s

H.242 (2004) Amendment 1	09-2005	Support for 14 kHz audio bandwidth extension of G.722.1 Annex C in H.242
H.243	10-2005	Procedures for establishing communication between three or more audiovisual terminals using digital channels up to 1920 kbit/s
H.244	07-1995	Synchronized aggregation of multiple 64 or 56 kbit/s channels
H.245	05-2006	Control protocol for multimedia communication
H.245 (2006) Erratum 1	10-2006	
H.246	05-2006	Interworking of H-series multimedia terminals with H-series multimedia terminals and voice/voiceband terminals on GSTN, ISDN and PLMN
H.246 (2006) Amendment 1	01-2007	Mapping of user priority level and country/international network of call origination between H.225 and ISUP
H.247	09-1998	Multipoint extension for broadband audiovisual communication systems and terminals
H.248.1	09-2005	Gateway control protocol: Version 3
H.248.2	01-2005	Gateway control protocol: Facsimile, text conversation and call discrimination packages
H.248.2 (2005) Amendment 1	01-2007	Discriminated call type enhancement
H.248.3	11-2000	Gateway control protocol: User interface elements and actions packages
H.248.3 (2000) Corrigendum 1	03-2004	
H.248.4	11-2000	Gateway control protocol: Transport over Stream Control Transmission Protocol (SCTP)
H.248.4 (2000) Corrigendum 1	03-2004	
H.248.5	11-2000	Gateway control protocol: Transport over ATM
H.248.6	11-2000	Gateway control protocol: Dynamic Tone Definition package
H.248.7	03-2004	Gateway control protocol: Generic Announcement package
H.248.8	09-2005	Gateway control protocol: Error code and service change reason description
H.248.9	01-2005	Gateway control protocol: Advanced media server packages
H.248.10	07-2001	Gateway control protocol: Media gateway resource congestion handling package
H.248.11	11-2002	Gateway control protocol: Media gateway overload control package
H.248.12	07-2001	Gateway control protocol: H.248.1 packages for H.323 and H.324 interworking
H.248.12 (2001) Amendment 1	11-2002	New Annex A: Extended H.324, H.245 command and H.245 indication packages
H.248.13	03-2002	Gateway control protocol: Quality Alert Ceasing package
H.248.14	03-2002	Gateway control protocol: Inactivity timer package
H.248.15	03-2002	Gateway control protocol: SDP H.248 package attribute
H.248.16	11-2002	Gateway control protocol: Enhanced digit collection packages and procedures
H.248.16 (2002) Corrigendum 1	03-2004	

H.248.17	11-2002	Gateway control protocol: Line test packages	
H.248.17 (2002) Corrigendum 1	03-2004		
H.248.18	11-2002	Gateway control protocol: Package for support of multiple profiles	
H.248.19	03-2004	Gateway control protocol: Decomposed multipoint control unit, audio, video and data conferencing packages	
H.248.19 (2004) Amendment 1	05-2006	New Text Overlay package and Border and Background package	
H.248.20	11-2002	Gateway control protocol: The use of local and remote descriptors with H.221 and H.223 multiplexing	
H.248.21	03-2004	Gateway control protocol: Semi-permanent connection handling package	
H.248.22	07-2003	Gateway control protocol: Shared Risk Group package	
H.248.22 (2003) Erratum 1	01-2004		
H.248.23	01-2005	Gateway control protocol: Enhanced Alerting packages	
H.248.23 (2005) Corrigendum 1	05-2006	Clarifications regarding dwa signal in the andisp package	
H.248.24	07-2003	Gateway control protocol: Multi-frequency tone generation and detection packages	
H.248.25	01-2007	Gateway control protocol: Basic CAS packages	
H.248.26	01-2005	Gateway control protocol: Enhanced analogue lines packages	
H.248.27	07-2003	Gateway control protocol: Supplemental tones packages	
H.248.28	01-2007	Gateway control protocol: International CAS packages	
H.248.29	01-2005	Gateway control protocol: International CAS compelled register signalling packages	
H.248.30	01-2007	Gateway control protocol: RTCP extended performance metrics packages	Available only in MS Word.
H.248.31	04-2004	Gateway control protocol: Adaptive jitter buffer package	
H.248.32	01-2005	Gateway control protocol: Detailed congestion reporting package	
H.248.33	01-2005	Gateway control protocol: PCM frame spare bit package	
H.248.34	01-2005	Gateway control protocol: Stimulus analogue line package	
H.248.35	01-2005	Gateway control protocol: Coin-operated phone control package	
H.248.36	09-2005	Gateway control protocol: Hanging Termination Detection package	
H.248.37	09-2005	Gateway control protocol: IP NAPT traversal package	
H.248.38	05-2006	Gateway control protocol: Base context package	
H.248.39	05-2006	Gateway control protocol: H.248 SDP parameter identification and wildcarding	
H.248.40	01-2007	Gateway control protocol: Application data inactivity detection package	
H.248.41	05-2006	Gateway control protocol: IP domain connection package	
H.248.42	05-2006	Gateway control protocol: DCME interworking package	
H.248.42 (2006) Erratum 1	10-2006		

H.248.44	01-2007	Gateway control protocol: Multi-level precedence and pre-emption package	
H.248.45	05-2006	Gateway control protocol: MGC information package	
H.248.46	01-2007	Gateway control protocol: Connection capability control package	
H.248.47	01-2007	Gateway control protocol: Statistic conditional reporting package	
H.249	05-2006	Extended user input indications	
H.261	03-1993	Video codec for audiovisual services at p x 64 kbit/s	
H.262	02-2000	Information technology – Generic coding of moving pictures and associated audio information: Video	
H.262 (2000) Technical Cor. 1	11-2000		
H.262 (2000) Amendment 1	11-2000	Content description data	
H.262 (2000) Amendment 1 Erratum 1	04-2002		
H.262 (2000) Technical Cor. 2	05-2006		
H.262 (2000) Amendment 2	01-2007	Support for colour spaces	
H.263	01-2005	Video coding for low bit rate communication	
H.263 Appendix III	06-2001	Examples for H.263 encoder/decoder implementations	
H.264	03-2005	Advanced video coding for generic audiovisual services	
H.264 (2005) Cor.1	09-2005		Not available, contact sales@itu.int.
H.264 (2005) Amendment 1	06-2006	Support of additional colour spaces and removal of the High 4:4:4 Profile	
H.264 (2005) Amendment 2	04-2007	New profiles for professional applications	Pre-published.
H.264.1	03-2005	Conformance specification for H.264 advanced video coding	
H.264.1 (2005) Corrigendum 1	09-2005		Pre-published.
H.264.2	03-2005	Reference software for H.264 advanced video coding	Available only in MS Word.
H.264.2 (2005) Cor.1	10-2005		Not available, contact sales@itu.int.
H.271	05-2006	Video back-channel messages for conveyance of status information and requests from a video receiver to a video sender	
H.272	01-2007	Procedures and values for video gamma compensation in multimedia systems	

H.281	11-1994	A far end camera control protocol for videoconferences using H.224	
H.282	05-1999	Remote device control protocol for multimedia applications	
H.283	05-1999	Remote device control logical channel transport	
H.310	09-1998	Broadband audiovisual communication systems and terminals	
H.310 (1998) Corrigendum 1	01-2005		
H.320	03-2004	Narrow-band visual telephone systems and terminal equipment	
H.321	02-1998	Adaptation of H.320 visual telephone terminals to B-ISDN environments	
H.321 (1998) Corrigendum 1	01-2005		
H.322	03-1996	Visual telephone systems and terminal equipment for local area networks which provide a guaranteed quality of service	
H.323	06-2006	Packet-based multimedia communications systems	
H.324	09-2005	Terminal for low bit-rate multimedia communication	
H.324 (2005) Corrigendum 1	05-2006	Clarification in Annex A: Protocol stack for control channel	
H.324 (2005) Amendment 1	08-2006	New Annex K "Media oriented negotiation acceleration procedure" and associated changes to Annex J	
H.324 (2005) Cor.2	01-2007	Corrections to Annex K "Media Oriented Negotiation Acceleration Procedure"	Not available, contact sales@itu.int.
H.331	03-1993	Broadcasting type audiovisual multipoint systems and terminal equipment	
H.332	09-1998	H.323 extended for loosely coupled conferences	
H.341	05-1999	Multimedia management information base	Available only in MS Word.
H.350	08-2003	Directory services architecture for multimedia conferencing	Available only in MS Word.
H.350.1	08-2003	Directory services architecture for H.323	Available only in MS Word.
H.350.2	08-2003	Directory services architecture for H.235	Available only in MS Word.
H.350.3	08-2003	Directory services architecture for H.320	Available only in MS Word.
H.350.4	08-2003	Directory services architecture for SIP	
H.350.5	08-2003	Directory services architecture for non-standard protocols	Available only in MS Word.
H.350.6	03-2004	Directory services architecture for call forwarding and preferences	
H.350.7	01-2007	Directory services architecture for XMPP	
H.360	03-2004	An architecture for end-to-end QoS control and signalling	

H.361	05-2006	End-to-end quality of service (QoS) and service priority signalling in H.323 systems
H.450.1	02-1998	Generic functional protocol for the support of supplementary services in H.323
H.450.2	02-1998	Call transfer supplementary service for H.323
H.450.3	02-1998	Call diversion supplementary service for H.323
H.450.4	05-1999	Call hold supplementary service for H.323
H.450.5	05-1999	Call park and call pickup supplementary services for H.323
H.450.5 Erratum 1	05-2000	
H.450.5 Erratum 2	04-2002	
H.450.6	05-1999	Call waiting supplementary service for H.323
H.450.7	05-1999	Message waiting indication supplementary service for H.323
H.450.8	02-2000	Name identification supplementary service for H.323
H.450.9	11-2000	Call completion supplementary services for H.323
H.450.10	03-2001	Call offering supplementary services for H.323
H.450.11	03-2001	Call intrusion supplementary service for H.323
H.450.12	07-2001	Common Information Addtional Network Feature for H.323
H.460.1	03-2002	Guidelines for the use of the generic extensible framework
H.460.2	07-2001	Number Portability interworking between H.323 and SCN networks
H.460.3	11-2002	Circuit maps within H.323 systems
H.460.4	01-2007	Call priority designation and country/international network of call origination identification for H.323 priority calls
H.460.5	11-2002	H.225.0 transport of multiple Q.931 information elements of the same type
H.460.6	11-2002	Extended Fast Connect feature
H.460.7	11-2002	Digit maps within H.323 systems
H.460.8	11-2002	Querying for alternate routes within H.323 systems
H.460.9	11-2002	Support for online QoS-monitoring reporting within H.323 systems
H.460.9 (2002) Amendment 1	03-2004	New Annex B – Extended performance metrics
H.460.10	03-2004	Call party category within H.323 systems
H.460.11	03-2004	Delayed call establishment within H.323 systems
H.460.12	03-2004	Glare control indicator within H.323 systems
H.460.13	03-2004	Called user release control within H.323 systems
H.460.14	03-2004	Support for Multi-Level Precedence and Preemption (MLPP) within H.323 systems
H.460.15	03-2004	Call signalling transport channel suspension and redirection within H.323 systems

H.460.16	01-2005	Multiple-message release sequence capability within H.323 systems	
H.460.17	09-2005	Using H.225.0 call signalling connection as transport for H.323 RAS messages	
H.460.18	09-2005	Traversal of H.323 signalling across network address translators and firewalls	
H.460.19	09-2005	Traversal of H.323 media across network address translators and firewalls	
H.460.20	09-2005	Location number within H.323 systems	
H.460.21	05-2006	Message broadcast for H.323 systems	
H.460.22	01-2007	Negotiation of security protocols to protect H.225.0 call signalling messages	Pre-published.
H.501	03-2002	Protocol for mobility management and intra/inter-domain communication in multimedia systems	
H.510	03-2002	Mobility for H.323 multimedia systems and services	
H.530	03-2002	Symmetric security procedures for H.323 mobility in H.510	
H.530 Corrigendum 1	07-2003		
H.610	07-2003	Full service VDSL – System architecture and customer premises equipment	
H.611	07-2003	Full-Service VDSL – Operations, Administration Maintenance & Provision aspects	
H.Sup1	05-1999	Application profile – Sign language and lip-reading real-time conversation using low bit rate video communication	
H.Sup3	05-2003	Operator requirements for full-service VDSL in ITU-T Recommendations H.610 and H.611	
H.Sup6	04-2006	Control load quantum for decomposed gateways	

Recommendation count: 268

Series I : Data communication over the telephone network

Number	*Approval Date*	*Recommendation Title*	*Status*
I.110	11-1988	Preamble and general structure of the I-Series Recommendations for the integrated services digital network (ISDN)	
I.111	11-1988	Relationship with other Recommendations relevant to ISDNs	
I.112	03-1993	Vocabulary of terms for ISDNs	
I.112 Appendix I	02-2002	General telecommunication terminology and definitions	
I.113	06-1997	Vocabulary of terms for broadband aspects of ISDN	
I.114	03-1993	Vocabulary of terms for universal personal telecommunication	
I.120	03-1993	Integrated services digital networks (ISDNs)	
I.121	04-1991	Broadband aspects of ISDN	
I.122	03-1993	Framework for frame mode bearer services	
I.130	11-1988	Method for the characterization of telecommunication services supported by an ISDN and network capabilities of an ISDN	
I.140	03-1993	Attribute technique for the characterization of telecommunication services supported by an ISDN and network capabilities of an ISDN	
I.141	11-1988	ISDN network charging capabilities attributes	
I.150	02-1999	B-ISDN asynchronous transfer mode functional characteristics	
I.200	11-1988	Guidance to the I.200-series of Recommendations	
I.210	03-1993	Principles of telecommunication services supported by an ISDN and the means to describe them	
I.211	03-1993	B-ISDN service aspects	
I.220	11-1988	Common dynamic description of basic telecommunication services	
I.221	03-1993	Common specific characteristics of services	
I.230	11-1988	Definition of bearer service categories	

I.231.1	11-1988	Circuit-mode 64 kbit/s unrestricted, 8 kHz structured bearer service	
I.231.2	11-1988	Circuit-mode 64 kbit/s, 8 kHz structured bearer service usable for speech information transfer	
I.231.3	11-1988	Circuit-mode 64 kbit/s, 8 kHz structured bearer service usable for 3.1 kHz audio information transfer	
I.231.4	11-1988	Circuit-mode, alternate speech / 64 kbit/s unrestricted, 8 kHz structured bearer service	
I.231.5	11-1988	Circuit-mode 2 x 64 kbit/s unrestricted, 8 kHz structured bearer service	
I.231.6	07-1996	Circuit-mode 384 kbit/s unrestricted, 8 kHz structured bearer service	
I.231.7	07-1996	Circuit-mode 1536 kbit/s unrestricted, 8 kHz structured bearer service	
I.231.8	07-1996	Circuit-mode 1920 kbit/s unrestricted, 8 kHz structured bearer service	
I.231.9	03-1993	Circuit-mode 64 kbit/s 8 kHz structured multi-use bearer service	
I.231.10	08-1992	Circuit-mode multiple-rate unrestricted 8 kHz structured bearer service	
I.232.1	11-1988	Virtual call and permanent virtual circuit bearer service category	
I.232.2	11-1988	Connectionless bearer service category	Not available, contact sales@itu.int.
I.232.3	03-1993	User signalling bearer service category (USBS)	
I.233.1	10-1991	ISDN frame relaying bearer service	
I.233.1 Annex F	07-1996	Frame relay multicast	
I.233.2	10-1991	ISDN frame switching bearer service	
I.240	11-1988	Definition of teleservices	
I.241.1	11-1988	Telephony	
I.241.2	11-1988	Teletex	
I.241.3	11-1988	Telefax 4	
I.241.4	11-1988	Mixed mode	
I.241.5	11-1988	Videotex	
I.241.6	11-1988	Telex	
I.241.7	03-1993	Telephony 7 kHz teleservice	
I.241.8	10-1995	Teleaction stage one service description	
I.250	11-1988	Definition of supplementary services	

I.251.1	08-1992	Direct-dialling-In	Available only in PDF.
I.251.2	08-1992	Multiple Subscriber Number	
I.251.3	08-1992	Calling Line Identification Presentation	
I.251.4	08-1992	Calling Line Identification Restriction	
I.251.5	02-1995	Connected Line Identification Presentation (COLP)	
I.251.6	02-1995	Connected Line Identification Restriction (COLR)	
I.251.7	08-1992	Malicious call Identification	
I.251.8	08-1992	Sub-addressing supplementary service	
I.251.9	07-1996	Calling name identification presentation	
I.251.10	07-1996	Calling name identification restriction	
I.252.1	11-1988	Call Transfer	
I.252.2	08-1992	Call Forwarding Busy	
I.252.3	08-1992	Call Forwarding No Reply	
I.252.4	08-1992	Call Forwarding Unconditional	
I.252.5	08-1992	Call Deflection	
I.252.6	11-1988	Line Hunting (LH)	
I.252.7	05-1997	Explicit call transfer	
I.253.1	07-1990	Call waiting (CW) supplementary service	Not available, contact sales@itu.int.
I.253.2	08-1992	Call Hold	
I.253.3	07-1996	Completion of calls to busy subscribers	
I.253.4	07-1996	Completion of calls on no reply	
I.254.1	11-1988	Conference calling (CONF)	
I.254.2	08-1992	Three-Party Supplementary Service	
I.254.5	05-1997	Meet-me conference	
I.255.1	08-1992	Closed User Group	
I.255.2	07-1996	Support of Private Numbering Plans	
I.255.3	07-1990	Multi-level precedence and preemption service (MLPP)	
I.255.4	07-1990	Priority service	
I.255.5	08-1992	Outgoing call barring	

I.256.1	11-1988	Credit card calling (CRED)	Not available, contact sales@itu.int.
I.256.2a	03-1993	Advice of charge: charging information at call set-up time (AOC-S)	
I.256.2b	03-1993	Advice of charge: charging information during the call (AOC-D)	
I.256.2c	03-1993	Advice of charge: charging information at the end of the call (AOC-E)	
I.256.3	08-1992	Reverse charging	
I.257.1	10-1995	User-to-User Signalling (UUS)	
I.258.1	10-1995	Terminal portability (TP)	
I.258.2	02-1995	In-call modification (IM)	
I.259.1	07-1996	Address screening (ADS)	
I.310	03-1993	ISDN – Network functional principles	
I.311	08-1996	B-ISDN general network aspects	
I.311 (1996) Amendment 1	03-2000		
I.312/Q.1201	10-1992	Principles of intelligent network architecture	
I.313	09-1997	B-ISDN network requirements	
I.320	11-1993	ISDN protocol reference model	
I.321	04-1991	B-ISDN protocol reference model and its application	
I.322	02-1999	Generic protocol reference model for telecommunication networks	
I.324	10-1991	ISDN network architecture	
I.325	03-1993	Reference configurations for ISDN connection types	
I.326	11-1988	Reference configuration for relative network resource requirements	
I.326	03-2003	Functional architecture of transport networks based on ATM	
I.327	03-1993	B-ISDN functional architecture	
I.328/Q.1202	09-1997	Intelligent network – Service plane architecture	
I.329/Q.1203	09-1997	Intelligent network – Global functional plane architecture	
I.330	11-1988	ISDN numbering and addressing principles	
E.164	02-2005	The international public telecommunication numbering plan	

E.164 Supplement 1	03-1998	Alternatives for carrier selection and network identification
E.164 Supplement 2	11-1998	Number Portability
E.164 Supplement 3	05-2004	Operational and administrative issues associated with national implementations of the ENUM functions
E.164 Supplement 4	05-2004	Operational and administrative issues associated with the implementation of ENUM for non-geographic country codes
I.333	03-1993	Terminal selection in ISDN
I.334	11-1988	Principles relating ISDN numbers/sub-addresses to the OSI reference model network layer addresses
I.340	11-1988	ISDN connection types
I.350	03-1993	General aspects of quality of service and network performance in digital networks, including ISDNs
G.820/I.351/Y.1501	07-2004	Relationships among ISDN, IP-based network and physical layer performance Recommendations
I.352	03-1993	Network performance objectives for connection processing delays in an ISDN
I.353	08-1996	Reference events for defining ISDN and B-ISDN performance parameters
I.354	03-1993	Network performance objectives for packet-mode communication in an ISDN
I.355	10-2000	ISDN 64 kbit/s connection type availability performance
I.356	03-2000	B-ISDN ATM layer cell transfer performance
I.356 (2000) Amendment 1	02-2004	New Appendix V – Support of Y.1541 QoS classes 0 and 2 in ATM-based networks
I.357	11-2000	B-ISDN semi-permanent connection availability
I.358	09-2003	Call processing performance for switched virtual channel connections (VCCs) in a B-ISDN
I.359	02-1999	Accuracy and dependability of ISDN 64 kbit/s circuit-mode connection types
I.361	02-1999	B-ISDN ATM layer specification
I.362	03-1993	B-ISDN ATM adaptation layer (AAL) functional description
I.363.1	08-1996	Type 1 AAL
I.363.2	11-2000	Type 2 AAL
I.363.3	08-1996	Type 3/4 AAL
I.363.5	08-1996	Type 5 AAL
I.364	02-1999	Support of the broadband connectionless data bearer service by the B-ISDN

I.365.1	11-1993	Frame relaying service specific convergence sublayer (FR-SSCS)
I.365.2	11-1995	Service-specific coordination function to provide the connection-oriented network service
I.365.3	11-1995	Service-specific coordination function to provide the connection-oriented transport service
I.365.4	08-1996	Service-specific convergence sublayer for HDLC applications
I.366.1	06-1998	Segmentation and Reassembly Service Specific Convergence Sublayer for the AAL type 2
I.366.2	11-2000	AAL type 2 service specific convergence sublayer for narrow-band services
I.366.2 (2000) Corrigendum 1	03-2002	
I.370	10-1991	Congestion management for the ISDN frame relaying bearer service
I.371.1	11-2000	Guaranteed frame rate ATM transfer capability
I.371.1	06-1997	Traffic control and congestion control in B-ISDN: Conformance definitions for ABT and ABR
I.371	03-2004	Traffic control and congestion control in B-ISDN
I.372	03-1993	Frame relaying bearer service network-to-network interface requirements
I.373	03-1993	Network capabilities to support universal personal telecommunication (UPT)
I.374	03-1993	Framework Recommendation on "network capabilities to support multimedia services"
I.375.1	06-1998	General aspects
I.375.2	06-1998	Example of multimedia retrieval service class – Video-on-demand service using an ATM-based network
I.375.3	03-2000	Example of multimedia distribution service class – Switched digital broadcasting
I.376	03-1995	ISDN network capabilities for the support of the teleaction service
I.377	10-2000	Network requirements to support charging and accounting in B-ISDN
I.378	12-2002	Traffic control and congestion control at the ATM Adaptation Layer type 2
I.378 (2002) Amendment 1	08-2003	New Appendix IV: Deriving AAL 2 traffic parameters from AAL 2 link characteristics
I.381	03-2001	ATM adaptation layer (AAL) Performance
I.410	11-1988	General aspects and principles relating to Recommendations on ISDN user-network interfaces
I.411	03-1993	ISDN user-network interfaces – Reference configurations
I.412	11-1988	ISDN user-network interfaces – Interface structures and access capabilities
I.413	03-1993	B-ISDN user-network interface

I.414	09-1997	Overview of Recommendations on layer 1 for ISDN and B-ISDN customer accesses
I.420	11-1988	Basic user-network interface
I.421	11-1988	Primary rate user-network interface
I.430	11-1995	Basic user-network interface – Layer 1 specification
I.431	03-1993	Primary rate user-network interface – Layer 1 specification
I.431 (1993) Amendment 1	06-1997	
I.432	03-1993	B-ISDN user-network interface – Physical layer specification
I.432.1	02-1999	General characteristics
I.432.2	02-1999	155 520 kbit/s and 622 080 kbit/s operation
I.432.3	02-1999	1544 kbit/s and 2048 kbit/s operation
I.432.4	02-1999	51 840 kbit/s operation
I.432.5	06-1997	25 600 kbit/s operation
Q.920	03-1993	ISDN user-network interface data link layer – General aspects
Q.920 (1993) Amendment 1	06-2000	
Q.921	09-1997	ISDN user-network interface – Data link layer specification
Q.921 (1997) Amendment 1	06-2000	
Q.930	03-1993	ISDN user-network interface layer 3 – General aspects
Q.931	05-1998	ISDN user-network interface layer 3 specification for basic call control
Q.931 (1998) Amendment 1	12-2002	Extensions for the support of digital multiplexing equipment
Q.931 (1998) Erratum 1	02-2003	
I.460	02-1999	Multiplexing, rate adaption and support of existing interfaces
X.30	03-1993	Support of X.21, X.21 bis and X.20 bis based Data Terminal Equipments (DTEs) by an Integrated Services Digital Network (ISDN)
X.31	11-1995	Support of packet mode terminal equipment by an ISDN
V.110	02-2000	Support by an ISDN of data terminal equipments with V-series type interfaces
I.464	02-1999	Multiplexing, rate adaption and support of existing interfaces for restricted 64 kbit/s transfer capability
V.120	10-1996	Support by an ISDN of data terminal equipment with V-series type interfaces with provision for statistical multiplexing
V.120 (1996) Corrigendum 1	05-1999	

I.470	11-1988	Relationship of terminal functions to ISDN
I.480	03-2000	1+1 protection switching for cell-based physical layer
I.500	03-1993	General structure of the ISDN interworking Recommendations
I.501	03-1993	Service interworking
I.510	03-1993	Definitions and general principles for ISDN interworking
I.511	11-1988	ISDN-to-ISDN layer 1 internetwork interface
I.515	03-1993	Parameter exchange for ISDN interworking
I.520	03-1993	General arrangements for network interworking between ISDNs
I.525	08-1996	Interworking between networks operating at bit rates less than 64 kbit/s with 64 kbit/s-based ISDN and B-ISDN
I.530	03-1993	Network interworking between an ISDN and a public switched telephone network (PSTN)
X.321	10-1996	General arrangements for interworking between Circuit-Switched Public Data Networks (CSPDNs) and Integrated Services Digital Networks (ISDNs) for the provision of data transmission services
X.325	10-1996	General arrangements for interworking between Packet-Switched Public Data Networks (PSPDNs) and Integrated Services Digital Networks (ISDNs) for the provision of data transmission services
I.555	09-1997	Frame Relaying Bearer Service interworking
U.202	03-1993	Technical requirements to be met in providing the international telex service within an integrated services digital network
I.570	03-1993	Public/private ISDN interworking
I.571	08-1996	Connection of VSAT based private networks to the public ISDN
I.572	03-2000	VSAT interconnection with the PSTN
I.580	11-1995	General arrangements for interworking between B-ISDN and 64 kbit/s based ISDN
I.581	09-1997	General arrangements for B-ISDN interworking
I.601	11-1988	General maintenance principles of ISDN subscriber access and subscriber installation
I.610	02-1999	B-ISDN operation and maintenance principles and functions
I.610 (1999) Corrigendum 1	03-2000	
I.610 (1999) Amendment 1	03-2000	
I.610 (1999) Amendment 2	12-2006	Measurement of round trip delay using loopback cell
I.620	10-1996	Frame relay operation and maintenance principles and functions
I.630	02-1999	ATM protection switching
I.630 (1999) Corrigendum 1	03-2000	

I.630 (1999) Amendment 1	03-2000	
I.731	10-2000	Types and general characteristics of ATM equipment
I.732	10-2000	Functional characteristics of ATM equipment
I.741	07-1999	Interworking and interconnection between ATM and switched telephone networks for the transmission of speech, voiceband data and audio signals
I.751	03-1996	Asynchronous transfer mode management of the network element view
I.761	03-2000	Inverse multiplexing for ATM (IMA)
I.762	03-2000	ATM over fractional physical links
I.Sup1	03-1998	Generic service descriptions for ten supplementary services defined in I.250-Series Recommendations

Recommendation count: 459

Series J : Cable networks and transmission of television, sound programme and other multimedia signals

Number	*Approval Date*	*Recommendation Title*	*Status*
J.1	09-1999	Terms, definitions and acronyms applicable to the transmission of television and sound-programme signals and of related data signals	
J.2	09-1999	Guidelines on the use of some ITU-T Recommendations in the J series	
J.11	11-1988	Hypothetical reference circuits for sound-programme transmissions	
J.12	11-1988	Types of sound-programme circuits established over the international telephone network	
J.13	11-1988	Definitions for international sound-programme circuits	
J.14	11-1988	Relative levels and impedances on an international sound-programme connection	
J.15	11-1988	Lining-up and monitoring an international sound-programme connection	
J.16	11-1988	Measurement of weighted noise in sound-programme circuits	
J.17	11-1988	Pre-emphasis used on sound-programme circuits	
J.18	11-1988	Crosstalk in sound-programme circuits set up on carrier systems	
J.19	11-1988	A conventional test signal simulating sound-programme signals for measuring interference in other channels	
J.21	08-1994	Performance characteristics of 15 kHz-type sound-programme circuits – Circuits for high quality monophonic and stereophonic transmissions	
J.22	10-1984	Performance characteristics of 10 kHz type sound-programme circuits	
J.23	11-1988	Performance characteristics of 7 kHz type (narrow bandwidth) sound-programme circuits	
J.24	02-1982	Modulation of signals carried by sound-programme circuits by interfering signals from power supply sources	
J.25	05-1986	Estimation of transmission performance of sound-programme circuits shorter or longer than the hypothetical reference circuit	
J.26	06-1990	Test signals to be used on international sound-programme connections	
J.27	06-1990	Signals for the alignment of international sound-programme connections	
J.31	11-1988	Characteristics of equipment and lines used for setting up 15 kHz type sound-programme circuits	
J.32	10-1984	Characteristics of equipment and lines used for setting up 10 kHz type sound-programme circuits	
J.33	11-1988	Characteristics of equipment and lines used for setting up 6.4 kHz type sound-programme circuits	
J.34	11-1988	Characteristics of equipment used for setting up 7 kHz type sound-programme circuits	

J.41	11-1988	Characteristics of equipment for the coding of analogue high quality sound programme signals for transmission on 384 kbit/s channels	
J.42	11-1988	Characteristics of equipment for the coding of analogue medium quality sound-programme signals for transmission on 384-kbit/s channels	
J.43	11-1988	Characteristics of equipment for the coding of analogue high quality sound programme signals for transmission on 320 kbit/s channels	
J.44	11-1988	Characteristics of equipment for the coding of analogue medium quality sound-programme signals for transmission on 320 kbit/s channels	
J.51	08-1994	General principles and user requirements for the digital transmission of high quality sound programmes	
J.52	07-1996	Digital transmission of high-quality sound-programme signals using one, two or three 64 kbit/s channels per mono signal (and up to six per stereo signal)	
J.52 (1996) Amendment 1	09-1999	New Appendix II – Extracts from EBU specification of an ISDN Codec capable of delivering high-quality audio	
J.53	05-2000	Sampling frequencies to be used for the digital transmission of studio-quality and high-quality sound-programme signals	
J.54	05-1986	Transmission of analogue high-quality sound-programme signals on mixed analogue-and-digital circuits using 384 kbit/s channels	
J.55	06-1990	Digital transmission of high-quality sound-programme signals on distribution circuits using 480 kbit/s (496 kbit/s) per audio channel	
J.56	06-1990	Transmission of high-quality sound-programme analogue signals over mixed analogue/digital circuits at 320 kbit/s	
J.57	06-1990	Transmission of digital studio quality sound signals over H1 channels	
J.61	06-2007	Transmission performance of television circuits designed for use in international connections	Not available, contact sales@itu.int.
J.62	02-1978	Single value of the signal-to-noise ratio for all television systems	
J.63	06-1990	Insertion of test signals in the field-blanking interval of monochrome and colour television signals	
J.64	02-1986	Definitions of parameters for simplified automatic measurement of television insertion test signals	
J.65	02-1978	Standard test signal for conventional loading of a television channel	
J.66	02-1978	Transmission of one sound programme associated with analogue television signal by means of time division multiplex in the line synchronizing pulse	
J.67	03-2001	Test signals and measurement techniques for transmission circuits carrying MAC/packet signals	
J.68	02-1982	Hypothetical reference chain for television transmissions over very long distances	
J.73	11-1988	Use of a 12-MHz system for the simultaneous transmission of telephony and television	

J.74	11-1988	Methods for measuring the transmission characteristics of translating equipments
J.75	11-1988	Interconnection of systems for television transmission on coaxial pairs and on radio-relay links
J.77	11-1988	Characteristics of the television signals transmitted over 18 MHz and 60-MHz systems
J.80	09-1993	Transmission of component-coded digital television signals for contribution-quality applications at bit rates near 140 Mbit/s
J.81	09-1993	Transmission of component-coded digital television signals for contribution-quality applications at the third hierarchical level of ITU-T Recommendation G.702
J.81 (1993) Amendment 1	10-1995	Appendix II to Annex A to Recommendation J.81 – Guidelines for implementation of a complete television codec
J.81 (1993) Corrigendum 1	10-1996	
J.81 (1993) Amendment 2	03-1998	Appendix IV to Annex A – Results of 34 Mbit/s codec interworking tests (February 1996)
J.82	07-1996	Transport of MPEG-2 constant bit rate television signals in B-ISDN
J.83	04-1997	Digital multi-programme systems for television, sound and data services for cable distribution
J.83 (1997) Erratum 1	07-1998	
J.83 (1997) Amendment 1	11-2006	Amendment to Annex B
J.84	03-2001	Distribution of digital multi-programme signals for television, sound and data services through SMATV networks
J.85	06-1990	Digital television transmission over long distances – General principles
J.86	06-1990	Mixed analogue-and-digital transmission of analogue composite television signals over long distances
J.87	03-2001	Use of hybrid cable television links for the secondary distribution of television into the user's premises
J.88	09-1999	Transmission of enhanced definition television signals over digital links
J.89	09-1999	Transport Mechanism for component-coded digital television signals using MPEG-2 4:2:2 P@ML including all service elements for contribution and primary distribution
J.90	05-2000	Electronic programme guides for delivery by digital cable television and similar methods – Reference operating scenario and requirements
J.91	08-1994	Technical methods for ensuring privacy in long-distance international television transmission
J.92	04-1997	Recommended operating guidelines for point-to-point transmission of television programmes
J.93	03-1998	Requirements for conditional access in the secondary distribution of digital television on cable television systems
J.94	11-1998	Service information for digital broadcasting in cable television systems
J.94 (1998) Amendment 1	10-2000	Annex B – Service information delivered out of band for digital cable television systems
J.94 (1998) Amendment 2	03-2001	Revised Annex C – Service information for digital multi-programme System C

J.95	09-1999	Copy protection of intellectual property for content delivered on cable television systems	
J.96	07-2002	Technical method for ensuring privacy in long-distance international MPEG-2 television transmission conforming to ITU-T Recommendation J.89	
J.97	07-2002	Metadata on cable networks	
J.98	05-2003	Metadata requirements for video-on-demand in cable networks	
J.100	06-1990	Tolerances for transmission time differences between the vision and sound components of a television signal	
J.101	06-1990	Measurement methods and test procedures for teletext signals	
J.110	04-1997	Basic principles for a worldwide common family of systems for the provision of interactive television services	
J.111	03-1998	Network independent protocols for interactive systems	
J.112	03-1998	Transmission systems for interactive cable television services	
J.112 Annex A	03-2001	Digital Video Broadcasting: DVB interaction channel for Cable TV (CATV) distribution systems	
J.112 Annex B	03-2004	Data-over-cable service interface specifications: Radio-frequency interface specification	
J.112 Annex C	02-2002	Data-over-cable service interface specifications: Radio-frequency interface specification using QAM technique	
J.113	03-1998	Digital video broadcasting interaction channel through the PSTN/ISDN	
J.114	09-1999	Interaction channel using digital enhanced cordless telecommunications	
J.115	09-1999	Interaction channel using the global system for mobile communications	
J.116	05-2000	Interaction channel for local multipoint distribution systems	
J.117	09-1999	Home digital network interface specification	
J.118	05-2000	Access systems for interactive services on SMATV/MATV networks	
J.120	05-2000	Distribution of sound and television programs over the IP network	Available only in MS Word.
J.121	02-2002	Quality control protocol for webcasting	
J.122	12-2002	Second-generation transmission systems for interactive cable television services – IP cable modems	
J.123	07-2002	Multiplexing format for webcasting on the TCP/IP network	
J.124	03-2004	Multiplexing format for multimedia webcasting over TCP/IP networks	
J.125	04-2004	Link privacy for cable modem implementations	
J.126	04-2004	Embedded Cable Modem device specification	
J.127	06-2004	Transmission protocol for multimedia webcasting over TCP/IP networks	
J.128	11-2005	Set-top gateway specification for transmission systems for interactive cable television services	
J.131	03-1998	Transport of MPEG-2 signals in PDH networks	

J.132	03-1998	Transport of MPEG-2 signals in SDH networks	
J.133	07-2002	Measurement of MPEG-2 transport streams in networks	
J.140	03-1998	Subjective picture quality assessment for digital cable television systems	
J.141	09-1999	Performance indicators for data services delivered over digital cable television systems	
J.142	05-2000	Methods for the measurement of parameters in the transmission of digital cable television signals	
J.143	05-2000	User requirements for objective perceptual video quality measurements in digital cable television	
J.144	03-2004	Objective perceptual video quality measurement techniques for digital cable television in the presence of a full reference	Pre-published.
J.145	03-2001	Measurement and control of the quality of service for sound transmission over contribution and distribution networks	
J.146	07-2002	Loop latency issues in contribution circuits for conversational TV programmes	
J.147	07-2002	Objective picture quality measurement method by use of in-service test signals	
J.148	05-2003	Requirements for an objective perceptual multimedia quality model	
J.149	03-2004	Method for specifying accuracy and cross-calibration of Video Quality Metrics (VQM)	Pre-published.
J.150	03-1998	Operational functionalities for the delivery of digital multiprogramme television, sound and data services through multichannel, multipoint distribution systems (MMDS)	
J.150 (1998) Amendment 1	09-1999	Additions to Recommendation J.150 to also encompass local multipoint distribution systems (LMDS)	
J.150 (1998) Amendment 2	03-2001		
J.151	10-2000	RF remodulator interface for digital television	
J.160	11-2005	Architectural framework for the delivery of time-critical services over cable television networks using cable modems	
J.161	06-2007	Audio and video codec requirements for the provision of bidirectional audio service over cable television networks using cable modems	Pre-published.
J.162	11-2005	Network call signalling protocol for the delivery of time-critical services over cable television networks using cable modems	
J.163	11-2005	Dynamic quality of service for the provision of real-time services over cable television networks using cable modems	
J.164	11-2005	Event message requirements for the support of real-time services over cable television networks using cable modems	
J.165	05-2003	IPCablecom Internet signalling transport protocol (ISTP)	
J.166	11-2005	IPCablecom Management Information Base (MIB) framework	
J.167	11-2005	Media terminal adapter (MTA) device provisioning requirements for the delivery of real-time services over cable television networks using cable modems	
J.168	03-2001	IPCablecom Media Terminal Adapter (MTA) MIB requirements	

J.169	03-2001	IPCablecom network call signalling (NCS) MIB requirements	
J.170	11-2005	IPCablecom security specification	Pre-published.
J.171	02-2002	IPCablecom Trunking Gateway Control Protocol (TGCP)	
J.171.0	11-2005	IPCablecom trunking gateway control protocol (TGCP): Profiles overview	
J.171.1	11-2005	IPCablecom trunking gateway control protocol (TGCP): Profile 1	
J.171.2	11-2005	IPCablecom trunking gateway control protocol (TGCP): Profile 2	
J.172	11-2005	IPCablecom management event mechanism	
J.173	11-2005	IPCablecom embedded MTA primary line support	
J.174	02-2002	IPCablecom interdomain quality of service	
J.175	11-2005	Audio server protocol	
J.176	07-2002	IPCablecom management event mechanism MIB	
J.177	11-2005	IPCablecom CMS subscriber provisioning specification	
J.178	11-2005	IPCablecom CMS to CMS signalling	Pre-published.
J.179	11-2005	IPCablecom support for multimedia	
J.180	05-2000	User requirements for statistical multiplexing of several programmes on a transmission channel	
J.181	06-2004	Digital program insertion cueing message for cable television systems	
J.181 (2004) Erratum 1	05-2006	Appendix I	
J.182	03-2001	Parameter sets for analogue interface specifications for the interconnection of set-top boxes and presentation devices in the home	
J.183	03-2001	Time-division multiplexing of multiple MPEG-2 transport streams over cable television systems	
J.184	03-2001	Digital broadband delivery system: Out-of-band transport	
J.185	02-2002	Transmission equipment for transferring multi-channel television signals over optical access networks by FM conversion	
J.186	02-2002	Transmission equipment for multi-channel television signals over optical access networks by sub-carrier multiplexing (SCM)	
J.187	07-2002	Transport mechanism for component-coded digital high-definition television signals using MPEG-2 video coding including all service elements for contribution and primary distribution	
J.187 (2002) Corrigendum 1	04-2003		
J.188	07-2002	A framework for an efficient parallel video transmission system including codecs with functions of failure detection and picture quality evaluation	
J.189	07-2002	Seamless splicing for MPEG-2 bit streams	
J.189 (2002) Corrigendum 1	04-2003		
J.190	07-2002	Architecture of MediaHomeNet that supports cable-based services	
J.191	03-2004	IP feature package to enhance cable modems	

J.192	11-2005	A residential gateway to support the delivery of cable data services	
J.193	06-2004	Requirements for the next generation of set-top-boxes	
J.197	11-2005	High level requirements for a Digital Rights Management (DRM) bridge from a cable access network to a home network	
J.199	11-2006	Battery backup for cable-based devices	
J.200	03-2001	Worldwide common core – Application environment for digital interactive television services	
J.200 (2001) Corrigendum 1	05-2004		
J.201	07-2004	Harmonization of declarative content format for interactive television applications	
J.201 (2004) Amendment 1	03-2005	Additional media types	
J.202	11-2005	Harmonization of procedural content formats for interactive TV applications	
J.203	11-2006	Common core for digital video recorder platform	Pre-published.
J.210	11-2006	Downstream RF interface for cable modem termination systems	
J.211	11-2006	Timing interface for cable modem termination systems	Pre-published.
J.212	11-2006	Downstream external Physical layer interface for modular cable modem termination systems	
J.213	11-2006	Layer 2 virtual private networks for IP cable modem systems	
J.214	07-2007	Cable modem TDM emulation interface	Not available, contact sales@itu.int.
J.218	07-2007	Cable modem IPv4 and IPv6 eRouter specification	Not available, contact sales@itu.int.
J.222.1	07-2007	Physical layer specification for third-generation transmission systems for interactive cable television services - IP cable modems	Pre-published.
J.222.2	07-2007	MAC and Upper Layer protocols for third-generation transmission systems for interactive cable television services - IP cable modems	Pre-published.
J.240	06-2004	Framework for remote monitoring of transmitted picture signal-to-noise ratio using spread-spectrum and orthogonal transform	
J.241	04-2005	Quality of service ranking and measurement methods for digital video services delivered over broadband IP networks	
J.242	12-2006	A method to reconstruct the received video sequence seen at the receiver using transmission error information to monitor the perceptual video quality at the receiver in digital cable television and video telephony	Pre-published.
J.243	11-2006	Requirements for operational monitoring in television programme transmission chains	

J.260	01-2005	Requirements for preferential telecommunications over IPCablecom networks	
J.280	12-2005	Digital Program Insertion: Splicing application program interface	
J.281	03-2005	Requirements for multichannel video signal transmission over IP-based fibre network	
J.282	11-2006	Architecture of multi-channel video signal distribution over IP-based networks	
J.283	11-2006	IP network architecture with network layer route diversity providing resilient IP multicast video distribution	
J.290	11-2006	Next generation set-top box core architecture	
J.291	11-2006	Next generation set-top-box cable architecture	
J.292	11-2006	Next generation set-top box media-independent architecture	
J.360	11-2006	IPCablecom2 Architecture Framework	Pre-published.
J.360 (2006) Amend.1	06-2007	New appendix IV - Home subscriber service (HSS)	Not available, contact sales@itu.int.
J.361	11-2006	IPCablecom2 codec media	Pre-published.
J.361 (2006) Amend.1	07-2007		Not available, contact sales@itu.int.
J.362	11-2006	IPCablecom2 control point discovery	Pre-published.
J.363	11-2006	IPCablecom2 data collection to support accounting	
J.365	11-2006	IPCablecom2 application manager interface	
J.366.0	11-2006	IPCablecom2 IP Multimedia Subsystem (IMS): Delta Recommendations overview	
J.366.1	07-2007	Organization of subscriber data specification (3GPP TS 23.008)	Not available, contact sales@itu.int.
J.366.5	07-2007	IP multimedia (IM) subsystem Cx and Dx interfaces; signalling flows and message contents specification (3GPP TS 29.228)	Not available, contact sales@itu.int.
J.366.6	07-2007	Cx/Dx interfaces based on the Diameter protocol specification (3GPP TS-29.229)	Not available, contact sales@itu.int.
J.366.8	11-2006	IPCablecom2 IP Multimedia Subsystem (IMS): Network domain security specification	
J.366.9	11-2006	IPCablecom2 IP Multimedia Subsystem (IMS): Generic authentication architecture specification	

J.366.10	07-2007	Zh and Zn interfaces based on the Diameter protocol; stage 3 specification (29.109)	Not available, contact sales@itu.int.
J.600	06-2004	Transport of Large Screen Digital Imagery (LSDI) applications that employ MPEG-2 encoded HDTV signals	
J.601	07-2007	Transport of Large Screen Digital Imagery (LSDI) applications for its expanded hierarchy	Not available, contact sales@itu.int.
J.Sup1	11-1998	Example of linking options between annexes of ITU-T Recommendation J.112 and annexes of ITU-T Recommendation J.83	
J.Sup2	11-1998	Guidelines for the implementation of annex A of Recommendation J.112, "Transmission systems for interactive cable television services" – Example of digital video broadcasting (DVB) interaction channel for cable television distribution	
J.Sup3	11-1998	Guidelines for the implementation of Recommendation J.111 "Network independent protocols" – Example of digital video broadcasting (DVB) systems for interactive services	
J.Sup5	09-1999	Guidelines on the use of some ITU-T Recommendations in the J series	

Recommendation count: 310

Series K : Protection against interference

Number	*Approval Date*	*Recommendation Title*	*Status*
K.1	11-1988	Connection to earth of an audio-frequency telephone line in cable	
K.2	11-1988	Protection of repeater power-feeding systems against interference from neighbouring electricity lines	
K.3	11-1988	Interference caused by audio-frequency signals injected into a power distribution network	
K.4	11-1988	Disturbance to signalling	
K.5	11-1988	Joint use of poles for electricity distribution and for telecommunications	
K.6	11-1988	Precautions at crossings	
K.7	11-1988	Protection against acoustic shock	
K.8	11-1988	Separation in the soil between telecommunication cables and earthing system of power facilities	
K.9	11-1988	Protection of telecommunication staff and plant against a large earth potential due to a neighbouring electric traction line	
K.10	10-1996	Low frequency interference due to unbalance about earth of telecommunication equipment	
K.11	10-1993	Principles of protection against overvoltages and overcurrents	
K.12	02-2006	Characteristics of gas discharge tubes for the protection of telecommunications installations	
K.13	11-1988	Induced voltages in cables with plastic-insulated conductors	
K.14	11-1988	Provision of a metallic screen in plastic-sheathed cables	
K.15	11-1988	Protection of remote-feeding systems and line repeaters against lightning and interference from neighbouring electricity lines	
K.16	11-1988	Simplified calculation method for estimating the effect of magnetic induction from power lines on remote-fed repeaters in coaxial pair telecommunication systems	
K.17	11-1988	Tests on power-fed repeaters using solid-state devices in order to check the arrangements for protection from external interference	
K.18	11-1988	Calculation of voltage induced into telecommunication lines from radio station broadcasts and methods of reducing interference	
K.19	11-1988	Joint use of trenches and tunnels for telecommunication and power cables	
K.20	07-2003	Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents	
K.20 (2003) Erratum 1	01-2004	Correction to table 7/K.20	
K.20 Amendment 1	11-2004	New Appendix I – Floating transverse power induction and earth potential rise test for ports connected to external symmetric pair cables	
K.21	07-2003	Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents	
K.21 (2003) Erratum 1	01-2004	Correction to table 7/K.21	
K.22	05-1995	Overvoltage resistibility of equipment connected to an ISDN T/S bus	

K.23	11-1988	Types of induced noise and description of noise voltage parameters for ISDN basic user networks
K.24	11-1988	Method for measuring radio-frequency induced noise on telecommunications pairs
K.25	02-2000	Protection of optical fibre cables
K.26	11-1988	Protection of telecommunication lines against harmful effects from electric power and electrified railway lines
K.27	05-1996	Bonding configurations and earthing inside a telecommunication building
K.28	03-1993	Characteristics of semi-conductor arrester assemblies for the protection of telecommunications installations
K.29	01-1992	Coordinated protection schemes for telecommunication cables below ground
K.30	12-2004	Self-restoring overcurrent protectors
K.31	03-1993	Bonding configurations and earthing of telecommunication installations inside a subscriber's building
K.32	05-1995	Immunity requirements and test methods for electrostatic discharge to telecommunication equipment – Generic EMC Recommendation
K.33	10-1996	Limits for people safety related to coupling into telecommunications system from a.c. electric power and a.c. electrified railway installations in fault conditions
K.34	07-2003	Classification of electromagnetic environmental conditions for telecommunication equipment – Basic EMC Recommendation
K.35	05-1996	Bonding configurations and earthing at remote electronic sites
K.36	05-1996	Selection of protective devices
K.37	02-1999	Low and high frequency EMC mitigation techniques for telecommunication installations and systems – Basic EMC Recommendation
K.38	10-1996	Radiated emission test procedure for physically large systems
K.39	10-1996	Risk assessment of damages to telecommunication sites due to lightning discharges
K.40	10-1996	Protection against LEMP in telecommunications centres
K.41	05-1998	Resistibility of internal interfaces of telecommunication centres to surge overvoltages
K.42	05-1998	Preparation of emission and immunity requirements for telecommunication equipment – General principles
K.43	07-2003	Immunity requirements for telecommunication equipment
K.43 (2003) Amendment 1	11-2004	
K.44	07-2003	Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation
K.45	07-2003	Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents
K.46	07-2003	Protection of telecommunication lines using metallic symmetric conductors against lightning-induced surges
K.47	12-2000	Protection of telecommunication lines using metallic conductors against direct lightning discharges
K.48	09-2006	EMC requirements for telecommunication equipment – Product family Recommendation

K.49	12-2005	Test requirements and performance criteria for voice terminal telephones subject to disturbance from digital mobile telecommunications systems	
K.50	02-2000	Safe limits of operating voltages and currents for telecommunication systems powered over the network	
K.51	02-2000	Safety criteria for telecommunication equipment	
K.52	12-2004	Guidance on complying with limits for human exposure to electromagnetic fields	
K.53	02-2000	Values of induced voltages on telecommunication installations to establish telecom and a.c. power and railway operators responsibilities	
K.54	12-2004	Conducted immunity test method and level at fundamental power frequencies	
K.55	08-2002	Overvoltage and overcurrent requirements for insulation displacement connectors (IDC) terminations	
K.56	07-2003	Protection of radio base stations against lightning discharges	
K.57	09-2003	Protection measures for radio base stations sited on power line towers	
K.58	07-2003	EMC, resistibility and safety requirements and procedures for co-located telecommunication installations	
K.59	07-2003	EMC, resistibility and safety requirements and procedures for connection to unbundled cables	
K.60	07-2003	Emission limits and test methods for telecommunication networks	
K.61	09-2003	Guidance to measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations	
K.62	02-2004	System level radiated emissions compliance using mathematical modelling	
K.63	02-2004	Maintaining the suitability of production telecommunications equipment to its intended electromagnetic environment	
K.64	02-2004	Safe working practices for outside equipment installed in particular environments	
K.65	12-2004	Overvoltage and overcurrent requirements for termination modules with contacts for test ports or SPDs	
K.66	12-2004	Protection of customer premises from overvoltages	
K.67	02-2006	Expected surges on telecommunications and signalling networks due to lightning	
K.68	02-2006	Management of electromagnetic interference on telecommunication systems due to power systems	
K.69	10-2006	Maintenance of protective measures	Pre-published.
K.71	07-2007	Protection of customer antenna installations	Pre-published.

Recommendation count: 106

Series L : Construction, installation and protection of cables and other elements of outside plant

Number	*Approval Date*	*Recommendation Title*	*Status*
L.1	11-1988	Construction, installation and protection of telecommunication cables in public networks	
L.2	11-1988	Impregnation of wooden poles	
L.3	11-1988	Armouring of cables	
L.4	11-1988	Aluminium cable sheaths	
L.5	11-1988	Cable sheaths made of metals other than lead or aluminium	
L.6	11-1988	Methods of keeping cables under gas pressure	
L.7	11-1988	Application of joint cathodic protection	
L.8	11-1988	Corrosion caused by alternating current	
L.9	11-1988	Methods of terminating metallic cable conductors	
L.10	12-2002	Optical fibre cables for duct and tunnel application	
L.11	11-1988	Joint use of tunnels by pipelines and telecommunication cables, and the standardization of underground duct plans	
L.12	05-2000	Optical fibre joints	
L.13	04-2003	Performance requirements for passive optical nodes: Sealed closures for outdoor environments	
L.14	07-1992	Measurement method to determine the tensile performance of optical fibre cables under load	
L.15	03-1993	Optical local distribution networks – Factors to be considered for their construction	
L.16	03-1993	Conductive plastic material (CPM) as protective covering for metal cable sheaths	
L.17	06-1995	Implementation of connecting customers into the public switched telephone network (PSTN) via optical fibres	
L.17 Appendix I	02-1997	Examples of possible applications	
L.18	10-1996	Sheath closures for terrestrial copper telecommunication cables	
L.19	11-2003	Multi-pair copper network cable supporting shared multiple services such as POTS, ISDN and xDSL	
L.20	10-1996	Creation of a fire security code for telecommunication facilities	
L.21	10-1996	Fire detection and alarm systems, detector and sounder devices	
L.22	10-1996	Fire protection	
L.23	10-1996	Fire extinction – Classification and location of fire extinguishing installations and equipment on premises	
L.24	10-1996	Classification of outside plant waste	
L.25	10-1996	Optical fibre cable network maintenance	
L.26	12-2002	Optical fibre cables for aerial application	
L.27	10-1996	Method for estimating the concentration of hydrogen in optical fibre cables	

L.28	10-2002	External additional protection for marinized terrestrial cables
L.29	01-2002	As-laid report and maintenance/repair log for marinized terrestrial cable installation
L.30	10-1996	Markers on marinized terrestrial cables
L.31	10-1996	Optical fibre attenuators
L.32	10-1998	Protection devices for through-cable penetrations of fire-sector partitions
L.33	10-1998	Periodic control of fire extinction devices in telecommunication buildings
L.34	10-1998	Installation of Optical Fibre Ground Wire (OPGW) cable
L.35	10-1998	Installation of optical fibre cables in the access network
L.36	10-1998	Single mode fibre optic connectors
L.37	02-2007	Optical branching components (non-wavelength selective)
L.38	09-1999	Use of trenchless techniques for the construction of underground infrastructures for telecommunication cable installation
L.39	05-2000	Investigation of the soil before using trenchless techniques
L.40	10-2000	Optical fibre outside plant maintenance support, monitoring and testing system
L.41	05-2000	Maintenance wavelength on fibres carrying signals
L.42	05-2003	Extending optical fibre solutions into the access network
L.43	12-2002	Optical fibre cables for buried application
L.44	10-2000	Electric power supply for equipment installed as outside plant
L.45	10-2000	Minimizing the effect on the environment from the outside plant in telecommunication networks
L.46	10-2000	Protection of telecommunication cables and plant from biological attack
L.47	10-2000	Access facilities using hybrid fibre/copper networks
L.48	03-2003	Mini-trench installation technique
L.49	03-2003	Micro-trench installation technique
L.50	11-2003	Requirements for passive optical nodes: Optical distribution frames for central office environments
L.51	04-2003	Passive node elements for fibre optic networks – General principles and definitions for characterization and performance evaluation
L.52	05-2003	Deployment of Passive Optical Networks (PON)
L.53	05-2003	Optical fibre maintenance criteria for access networks
L.54	02-2004	Splice closure for marinized terrestrial cables (MTC)
L.55	11-2003	Digital database for marine cables and pipelines
L.56	05-2003	Installation of optical fibre cables along railways
L.57	05-2003	Air-assisted installation of optical fibre cables
L.58	03-2004	Optical fibre cables: Special needs for access network
L.59	09-2004	Optical fibre cables for indoor applications
L.60	09-2004	Construction of optical/metallic hybrid cables

L.61	07-2004	Optical fibre cable installation by floating technique	
L.62	09-2004	Practical aspects of unbundling services by multiple operators in copper access networks	
L.63	10-2004	Safety procedures for outdoor installations	Pre-published.
L.64	02-2007	ID tag requirements for infrastructure and network elements management	Pre-published.
L.65	12-2006	Optical fibre distribution of access networks	Pre-published.
L.66	05-2007	Optical fibre cable maintenance criteria for in-service fibre testing in access networks	Pre-published.
L.67	10-2006	Small count optical fibre cables for indoor applications	Pre-published.
L.69	06-2007	Personal digital assistant requirements and relevant data structure for infrastructure and network elements management	Not available, contact sales@itu.int.

Recommendation count: 108

Series M : Telecommunication management, including TMN and network maintenance

Number	*Approval Date*	*Recommendation Title*	*Status*
M.10	10-1992	Scope and application of Recommendations for maintenance of telecommunication networks and services	
M.15	11-1988	Maintenance considerations for new systems	
M.20	10-1992	Maintenance philosophy for telecommunication networks	
M.21	10-1992	Maintenance philosophy for telecommunication services	
M.32	11-1988	Principles for using alarm information for maintenance of international transmission systems and equipment	
M.34	11-1988	Performance monitoring on international transmission systems and equipment	
M.35	11-1988	Principles concerning line-up and maintenance limits	
M.50	11-1988	Use of telecommunication terms for maintenance	Not available, contact sales@itu.int.
M.60	03-1993	Maintenance terminology and definitions	
M.70	11-1988	Guiding principles on the general maintenance organization for telephone-type international circuits	
M.75	10-1992	Technical service	
M.80	11-1988	Control stations	
M.85	10-1992	Fault report points	
M.90	11-1988	Sub-control stations	
M.100	11-1988	Service circuits	
M.110	11-1988	Circuit testing	
M.120	11-1988	Access points for maintenance	
M.125	11-1988	Digital loopback mechanisms	
M.160	11-1988	Stability of transmission	
M.320	11-1988	Numbering of the channels in a group	
M.330	11-1988	Numbering of groups within a supergroup	
M.340	11-1988	Numbering of supergroups within a mastergroup	
M.350	11-1988	Numbering of mastergroups within a supermastergroup	
M.380	11-1988	Numbering in coaxial systems	
M.390	11-1988	Numbering in systems on symmetric pair cable	
M.400	11-1988	Numbering in radio-relay links or open-wire line systems	
M.410	11-1988	Numbering of digital blocks in transmission systems	

M.450	11-1988	Bringing a new international transmission system into service
M.460	11-1988	Bringing international group, supergroup, etc., links into service
M.470	11-1988	Setting up and lining up analogue channels for international telecommunication services
M.475	11-1988	Setting up and lining up mixed analogue/digital channels for international telecommunication services
M.495	11-1988	Transmission restoration and transmission route diversity: Terminology and general principles
M.496	11-1988	Functional organization for automatic transmission restoration
M.500	11-1988	Routine maintenance measurements to be made on regulated line sections
M.510	11-1988	Readjustment to the nominal value of a regulated line section (on a symmetric pair line, a coaxial line or a radio-relay link)
M.520	11-1988	Routine maintenance on international group, supergroup, etc., links
M.525	11-1988	Automatic maintenance procedures for international group, supergroup, etc., links
M.530	11-1988	Readjustment to the nominal value of an international group, supergroup, etc., link
M.535	11-1988	Special maintenance procedures for multiple destination, unidirectional (MU) group and supergroup links
M.540	11-1988	Routine maintenance of carrier and pilot generating equipment
M.556	11-1988	Setting up and initial testing of digital channels on an international digital path or block
M.560	11-1988	International telephone circuits – Principles, definitions and relative transmission levels
M.562	11-1988	Types of circuit and circuit section
M.565	11-1988	Access points for international telephone circuits
M.570	11-1988	Constitution of the circuit; preliminary exchange of information
M.580	11-1988	Setting up and lining up an international circuit for public telephony
M.585	11-1988	Bringing an international digital circuit into service
M.590	11-1988	Setting up and lining up a circuit fitted with a compandor
M.600	11-1988	Organization of routine maintenance measurements on circuits
M.605	11-1988	Routine maintenance schedule for international public telephony circuits
M.610	11-1988	Periodicity of maintenance measurements on circuits
M.620	11-1988	Methods for carrying out routine measurements on circuits
M.630	11-1988	Maintenance of circuits using control chart methods
M.650	11-1988	Routine line measurements to be made on the line repeaters of audio-frequency sections or circuits
M.660	11-1988	Periodical in-station tests of echo suppressors complying with Recommendations G.161 and G.164
M.665	11-1988	Testing of echo cancellers
M.670	11-1988	Maintenance of a circuit fitted with a compandor

M.675	11-1988	Lining up and maintaining international demand assignment circuits (SPADE)
M.710	11-1988	General maintenance organization for the international automatic and semi-automatic telephone service
M.715	11-1988	Fault report point (circuit)
M.716	11-1988	Fault report point (network)
M.717	11-1988	Testing point (transmission)
M.718	11-1988	Testing point (line signalling)
M.719	11-1988	Testing point (switching and interregister signalling)
M.720	11-1988	Network analysis point
M.721	11-1988	System availability information point
M.722	11-1980	Network management point
M.723	11-1988	Circuit control station
M.724	11-1988	Circuit sub-control station
M.725	11-1988	Restoration control point
M.726	11-1988	Maintenance organization for the wholly digital international automatic and semi-automatic telephone service
M.729	11-1988	Organization of the maintenance of international public switched telephone circuits used for data transmission
M.730	11-1988	Maintenance methods
M.731	11-1988	Subjective testing
M.732	11-1988	Signalling and switching routine maintenance tests and measurements
M.733	11-1988	Transmission routine maintenance measurements on automatic and semi-automatic telephone circuits
M.734	11-1988	Exchange of information on incoming test facilities at international switching centres
M.760	11-1988	Transfer link for common channel Signalling System No. 6
M.762	11-1988	Maintenance of common channel Signalling System No. 6
M.800	11-1988	Use of circuits for voice-frequency telegraphy
M.810	11-1988	Setting up and lining up an international voice-frequency telegraph link for public telegraph circuits (for 50, 100 and 200 baud modulation rates)
M.820	11-1988	Periodicity of routine tests on international voice-frequency telegraph links
M.830	11-1988	Routine measurements to be made on international voice-frequency telegraph links
M.850	11-1988	International time division multiplex (TDM) telegraph systems
M.880	11-1988	International phototelegraph transmission
M.900	11-1988	Use of leased group and supergroup links for wide-spectrum signal transmission (data, facsimile, etc.)

M.910	11-1988	Setting up and lining up an international leased group link for wide-spectrum signal transmission
M.1010	11-1988	Constitution and nomenclature of international leased circuits
M.1012	11-1988	Circuit control station for leased and special circuits
M.1013	11-1988	Sub-control station for leased and special circuits
M.1014	11-1988	Transmission maintenance point (international line) (TMP-IL)
M.1015	11-1988	Types of transmission on leased circuits
M.1016	11-1988	Assessment of the service availability performance of international leased circuits
M.1020	03-1993	Characteristics of special quality international leased circuits with special bandwidth conditioning
M.1025	03-1993	Characteristics of special quality international leased circuits with basic bandwidth conditioning
M.1030	11-1988	Characteristics of ordinary quality international leased circuits forming part of private switched telephone networks
M.1040	11-1988	Characteristics of ordinary quality international leased circuits
M.1045	05-1996	Preliminary exchange of information for the provision of international leased circuits and international data transmission systems
M.1050	06-1998	Lining up an international point-to-point leased circuit with analogue presentation to the user
M.1055	11-1988	Lining up an international multiterminal leased circuit
M.1060	11-1988	Maintenance of international leased circuits
M.1130	10-1992	General definitions and general principles of operation/maintenance procedures to be used in satellite mobile systems
M.1140	10-1992	Maritime mobile telecommunication services via satellite
M.1150	04-1997	Maintenance aspects of maritime/land mobile telecommunication store-and-forward services (packet mode) via satellite
M.1160	04-1997	Maintenance aspects of aeronautical mobile telecommunication service via satellite
M.1170	04-1997	Maintenance aspects of mobile digital telecommunication service via satellite
M.1230	05-1996	Method to improve the management of operations and maintenance processes in the international telephone network
M.1235	11-1988	Use of automatically generated test calls for assessment of network performance
M.1300	10-1997	Maintenance of international data transmission systems operating in the range 2.4 kbit/s to 140 Mbit/s
M.1301	01-2001	General description and operational procedures for international SDH leased circuits
M.1320	11-1988	Numbering of channels in data transmission systems
M.1340	02-2000	Performance objectives, allocations and limits for international PDH leased circuits and supporting data transmission links and systems

M.1340 (2000) Corrigendum 1	08-2001		Available only in PDF.
M.1350	11-1988	Setting up, lining up and characteristics of international data transmission systems operating in the range 2.4 kbit/s to 14.4 kbit/s	
M.1355	11-1988	Maintenance of international data transmission systems operating in the range 2.4 to 14.4 kbit/s	
M.1370	06-1998	Bringing-into-service of international data transmission systems	
M.1375	06-1998	Maintenance of international data transmission systems	
M.1380	02-2000	Bringing-into-service of international leased circuits that are supported by international data transmission systems	
M.1385	02-2000	Maintenance of international leased circuits that are supported by international data transmission systems	
M.1400	07-2006	Designations for interconnections among operators' networks	
M.1401	07-2006	Formalization of interconnection designations among operators' telecommunication networks	
M.1510	10-1992	Exchange of contact point information for the maintenance of international services and the international network	
M.1520	10-1992	Standardized information exchange between Administrations	
M.1530	03-1999	Network maintenance information	
M.1532	02-2000	Network maintenance service performance agreement (MSPA)	
M.1535	05-1996	Principles for maintenance information to be exchanged at customer contact point (MICC)	
M.1537	10-1997	Definition of maintenance information to be exchanged at customer contact point (MICC)	
M.1539	03-1999	Management of the grade of network maintenance services at the Maintenance Service Customer Contact Point (MSCC)	
M.1540	10-1994	Exchange of information for planned outages of transmission systems	
M.1550	10-1992	Escalation procedure	
M.1560	10-1992	Escalation procedure for international leased circuits	
M.2100	04-2003	Performance limits for bringing-into-service and maintenance of international multi-operator PDH paths and connections	
M.2101	06-2003	Performance limits for bringing-into-service and maintenance of international multi-operator SDH paths and multiplex sections	
M.2102	02-2000	Maintenance thresholds and procedures for recovery mechanisms (protection and restoration) of international SDH VC trails (paths) and multiplex sections	
M.2110	07-2002	Bringing into service international multi-operator paths, sections and transmission systems	
M.2120	07-2002	International multi-operator paths, sections and transmission systems fault detection and localization procedures	
M.2130	02-2000	Operational procedures for the maintenance of the transport network	
M.2140	02-2000	Transport network event correlation	
M.2201	03-2001	Performance objectives, allocations and limits for bringing-into-service and maintenance of international ATM virtual path and virtual channel connections	

M.2301	07-2002	Performance objectives and procedures for provisioning and maintenance of IP-based networks	
M.2401	12-2003	Error performance limits and procedures for bringing-into-service and maintenance of multi-operator international paths and sections within an optical transport network	
M.3000	02-2000	Overview of TMN Recommendations	
M.3010	02-2000	Principles for a telecommunications management network	
M.3010 (2000) Amendment 1	12-2003	TMN conformance and TMN compliance	
M.3010 (2000) Amendment 2	11-2005	Additions and corrections	
M.3013	02-2000	Considerations for a telecommunications management network	
M.3016.0	05-2005	Security for the management plane: Overview	
M.3016.1	04-2005	Security for the management plane: Security requirements	
M.3016.1 (2005) Corrigendum 1	11-2005		
M.3016.2	04-2005	Security for the management plane: Security services	
M.3016.3	04-2005	Security for the management plane: Security mechanism	
M.3016.4	04-2005	Security for the management plane: Profile proforma	
M.3017	06-2003	Framework for the integrated management of hybrid circuit/packet networks	
M.3017 (2003) Amendment 1	04-2005	Additional options	
M.3020	07-2007	TMN interface specification methodology	Not available, contact sales@itu.int.
M.3030	08-2002	Telecommunications Markup Language (tML) framework	
M.3031	07-2004	Guidelines for Implementation Conformance Statement proformas for tML schemas	
M.3031 (2004) Corrigendum 1	11-2005		
M.3050.0	03-2007	Enhanced Telecom Operations Map (eTOM) – Introduction	Pre-published.
M.3050.1	03-2007	Enhanced Telecom Operations Map (eTOM) – The business process framework	Pre-published.
M.3050.2	03-2007	Enhanced Telecom Operations Map (eTOM) – Process decompositions and descriptions	Pre-published.
M.3050.3	03-2007	Enhanced Telecom Operations Map (eTOM) – Representative process flows	Pre-published.
M.3050.4	03-2007	Enhanced Telecom Operations Map (eTOM) – B2B integration: Using B2B inter-enterprise integration with the eTOM	Pre-published.
M.3050 Supplement 1	02-2007	Enhanced Telecom Operations Map (eTOM) – ITIL application note	Pre-published.
M.3050 Supplement 2	02-2007	Enhanced Telecom Operations Map (eTOM) – Public B2B Business Operations Map (BOM)	

M.3050 Supplement 3	05-2004	Enhanced Telecom Operations Map (eTOM) – eTOM to M.3400 mapping	
M.3050 Supplement 4	02-2007	Enhanced Telecom Operations Map (eTOM) – An eTOM primer	Pre-published.
M.3060/Y.2401	03-2006	Principles for the Management of Next Generation Networks	
M.3100	04-2005	Generic network information model	
M.3100 (2005) Cor.1	11-2005		Not available, contact sales@itu.int.
M.3101	07-1995	Managed object conformance statements for the generic network information model	
M.3108.1	03-1999	Information model for management of leased circuit and reconfigurable services	
M.3108.1 (1999) Corrigendum 1	01-2001		
M.3108.2	02-2000	Information model for connection management of preprovisioned service link connections to form a reconfigurable leased service	
M.3108.3	01-2001	Information model for management of virtual private network service	
M.3120	10-2001	CORBA generic network and network element level information model	Available only in MS Word.
M.3120 (2001) Amendment 1	05-2002	Protection switching	
M.3120 (2001) Amendment 2	03-2003		
M.3170.0	03-2007	Multi-technology network management: Introduction and supporting documentation	Pre-published.
M.3170.1	03-2007	Multi-technology network management: Business agreement (TMF513)	Pre-published.
M.3170.2	03-2007	Multi-technology network management: Information agreement (TMF608)	Pre-published.
M.3170.3	03-2007	Multi-technology network management: CORBA IDL solution set (TMF814) with implementation statement templates and guidelines (TMF814A)	Pre-published.
M.3180	10-1992	Catalogue of TMN management information	
M.3200	04-1997	TMN management services and telecommunications managed areas: overview	
M.3207.1	05-1996	TMN management service: Maintenance aspects of B-ISDN management	
M.3208.1	10-1997	Leased circuit services	
M.3208.1 (1997) Corrigendum 1	02-2000		
M.3208.2	03-1999	Connection management of pre-provisioned service link connections to form a leased circuit service	
M.3208.2 (1999) Corrigendum 1	01-2001		
M.3208.3	02-2000	Virtual private network service	

M.3210.1	01-2001	TMN management services for IMT-2000 security management	
M.3211.1	05-1996	TMN management service: Fault and performance management of the ISDN access	
M.3300	06-1998	TMN F interface requirements	
M.3320	04-1997	Management requirements framework for the TMN X-Interface	
M.3341	12-2003	Requirements for QoS/SLA management over the TMN X-interface for IP-based services	
M.3342	07-2006	Guidelines for the definition of SLA representation templates	
M.3343	01-2007	Requirements and analysis for NGN trouble administration across B2B and C2B interfaces	Pre-published.
M.3350	05-2004	TMN service management requirements for information interchange across the TMN X-interface to support provisioning of Emergency Telecommunication Service (ETS)	
M.3400	02-2000	TMN management functions	
M.3600	10-1992	Principles for the management of ISDNs	
M.3602	10-1992	Application of maintenance principles to ISDN subscriber installations	
M.3603	10-1992	Application of maintenance principles to ISDN basic rate access	
M.3604	10-1992	Application of maintenance principles to ISDN primary rate access	
M.3605	10-1992	Application of maintenance principles to static multiplexed ISDN basic rate access	
M.3610	05-1996	Principles for applying the TMN concept to the management of B-ISDN	
M.3611	04-1997	Test management of the B-ISDN ATM layer using the TMN	
M.3620	10-1992	Principles for the use of ISDN test calls, systems and responders	
M.3621	07-1995	Integrated management of the ISDN customer access	
M.3640	10-1992	Management of the D-channel – Data link layer and network layer	
M.3641	10-1994	Management information model for the management of the data link and network layer of the ISDN D-channel	
M.3650	04-1997	Network performance measurements of ISDN calls	
M.3660	10-1992	ISDN interface management services	
M.4010	10-1992	Inter-Administration agreements on common channel Signalling System No. 6	
M.4030	10-1992	Transmission characteristics for setting up and lining up a transfer link for common channel Signalling System N° 6 (analogue version)	
M.4100	05-1996	Maintenance of common channel Signalling System No. 7	
M.4110	05-1996	Inter-Administration agreements on common channel Signalling System No. 7	

Recommendation count: 403

Series N : Maintenance: international sound programme and television transmission circuits

Number	*Approval Date*	*Recommendation Title*	*Status*
N.1	03-1993	Definitions for application to international sound-programme and television-sound transmission	
N.2	11-1988	Different types of sound-programme circuit	
N.3	11-1988	Control circuits	
N.4	11-1988	Definition and duration of the line-up period and the preparatory period	
N.5	11-1988	Sound-programme control, sub-control and send reference stations	
N.10	03-1993	Limits for the lining-up of international sound-programme links and connections	
N.11	11-1988	Essential transmission performance objectives for international sound-programme centres (ISPC)	
N.12	11-1988	Measurements to be made during the line-up period that precedes a sound-programme transmission	
N.13	11-1988	Measurements to be made by the broadcasting organizations during the preparatory period	
N.15	11-1988	Maximum permissible power during an international sound-programme transmission	
N.16	11-1988	Identification signal	
N.17	11-1988	Monitoring the transmission	
N.18	11-1988	Monitoring for charging purposes, releasing	
N.21	11-1988	Limits and procedures for the lining-up of a sound-programme circuit	
N.23	11-1988	Maintenance measurements to be made on international sound-programme circuits	
N.51	11-1988	Definitions for application to international television transmissions	
N.52	11-1988	Multiple destination television transmissions and coordination centres	
N.54	11-1988	Definition and duration of the line-up period and the preparatory period	
N.55	03-1993	Organization, responsibilities and functions of control and sub-control international television centres and control and sub-control stations for international television connections, links, circuits and circuit sections	
N.60	03-1993	Nominal amplitude of video signals at video interconnection points	
N.61	11-1988	Measurements to be made before the line-up period that precedes a television transmission	
N.62	03-1993	Tests to be made during the line-up period that precedes a television transmission	
N.63	11-1988	Test signals to be used by the broadcasting organizations during the preparatory period	
N.64	11-1988	Quality and impairment assessment	
N.67	03-1993	Monitoring television transmissions – Use of the field blanking interval	

N.73	11-1988	Maintenance of permanent international television circuits, links and connections
N.86	03-1993	Line-up and service commissioning of international videoconference systems operating at transmission bit rates of 1544 and 2048 kbit/s
N.90	03-1993	Maintenance of international videoconference systems operating at transmission bit rates of 1544 and 2048 kbit/s

Recommendation count: 58

Series O : Specifications of measuring equipment

Number	*Approval Date*	*Recommendation Title*	*Status*
O.1	02-2000	Scope and application of measurement equipment specifications covered in the O-series Recommendations	
O.3	10-1992	Climatic conditions and relevant tests for measuring equipment	
O.6	11-1988	1020 Hz reference test frequency	
O.9	03-1999	Measuring arrangements to assess the degree of unbalance about earth	
O.11	10-1992	Maintenance access lines	
O.22	10-1992	CCITT automatic transmission measuring and signalling testing equipment ATME No. 2	
O.25	11-1988	Semiautomatic in-circuit echo suppressor testing system (ESTS)	
O.27	11-1988	In-station echo canceller test equipment	
O.31	11-1988	Automatic measuring equipment for sound-programme circuits	
O.32	11-1988	Automatic measuring equipment for stereophonic pairs of sound-programme circuits	
O.33	07-1995	Automatic equipment for rapidly measuring stereophonic pairs and monophonic sound-programme circuits, links and connections	
O.41	10-1994	Psophometer for use on telephone-type circuits	
O.42	11-1988	Equipment to measure non-linear distortion using the 4-tone intermodulation method	
O.61	11-1988	Simple equipment to measure interruptions on telephone-type circuits	
O.62	11-1988	Sophisticated equipment to measure interruptions on telephone-type circuits	
O.71	11-1988	Impulsive noise measuring equipment for telephone-type circuits	
O.81	11-1988	Group-delay measuring equipment for telephone-type circuits	
O.81 Appendix I	06-1998	A measuring signal (multitone test signal) for fast measurement of amplitude and phase for telephone type circuits	
O.81 Appendix I Erratum1	06-2000		
O.82	11-1988	Group-delay measuring equipment for the range 5 to 600 kHz	
O.91	11-1988	Phase jitter measuring equipment for telephone-type circuits	
O.95	11-1988	Phase and amplitude hit counters for telephone-type circuits	
O.111	11-1988	Frequency shift measuring equipment for use on carrier channels	

O.131	11-1988	Quantizing distortion measuring equipment using a pseudo-random noise test signal	
O.132	11-1988	Quantizing distortion measuring equipment using a sinusoidal test signal	
O.133	03-1993	Equipment for measuring the performance of PCM encoders and decoders	
O.150	05-1996	General requirements for instrumentation for performance measurements on digital transmission equipment	
O.150 (1996) Corrigendum 1	05-2002		
O.151	10-1992	Error performance measuring equipment operating at the primary rate and above	
O.151 (1992) Corrigendum 1	05-2002		
O.152	10-1992	Error performance measuring equipment for bit rates of 64 kbit/s and N x 64 kbit/s	
O.153	10-1992	Basic parameters for the measurement of error performance at bit rates below the primary rate	
O.161	11-1988	In-service code violation monitors for digital systems	
O.162	10-1992	Equipment to perform in-service monitoring on 2048, 8448, 34 368 and 139 264 kbit/s signals	
O.163	11-1988	Equipment to perform in-service monitoring on 1544 kbit/s signals	
O.171	04-1997	Timing jitter and wander measuring equipment for digital systems which are based on the plesiochronous digital hierarchy (PDH)	
O.172	04-2005	Jitter and wander measuring equipment for digital systems which are based on the synchronous digital hierarchy (SDH)	
O.172 (2005) Erratum 1	10-2005		
O.173	03-2007	Jitter measuring equipment for digital systems which are based on the Optical Transport Network (OTN)	Pre-published.
O.181	05-2002	Equipment to assess error performance on STM-N interfaces	
O.182	07-2007	Equipment to assess error performance on OTN interfaces	Pre-published.
O.191	02-2000	Equipment to measure the cell transfer performance of ATM connections	
O.201	07-2003	Q-factor test equipment to estimate the transmission performance of optical channels	
O.211	01-2006	Test and measurement equipment to perform tests at the IP layer	
O.220	03-2007	Framework for the End-to-End QoS measurement and supervision for leased circuit services	Pre-published.

Recommendation count: 87

Series P : Specifications of measuring equipment

Number	*Approval Date*	*Recommendation Title*	*Status*
P.10/G.100	07-2006	Vocabulary for performance and quality of service	
P.10/G.100 (2006) Amendment 1	01-2007	New Appendix I – Definition of Quality of Experience (QoE)	
P.11	03-1993	Effect of transmission impairments	
P.16	11-1988	Subjective effects of direct crosstalk; thresholds of audibility and intelligibility	
P.32	11-1988	Evaluation of the efficiency of telephone booths and acoustic hoods	
P.33	11-1988	Subscriber telephone sets containing either loudspeaking receivers or microphones associated with amplifiers	
P.38	03-1993	Transmission characteristics of operator telephone systems (OTS)	
P.48	11-1988	Specification for an intermediate reference system	
P.50	09-1999	Artificial voices	
P.50 Erratum 1	05-2000		
P.50 Appendix I	02-1998	Test signals	
P.51	08-1996	Artificial mouth	
P.52	03-1993	Volume meters	
O.41	10-1994	Psophometer for use on telephone-type circuits	
P.54	11-1988	Sound level meters (apparatus for the objective measurement of room noise)	
P.55	11-1988	Apparatus for the measurement of impulsive noise	
P.56	03-1993	Objective measurement of active speech level	
P.57	11-2005	Artificial ears	
P.58	08-1996	Head and torso simulator for telephonometry	
P.58 Erratum 1	01-2003		
P.59	03-1993	Artificial conversational speech	
P.61	11-1988	Methods for the calibration of condenser microphones	
P.62	03-1993	Measurements on subscribers' telephone equipment	
P.63	11-1988	Methods for the evaluation of transmission quality on the basis of objective measurements	

P.64	09-1999	Determination of sensitivity/frequency characteristics of local telephone systems	
P.64 Erratum 1	05-2000		
P.64 (1999) Amendment 1	03-2007		Pre-published.
P.65	03-1993	Objective instrumentation for the determination of loudness ratings	
P.66	03-1993	Methods for evaluating the transmission performance of digital telephone sets	
P.75	11-1988	Standard conditioning method for handsets with carbon microphones	
P.76	11-1988	Determination of loudness ratings; fundamental principles	
P.78	02-1996	Subjective testing method for determination of loudness ratings in accordance with Recommendation P.76	
P.79	09-1999	Calculation of loudness ratings for telephone sets	
P.79 Erratum 1	05-2000		
P.79 (1999) Corrigendum 1	10-2000		
P.79 (1999) Corrigendum 2	02-2001		
P.79 (1999) Corrigendum 3	01-2005		
P.79 Annex G	11-2001	Wideband loudness rating algorithm	
P.82	11-1988	Method for evaluation of service from the standpoint of speech transmission quality	
P.85	06-1994	A method for subjective performance assessment of the quality of speech voice output devices	
P.300	11-2001	Transmission performance of group audio terminals (GATs)	
P.310	03-2003	Transmission characteristics for telephone band (300-3400 Hz) digital telephones	
P.311	06-2005	Transmission characteristics for wideband (150-7000 Hz) digital handset telephones	
P.313	03-2007	Transmission characteristics for cordless and mobile digital terminals	Pre-published.
P.330	03-2003	Speech processing devices for acoustic enhancement	
P.330 (2003) Amendment 1	09-2003		
P.340	05-2000	Transmission characteristics and speech quality parameters of hands-free terminals	
P.340 (2000) Corrigendum 1	03-2004		
P.341	06-2005	Transmission characteristics for wideband (150-7000 Hz) digital hands-free telephony terminals	
P.342	05-2000	Transmission characteristics for telephone band (300-3400 Hz) digital loudspeaking and hands-free telephony terminals	
P.350	03-2001	Handset dimensions	

P.360	07-2006	Efficiency of devices for preventing the occurrence of excessive acoustic pressure by telephone receivers and assessment of daily noise exposure of telephone users	
P.370	08-1996	Coupling hearing aids to telephone sets	
P.380	11-2003	Electro-acoustic measurements on headsets	
P.501	05-2000	Test signals for use in telephonometry	Available only in MS Word.
P.501 Erratum 1	09-2001		
P.501 Amendment 1	05-2004	New annexes A and B	
P.501 (2000) Amend.2	06-2007	Revised Annex B	Not available, contact sales@itu.int.
P.502	05-2000	Objective test methods for speech communication systems using complex test signals	
P.502 Erratum 1	07-2001		
P.505	11-2005	One-view visualization of speech quality measurement results	
P.561	07-2002	In-service non-intrusive measurement device – Voice service measurements	
P.561 Appendix III	02-1998	Digital speech recordings	
P.562	05-2004	Analysis and interpretation of INMD voice-service measurements	
P.563	05-2004	Single-ended method for objective speech quality assessment in narrow-band telephony applications	Available only in MS Word.
P.564	07-2006	Conformance testing for narrowband voice over IP transmission quality assessment models	Available only in MS Word.
P.581	05-2000	Use of head and torso simulator (HATS) for hands-free terminal testing	
P.800	08-1996	Methods for subjective determination of transmission quality	
P.800.1	07-2006	Mean Opinion Score (MOS) terminology	
P.805	04-2007	Subjective evaluation of conversational quality	Pre-published.
P.810	02-1996	Modulated noise reference unit (MNRU)	
P.830	02-1996	Subjective performance assessment of telephone-band and wideband digital codecs	
P.831	12-1998	Subjective performance evaluation of network echo cancellers	
P.832	05-2000	Subjective performance evaluation of hands-free terminals	
P.833	02-2001	Methodology for derivation of equipment impairment factors from subjective listening-only tests	
P.834	07-2002	Methodology for the derivation of equipment impairment factors from instrumental models	Available only in MS Word.
P.834 (2002) Corrigendum 1	01-2005		

P.835	11-2003	Subjective test methodology for evaluating speech communication systems that include noise suppression algorithm	
P.840	11-2003	Subjective listening test method for evaluating circuit multiplication equipment	
P.851	11-2003	Subjective quality evaluation of telephone services based on spoken dialogue systems	
P.861	02-1998	Objective quality measurement of telephone-band (300-3400 Hz) speech codecs	
P.862	02-2001	Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs	Available only in MS Word.
P.862 (2001) Amend.2	11-2005	Revised Annex A – Reference implementations and conformance testing for ITU-T Recs P.862, P.862.1 and P.862.2	Available only in MS Word.
P.862.1	11-2003	Mapping function for transforming P.862 raw result scores to MOS-LQO	
P.862.2	11-2005	Wideband extension to Recommendation P.862 for the assessment of wideband telephone networks and speech codecs	
P.862.3	11-2005	Application guide for objective quality measurement based on Recommendations P.862, P.862.1 and P.862.2	
P.880	05-2004	Continuous evaluation of time-varying speech quality	
P.910	09-1999	Subjective video quality assessment methods for multimedia applications	
P.911	12-1998	Subjective audiovisual quality assessment methods for multimedia applications	
P.911 (1998) Corrigendum 1	09-1999		
P.920	05-2000	Interactive test methods for audiovisual communications	
P.930	08-1996	Principles of a reference impairment system for video	
P.931	12-1998	Multimedia communications delay, synchronization and frame rate measurement	
P.1010	07-2004	Fundamental voice transmission objectives for VoIP terminals and gateways	
P.supp10	11-1988	Considerations relating to transmission characteristics for analogue handset telephones	
P.supp16	11-1988	Guidelines for placement of microphones and loudspeakers in telephone conference rooms and for group audio terminals (GATs)	
P.supp20	03-1993	Examples of measurements of handset receive-frequency responses: dependence on earcap leakage losses	
P.Sup23	02-1998	ITU-T coded-speech database	
P.Sup24	10-2005	Parameters describing the interaction with spoken dialogue systems	

Recommendation count: 164

Series Q : Integrated services digital network

Number	*Approval Date*	*Recommendation Title*	*Status*
Q.1	11-1988	Signal receivers for manual working	
Q.2	11-1988	Signal receivers for automatic and semi-automatic working, used for manual working	
Q.4	11-1988	Automatic switching functions for use in national networks	
Q.5	11-1988	Advantages of semi-automatic service in the international telephone service	
Q.6	11-1988	Advantages of international automatic working	
Q.7	11-1988	Signalling systems to be used for international automatic and semi-automatic telephone working	
Q.8	11-1988	Signalling systems to be used for international manual and automatic working on analogue leased circuits	
Q.9	11-1988	Vocabulary of switching and signalling terms	
Q.10	11-1988	Definitions relating to national and international numbering plans	
E.164	02-2005	The international public telecommunication numbering plan	
E.164 Supplement 1	03-1998	Alternatives for carrier selection and network identification	
E.164 Supplement 2	11-1998	Number Portability	
E.164 Supplement 3	05-2004	Operational and administrative issues associated with national implementations of the ENUM functions	
E.164 Supplement 4	05-2004	Operational and administrative issues associated with the implementation of ENUM for non-geographic country codes	
Q.12	11-1988	Overflow – alternative routing – rerouting – automatic repeat attempt	
Q.14	11-1988	Means to control the number of satellite links in an international telephone connection	
Q.15	11-1988	Nominal mean power during the busy hour	
Q.20	11-1988	Comparative advantages of "in-band" and "out-band" systems	
Q.21	11-1988	Systems recommended for out-band signalling	
Q.22	11-1988	Frequencies to be used for in-band signalling	
Q.23	11-1988	Technical features of push-button telephone sets	
Q.24	11-1988	Multifrequency push-button signal reception	

Q.25	11-1988	Splitting arrangements and signal recognition times in "in-band" signalling systems
Q.26	11-1988	Direct access to the international network from the national network
Q.27	11-1988	Transmission of the answer signal
Q.28	11-1988	Determination of the moment of the called subscriber's answer in the automatic service
Q.29	11-1988	Causes of noise and ways of reducing noise in telephone exchanges
Q.30	11-1988	Improving the reliability of contacts in speech circuits
Q.31	11-1988	Noise in a national 4-wire automatic exchange
Q.32	11-1988	Reduction of the risk of instability by switching means
Q.33	11-1988	Protection against the effects of faulty transmission on groups of circuits
E.180/Q.35	03-1998	Technical characteristics of tones for the telephone service
Q.40	11-1988	The transmission plan
Q.41	11-1988	Mean one-way propagation time
Q.43	11-1988	Transmission losses, relative levels
Q.44	11-1988	Attenuation distortion
Q.45	10-1984	Transmission characteristics of an analogue international exchange
Q.45bis	11-1988	
Q.48	11-1988	Demand assignment signalling systems
O.22	10-1992	CCITT automatic transmission measuring and signalling testing equipment ATME No. 2
Q.50	07-2001	Signalling between Circuit Multiplication Equipment (CME) and International Switching Centres (ISC)
Q.50 (2001) Erratum 1	08-2006	
Q.50.1	07-2001	Signalling between International Switching Centres (ISC) and Digital Circuit Multiplication Equipment (DCME) including the control of compression/decompression
Q.50.2	12-2002	Signalling between International Switching Centres (ISC) and Digital Circuit Multiplication Equipment (DCME) including the control of compression/decompression over an IP network
Q.52	03-2001	Signaling between international switching centers and stand-alone echo control devices
Q.55	12-1999	Signalling between signal processing network equipments (SPNE) and international switching centres (ISC)
Q.56	05-2001	Signalling between signal processing network equipment (SPNE) and international switching centres (ISC) over an IP network

Q.65	06-2000	The unified functional methodology for the characterization of services and network capabilities including alternative object oriented techniques	
Q.68	03-1993	Overview of methodology for developing management services	
Q.71	03-1993	ISDN circuit mode switched bearer services	
Q.72	03-1993	Stage 2 description for packet mode services	
Q.76	02-1995	Service procedures for Universal Personal Telecommunication – Functional modelling and information flows	
Q.80	11-1988	Introduction to stage 2 service descriptions for supplementary services	
Q.81.1	11-1988	Direct dialling-in	
Q.81.2	02-1992	Multiple subscriber number	
Q.81.3	09-1991	Calling line identification presentation (CLIP) and calling line identification restriction (CLIR)	
Q.81.5	09-1991	Connected line identification, presentation and restriction (COLP) and (COLR)	
Q.81.7	06-1997	Malicious call identification (MCID)	
Q.81.8	02-1992	Sub-addressing (SUB)	
Q.82.1	11-1988	Call transfer	Not available, contact sales@itu.int.
Q.82.2	03-1993	call forwarding	
Q.82.3	03-1993	Call deflection	
Q.82.4	11-1988	Line hunting	
Q.82.7	07-1996	Explicit call transfer	
Q.83.1	09-1991	Call waiting (CW)	
Q.83.2	02-1992	Call hold	
Q.83.3	11-1988	Completion of call to busy subscriber	Available only in PDF.
Q.83.4	09-1991	Terminal portability	Not available, contact sales@itu.int.
Q.84.1	03-1993	Conference calling (CONF)	
Q.84.2	10-1995	Three-party service	

Q.85.1	02-1992	Closed user group	
Q.85.3	02-1992	Multi-level precedence and preemption (MLPP)	
Q.85.6	02-1995	Global Virtual Network Service (GVNS)	
Q.85.6 Annex A	07-1996	Service procedures and information flows based on intelligent network CS-1 capabilities	
Q.86.1	11-1988	Credit card call	Not available, contact sales@itu.int.
Q.86.2	10-1995	Advice of charge (AOC)	
Q.86.3	03-1993	Reverse charging (REV)	
Q.86.4	06-1997	International Freephone Service (IFS)	
Q.86.7	10-1995	International Telecommunication Charge Card (ITCC)	
Q.87.1	03-1993	User-to-user signalling (UUS)	
Q.87.2	11-1988	User signalling bearer services	Not available, contact sales@itu.int.
Q.101	11-1988	Facilities provided in international semi-automatic working	
Q.102	11-1988	Facilities provided in international automatic working	
Q.103	11-1988	Numbering used	
Q.104	11-1988	Language digit or discriminating digit	
Q.105	11-1988	National (significant) number	
Q.106	11-1988	The sending-finished signal	
Q.107	11-1988	Standard sending sequence of forward address information	
Q.107bis	03-1993	Analysis of forward address information for routing	
Q.108	11-1988	One-way or both-way operation of international circuits	
Q.109	11-1988	Transmission of the answer signal in international exchanges	
Q.110	11-1988	General aspects of the utilization of standardized CCITT signalling systems on PCM links	
Q.112	11-1988	Signal levels and signal receiver sensitivity	
Q.113	11-1988	Connection of signal receivers in the circuit	
Q.114	11-1988	Typical transmission requirements for signal senders and receivers	

Q.115.0	12-2002	Protocols for the control of signal processing network elements and functions	
Q.115.0 Erratum 1	09-2003		
Q.115.0 (2002) Corrigendum 1	06-2007		Pre-published.
Q.115.1	12-2002	Logic for the control of echo control devices and functions	
Q.115.2	01-2007	Logic for the control of voice enhancement devices and functions	Pre-published.
Q.116	11-1988	Indication given to the outgoing operator or calling subscriber in case of an abnormal condition	
Q.117	11-1988	Alarms for technical staff and arrangements in case of faults	
Q.118	09-1997	Abnormal conditions – Special release arrangements	
Q.118bis	11-1988	Indication of congestion conditions at transit exchanges	
Q.120-Q.139	11-1988	Specifications of Signalling system No. 4	
Q.140-Q.180	11-1988	Specifications of Signalling System No. 5	
Q.251-Q.300	11-1988	Specifications of Signalling System No. 6	
Q.310-Q.332	11-1988	Specifications of Signalling System R1	
Q.400-Q.490	11-1988	Specifications of Signalling System R2	
Q.500	11-1988	Digital local, combined, transit and international exchanges – Introduction and field of application	
Q.511	11-1988	Exchange interfaces towards other exchanges	
Q.512	02-1995	Digital exchange interfaces for subscriber access	
Q.513	03-1993	Digital exchange interfaces for operations, administration and maintenance	
Q.521	03-1993	Digital exchange functions	
Q.522	11-1988	Digital exchange connections, signalling and ancillary functions	
Q.541	03-1993	Digital exchange design objectives – General	
Q.542	03-1993	Digital exchange design objectives – Operations and maintenance	
Q.543	03-1993	Digital exchange performance design objectives	
Q.544	11-1988	Digital exchange measurements	
Q.551	01-2002	Transmission characteristics of digital exchanges	
Q.552	11-2001	Transmission characteristics at 2-wire analogue interfaces of digital exchanges	

Q.553	11-2001	Transmission characteristics at 4-wire analogue interfaces of digital exchanges
Q.554	11-1996	Transmission characteristics at digital interfaces of digital exchanges
Q.601	03-1993	Interworking of signalling systems – General
Q.602	03-1993	Interworking of signalling systems – Introduction
Q.603	11-1988	Events
Q.604	03-1993	Interworking of signalling systems – Information analysis tables
Q.605	11-1988	Drawing conventions
Q.606	11-1988	Logic procedures
Q.607	11-1988	Interworking requirements for new signalling systems
Q.608	11-1988	Miscellaneous interworking aspects
Q.611	11-1988	Logic procedures for incoming signalling system No. 4
Q.612	11-1988	Logic procedures for incoming signalling system No. 5
Q.613	11-1988	Logic procedures for incoming signalling system No. 6
Q.614	03-1993	Logic procedures for incoming Signalling System No. 7 (TUP)
Q.615	11-1988	Logic procedures for incoming signalling system R1
Q.616	11-1988	Logic procedures for incoming signalling system R2
Q.617	03-1993	Logic procedures for incoming signalling system No. 7 (ISUP)
Q.621	11-1988	Logic procedures for outgoing signalling system No. 4
Q.622	11-1988	Logic procedures for outgoing signalling system No. 5
Q.623	11-1988	Logic procedures for outgoing signalling system No. 6
Q.624	03-1993	Logic procedures for outgoing Signalling System No. 7 (TUP)
Q.625	11-1988	Logic procedures for outgoing signalling system R1
Q.626	11-1988	Logic procedures for outgoing signalling system R2
Q.627	03-1993	Logic procedures for outgoing Signalling System No. 7 (ISUP)
Q.634	11-1988	Logic procedures for interworking of signalling system No. 4 to R2
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Q.2983	12-1999	Broadband integrated services digital network (B-ISDN) – Digital subscriber signalling system No. 2 (DSS2) – Bearer control protocol	
Q.2984	12-1999	Broadband integrated services digital network (B-ISDN) and broadband private integrated services network (B-PISN) – Prenegotiation	
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Recommendation count: 1371

Series R : Telegraph transmission

Number	*Approval Date*	*Recommendation Title*	*Status*
R.2	11-1988	Element error rate	
R.4	11-1988	Methods for the separate measurements of the degrees of various types of telegraph distortion	
R.5	03-1993	Observation conditions recommended for routine distortion measurements on international telegraph circuits	
R.9	03-1993	How the laws governing distribution of distortion should be arrived at	
R.11	03-1993	Calculation of the degree of distortion of a telegraph circuit in terms of the degrees of distortion of the component links	
R.20	11-1988	Telegraph modem for subscriber lines	
R.21	08-1996	9600 bit/s modem standardized for use in the telegraph TDM system	
R.22	08-1996	Data over voice 19 200 bit/s modem standardized for use on telephone network subscriber lines	
R.30	11-1988	Transmission characteristic for international VFT links	
R.31	11-1988	Standardization of AMVFT systems for a modulation rate of 50 bauds	
R.35	11-1988	Standardization of FMVFT systems for a modulation rate of 50 bauds	
R.35bis	11-1988	50-baud wideband VFT systems	
R.36	11-1988	Coexistence of 50-baud/120-Hz channels, 100-baud/240-Hz channels, 200-baud/360-Hz or 480-Hz channels on the same voice-frequency telegraph system	
R.37	11-1988	Standardization of FMVFT systems for a modulation rate of 100 bauds	
R.38 A	11-1988	Standardization of FMVFT system for a modulation rate of 200 bauds with channels spaced at 480 Hz	
R.38B	11-1988	Standardization of FMVFT systems for a modulation rate of 200 bauds with channels spaced at 360 Hz usable on long intercontinental bearer circuits generally used with a 3-kHz spacing	
R.39	11-1988	Voice-frequency telegraphy on radio circuits	
R.40	11-1988	Coexistence in the same cable of telephony and super-telephone telegraphy	
R.43	11-1988	Simultaneous communication by telephone and telegraph on a telephone-type circuit	
R.44	11-1988	6-unit synchronous time-division 2-3-channel multiplex telegraph system for use over FMVFT channels spaced at 120 Hz for connection to standardized teleprinter networks	
R.49	11-1988	Interband telegraphy over open-wire 3-channel carrier systems	
R.50	11-1988	Tolerable limits for the degree of isochronous distortion of code-independent 50-baud telegraph circuits	

R.51	11-1988	Standardized text for distortion testing of the code-independent elements of a complete circuit
R.51bis	11-1988	Standardized text for testing the elements of a complete circuit
R.52	11-1988	Standardization of international texts for the measurement of the margin of start-stop equipment
R.53	11-1988	Permissible limits for the degree of distortion on an international 50-baud/120-Hz VFT channel (frequency and amplitude modulation)
R.54	03-1993	Conventional degree of distortion tolerable for standardized start-stop 50-baud systems
R.55	03-1993	Conventional degree of distortion
R.56	03-1993	Telegraph distortion limits to be quoted in Recommendations for equipment and transmission plans
R.57	11-1988	Standard limits of transmission quality for planning code-independent international point-to-point telegraph communications and switched networks using 50-baud start-stop equipment
R.58	11-1988	Standard limits of transmission quality for the gentex and telex networks
R.58bis	11-1988	Limits on signal transfer delay for telegraph, telex and gentex networks
R.59	11-1988	Interface requirements for 50-baud start-stop telegraph transmission in the maritime mobile satellite service
R.60	11-1988	Conditions to be fulfilled by regenerative repeaters for start-stop signals of International Telegraph Alphabet No. 2
R.62	11-1988	Siting of regenerative repeaters in international telex circuits
R.70	11-1988	Designation of international telegraph circuits
R.70bis	11-1988	Numbering of international VFT channels
R.71	11-1988	Organization of the maintenance of international telegraph circuits
R.72	11-1988	Periodicity of maintenance measurements to be carried out on the channels of international VFT systems
R.73	11-1988	Maintenance measurements to be carried out on VFT systems
R.74	11-1988	Choice of type of telegraph distortion-measuring equipment
R.75	11-1988	Maintenance measurements on code-independent international sections of international telegraph circuits
R.75bis	11-1988	Maintenance measurements of character error rate on international sections of international telegraph circuits
R.76	11-1988	Reserve channels for maintenance measurements on channels of international VFT systems
R.77	11-1988	Use of bearer circuits for voice-frequency telegraphy
R.78	11-1988	Pilot channel for AMVFT systems
R.79	11-1988	Automatic tests of transmission quality on telegraph circuits between switching centres
R.80	11-1988	Causes of disturbances to signals in VFT channels and their effect on telegraph distortion
R.81	11-1988	Maximum acceptable limit for the duration of interruption of telegraph channels arising from failure of the normal power supplies

R.82	11-1988	Appearance of false calling and clearing signals in circuits operated by switched teleprinter services
R.83	11-1988	Changes of level and interruptions in VFT channels
R.90	11-1988	Organization for locating and clearing faults in international telegraph switched networks
R.91	11-1988	General maintenance aspects for the maritime satellite telex service
R.100	03-1993	Transmission characteristics of international TDM links
R.101	03-1993	Code and speed dependent TDM system for anisochronous telegraph and data transmission using bit interleaving
R.102	03-1993	4800 bit/s code and speed dependent and hybrid TDM systems for anisochronous telegraph and data transmission using bit interleaving
R.103	11-1988	Code and speed-dependent TDM 600 bit/s system for use in point-to-point or branch-line muldex configurations
R.105	03-1993	Duplex muldex concentrator, connecting a group of gentex and telex subscribers to a telegraph exchange by assigning virtual channels to time slots of a bit-interleaved TDM system
R.106	08-1995	Muldex unit for telegraph and low speed data transmission using TDM bit interleaving with an aggregate bit rate higher than 4800 bit/s
R.111	03-1993	Code and speed independent TDM system for anisochronous telegraph and data transmission
R.112	03-1993	TDM hybrid system for anisochronous telegraph and data transmission using bit interleaving
R.113	03-1993	Combined muldex for telegraphy and synchronous data transmission
R.114	03-1993	Numbering of international TDM channels
R.115	03-1993	Maintenance loops for TDM-systems
R.116	11-1988	Maintenance tests to be carried out on international TDM systems
R.117	03-1993	End-to-end error performance for telegraph, telex and gentex connections involving regenerative equipment
R.118	03-1993	Performance and availability monitoring in regenerative TDM
R.120	11-1988	Tolerable limits for the degree of isochronous distortion of code-independent telegraph circuits operating at modulation rates of 75, 100 and 200 bauds
R.121	11-1988	Standard limits of transmission quality for start-stop user classes of service 1 and 2 on anisochronous data networks
R.122	11-1988	Summary of transmission plans for rates up to 300 bauds
R.140	11-1988	Definitions of essential technical terms in the field of telegraph transmission
R.150	11-1988	Automatic protection switching of dual diversity bearers

Recommendation count: 161

Series S : Telegraph services terminal equipment

Number	Approval Date	Recommendation Title	Status
S.1	03-1993	International Telegraph Alphabet No. 2	
S.2	11-1988	Coding scheme using International Telegraph Alphabet No. 2 (ITA2) to allow the transmission of capital and small letters	
S.3	11-1988	Transmission characteristics of the local end with its termination (ITA2)	
S.4	03-1993	Special use of certain characters of the International Telegraph Alphabet No. 2	
S.5	11-1988	Standardization of page-printing start-stop equipment and cooperation between page-printing and tape-printing start-stop equipment (ITA2)	
S.6	11-1988	Characteristics of answerback units (ITA2)	
S.7	11-1988	Control of teleprinter motors	
S.8	03-1993	Intercontinental standardization of the modulation rate of start-stop apparatus and of the use of combination No. 4 in figure-shift	
S.9	11-1988	Switching equipment of start-stop apparatus	
S.10	11-1988	Transmission at reduced character transfer rate over a standardized 50-baud telegraph channel	
S.11	11-1988	Use of start-stop reperforating equipment for perforated tape retransmission	
S.12	11-1988	Conditions that must be satisfied by synchronous systems operating in connection with standard 50-baud teleprinter circuits	
S.13	11-1988	Use on radio circuits of 7-unit synchronous systems giving error correction by automatic repetition	
S.14	11-1988	Suppression of unwanted reception in radiotelegraph multi-destination teleprinter systems	
S.15	11-1988	Use of the telex network for data transmission at 50 bauds	
S.16	03-1993	Connection to the telex network of an automatic terminal using a V.24 DCE/DTE interface	
S.17	11-1988	Answer-back unit simulators	
S.18	11-1988	Conversion between International Telegraph Alphabet No. 2 and International Alphabet No. 5	
S.19	11-1988	Calling and answering in the telex network with automatic terminal equipment	
S.20	03-1993	Automatic clearing procedure for a telex terminal	
S.21	03-1993	Use of display screens in telex machines	
S.22	03-1993	"Conversation impossible" and or pre-recorded message in response to J/BELL signals from a telex terminal	
S.23	03-1993	Automatic request of the answerback of the terminal of the calling party, by the telex terminal of the called party or by the international network	
S.30	11-1988	Standardization of basic model page-printing machine using International Alphabet No. 5	
S.31	11-1988	Transmission characteristics for start-stop data terminal equipment using International Alphabet No. 5	

S.32	11-1988	Answer-back units for 200- and 300-baud start-stop machines in accordance with Recommendation S.30
S.33	03-1993	Alphabets and presentation characteristics for the intex service
S.34	03-1993	Intex terminals – Requirements to effect interworking with the international telex service
S.35	03-1993	Answerback coding for the Intex service
S.36	07-1996	Intex and similar services – Terminal requirements to effect interworking between terminals operating at different speeds
S.140	11-1988	Definitions of essential technical terms relating to apparatus for alphabetic telegraphy
S.supp1	11-1988	Minimal specifications for the bilingual (arabic/latin) teleprinter

Recommendation count: 68

Series T : Terminals for telematic services

Number	*Approval Date*	*Recommendation Title*	*Status*
T.0	07-1996	Classification of facsimile terminals for document transmission over the public networks	
T.1	11-1988	Standardization of phototelegraph apparatus	
T.2	11-1988	Standardization of Group 1 facsimile apparatus for document transmission	
T.3	11-1988	Standardization of Group 2 facsimile apparatus for document transmission	
T.4	07-2003	Standardization of Group 3 facsimile terminals for document transmission	
G.511	02-1998	Test methodology for Group 3 facsimile processing equipment in the Public Switched Telephone Network	
T.6	11-1988	Facsimile coding schemes and coding control functions for Group 4 facsimile apparatus	
T.10	11-1988	Document facsimile transmissions on leased telephone-type circuits	
T.10bis	11-1988	Document facsimile transmissions in the general switched telephone network	
H.41/T.11	11-1988	Phototelegraph transmissions on telephone-type circuit	
H.42/T.12	11-1988	Range of phototelegraph transmissions on a telephone-type circuit	
T.15	11-1988	Phototelegraph transmission over combined radio and metallic circuits	
T.20	11-1988	Standardized test chart for facsimile transmissions	
T.21	11-1988	Standardized test charts for document facsimile transmissions	
T.22	03-1993		
T.23	04-1994	Standardized colour test chart for document facsimile transmissions	
T.24	06-1998	Standardized digitized image set	Available only in PDF.
T.24 (1998) Amend.1	02-2000		Not available, contact sales@itu.int.
T.30	09-2005	Procedures for document facsimile transmission in the general switched telephone network	
T.30 (2005) Amendment 1	01-2007	Extension of silence period during fallback from V.34	
T.31	08-1995	Asynchronous facsimile DCE control – Service Class 1	
T.31 (1995) Amendment 1	07-1996	Annex B: Procedure for Service Class 1 support of V.34 modems	
T.32	08-1995	Asynchronous facsimile DCE control – Service Class 2	

T.32 (1995) Amendment 1	07-1996		
T.33	07-1996	Facsimile routing utilizing the subaddress	
T.35	02-2000	Procedure for the allocation of ITU-T defined codes for non-standard facilities	
T.36	07-1997	Security capabilities for use with Group 3 facsimile terminals	
T.36 (1997) Amendment 1	04-1999		
T.37	06-1998	Procedures for the transfer of facsimile data via store-and-forward on the Internet	
T.37 (1998) Amendment 1	09-1999	Full Mode	
T.37 (1998) Amendment 2	03-2001	Replacement of reference RFC 2531 by RFC 2879	
T.37 (1998) Amendment 3	11-2002	Support of image/tiff and image/tiff-fx MIME content-types	
T.38	04-2007	Procedures for real-time Group 3 facsimile communication over IP networks	Pre-published.
T.39	10-1997	Application profiles for simultaneous voice and facsimile terminals	
T.42	07-2003	Continuous-tone colour representation method for facsimile	
T.42 (2003) Corrigendum 1	03-2004		
T.43	07-1997	Colour and gray-scale image representations using lossless coding scheme for facsimile	
T.43 (1997) Amendment 1	02-2000	Accommodation of new and future Resolutions	
T.44	01-2005	Mixed Raster Content (MRC)	
T.44 (2005) Erratum 1	06-2005		
T.45	02-2000	Run-length Colour Encoding	
T.50	09-1992	International Reference Alphabet (IRA) (Formerly International Alphabet No. 5 or IA5) – Information technology – 7-bit coded character set for information interchange	
T.51	09-1992	Latin based coded character sets for telematic services	
T.51 (1992) Amendment 1	08-1995		
T.52	03-1993	Non-latin coded character sets for telematic services	
T.52 (1993) Amendment 1	10-1996		
T.53	04-1994	Character coded control functions for telematic services	
T.60	03-1993	Terminal equipment for use in the teletex service	
T.61	03-1993	Character repertoire and coded character sets for the international teletex service	

T.62	03-1993	Control procedures for teletex and Group 4 facsimile services
T.62bis	03-1993	Control procedures for teletex and G4 facsimile services based on Recommendations X.215 and X.225
T.63	03-1993	Provisions for verification of teletex terminal compliance
T.64	03-1993	Conformance testing procedures for the teletex Recommendations
T.65	11-1988	Applicability of telematic protocols and terminal characteristics to computerized communication terminals (CCTs)
T.66	03-2002	Facsimile code points for use with Recommendations V.8 and V.8 bis
T.70	03-1993	Network-independent basic transport service for the telematic services
T.71	11-1988	Link access protocol balanced (LAPB) extended for half-duplex physical level facility
T.80	09-1992	Common components for image compression and communication – Basic principles
T.81	09-1992	Information technology – Digital compression and coding of continuous-tone still images – Requirements and guidelines
T.81 (1992) Corrigendum 1	01-2004	Patent information update
T.82	03-1993	Information technology – Coded representation of picture and audio information – Progressive bi-level image compression
T.82 (1993) Technical Cor.1	03-1995	
T.82 (1993) Technical Cor.2	03-2001	
T.83	11-1994	Information technology – Digital compression and coding of continuous-tone still images: Compliance testing
T.84	07-1996	Information technology – Digital compression and coding of continuous-tone still images: Extensions
T.84 (1996) Amendment 1	04-1999	Provisions to allow registration of new compression types and versions in the SPIFF header
T.85	08-1995	Application profile for Recommendation T.82 – Progressive bi-level image compression (JBIG coding scheme) for facsimile apparatus
T.85 (1995) Amendment 1	10-1996	
T.85 (1995) Corrigendum 1	02-1997	
T.85 (1995) Amendment 2	10-1997	
T.86	06-1998	Information technology – Digital compression and coding of continuous-tone still images: Registration of JPEG Profiles, SPIFF Profiles, SPIFF Tags, SPIFF colour Spaces, APPn Markers, SPIFF Compression types and Registration authorities (REGAUT)
T.87	06-1998	Information technology – Lossless and near-lossless compression of continuous-tone still images – Baseline
T.88	02-2000	Information technology – Lossy/lossless coding of bi-level images
T.88 (2000) Amendment 1	06-2003	Encoder

T.88 (2000) Amendment 2	06-2003	Extension of adaptive templates for halftone coding	
T.88 Amendment 1 Erratum 1	12-2004		
T.89	09-2001	Application profiles for Recommendation T.88 – Lossy/lossless coding of bi-level images (JBIG2) for facsimile	
T.90	02-1992	Characteristics and protocols for terminals for telematic services in ISDN	
T.90 (1992) Amendment 1	11-1994		
T.90 (1992) Amendment 2	07-1996		
T.90 (1992) Amendment 3	06-1998	Cause value for a G4 fax fallback	
T.100	11-1988	International information exchange for interactive Videotex	
T.101	11-1994	International interworking for Videotex services	
T.102	03-1993	Syntax-based Videotex end-to-end protocols for the circuit mode ISDN	
T.103	03-1993	Syntax-based Videotex end-to-end protocols for the packet mode ISDN	
T.104	03-1993	Packet mode access for syntax-based Videotex via PSTN	
T.105	11-1994	Syntax-based Videotex application layer protocol	
T.106	03-1993	Framework of videotex terminal protocols	
T.107	08-1995	Enhanced man machine interface for videotex and other retrieval services (VEMMI)	
T.120	01-2007	Data protocols for multimedia conferencing	Pre-published.
T.121	07-1996	Generic application template	
T.122	02-1998	Multipoint communication service – Service definition	
T.123	01-2007	Network-specific data protocol stacks for multimedia conferencing	Pre-published.
T.124	01-2007	Generic Conference Control	Pre-published.
T.125	02-1998	Multipoint communication service protocol specification	
T.126	07-1997	Multipoint still image and annotation protocol	
T.127	08-1995	Multipoint binary file transfer protocol	
T.128	02-1998	Multipoint application sharing	
T.134	02-1998	Text chat application entity	
T.135	02-1998	User-to-reservation system transactions within T.120 conferences	
T.136	05-1999	Remote device control application protocol	
T.137	02-2000	Virtual meeting room management for multimedia conferencing audio-visual control	
T.140	02-1998	Protocol for multimedia application text conversation	

T.140 Addendum 1	02-2000	
T.150	11-1988	Telewriting terminal equipment
T.170	02-1998	Framework of the T.170-Series of Recommendations
T.171	10-1996	Protocols for interactive audiovisual services: Coded representation of multimedia and hypermedia objects
T.172	02-1998	MHEG-5 – Support for base-level interactive applications
T.173	07-1997	MHEG-3 script interchange representation
T.174	10-1996	Application programming interface (API) for MHEG-1
T.175	02-1998	Application programming interface (API) for MHEG-5
T.176	02-1998	Application programming interface (API) for digital storage media command and control (DSM-CC)
T.180	06-1998	Homogeneous access mechanism to communication services
T.190	08-1995	Cooperative Document Handling (CDH) – Framework and basic services
T.191	07-1996	Cooperative document handling (CDH) – Joint synchronous editing (point-to-point)
T.192	06-1998	Cooperative document handling – Complex services: Joint synchronous editing and joint document presentation/viewing
T.200	10-1996	Programmable communication interface for terminal equipment connected to ISDN
T.300	11-1988	General principles of telematic interworking
T.330	11-1988	Telematic access to interpersonal messaging system
T.351	11-1988	Imaging process of character information on facsimile apparatus
T.390	11-1988	Teletex requirements for interworking with the telex service
T.400	11-1988	Introduction to document architecture, transfer and manipulation
T.411	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Introduction and general principles
T.411 (1993) Technical Cor. 1	10-1997	
T.412	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Document structures
T.412 (1993) Technical Cor. 1	10-1997	
T.412 (1993) Technical Cor. 2	10-1997	
T.413	11-1994	Information technology – Open Document Architecture (ODA) and interchange format: Abstract interface for the manipulation of ODA documents

T.414	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Document profile
T.414 (1993) Technical Cor. 1	10-1997	
T.414 (1993) Technical Cor. 2	10-1997	
T.415	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Open document interchange format (ODIF)
T.415 (1993) Technical Cor. 1	10-1997	
T.415 (1993) Technical Cor. 2	10-1997	
T.416	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Character content architectures
T.416 (1993) Technical Cor. 1	10-1997	
T.417	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Raster graphics content architectures
T.417 (1993) Technical Cor. 1	10-1997	
T.417 (1993) Amendment 1	10-1997	
T.417 (1993) Amendment 2	02-2000	
T.418	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Geometric graphics content architecture
T.419	08-1995	Information technology – Open Document Architecture (ODA) and interchange format: Audio content architectures
T.421	11-1994	Information technology – Open Document Architecture (ODA) and interchange format: Tabular structures and tabular layout
T.422	08-1995	Information technology – Open Document Architecture (ODA) and interchange format: Identification of document fragments
T.424	07-1996	Information technology – Open Document Architecture (ODA) and interchange format: Temporal relationships and non-linear structures
T.431	09-1992	Document Transfer And Manipulation (DTAM) – Services and protocols – Introduction and general principles
T.432	09-1992	Document Transfer And Manipulation (DTAM) – Services and protocols – Service definition
T.432 (1992) Amendment 1	08-1995	Revisions of T.432 to support G4 colour and file transfer
T.433	09-1992	Document Transfer And Manipulation (DTAM) – Services and protocols – Protocol specification
T.433 (1992) Amendment 1	08-1995	Revisions of T.433 to support G4 colour and file transfer
T.434	04-1999	Binary file transfer format for the telematic services
T.435	08-1995	Document Transfer And Manipulation (DTAM) – Services and protocols – Abstract service definition and procedures for confirmed document manipulation
T.436	08-1995	Document Transfer and Manipulation (DTAM) – Services and protocols – Protocol specifications for confirmed document manipulation

T.441	11-1988	Document Transfer And Manipulation (DTAM) – Operational structure
T.501	03-1993	Document application profile MM for the interchange of formatted mixed mode documents
T.502	11-1994	Document application profile PM-11 for the interchange of simple structure, character content documents in processable and formatted forms
T.503	02-2000	Document application profile for the interchange of Group 4 facsimile documents
T.504	03-1993	Document application profile for videotex interworking
T.505	11-1994	Document application profile PM-26 for the interchange of enhanced structure, mixed content documents in processable and formatted forms
T.506	08-1993	Document application profile PM-36 for the interchange of extended document structures and mixed content documents in processable and formatted forms
T.510	03-1993	General overview of the T.510-Series Recommendations
T.521	11-1994	Communication application profile BT0 for document bulk transfer based on the session service
T.521 (1994) Amendment 1	08-1995	
T.522	09-1992	Communication application profile BT1 for document bulk transfer
T.523	03-1993	Communication application profile DM-1 for videotex interworking
T.541	03-1993	Operational application profile for videotex interworking
T.561	11-1988	Terminal characteristics for mixed mode of operation MM
T.562	11-1988	Terminal characteristics for teletex processable mode PM.1
T.563	10-1996	Terminal characteristics for Group 4 facsimile apparatus
T.563 (1996) Amendment 1	07-1997	
T.563 (1996) Amendment 2	10-1997	Annex C – T.30 frames for G4 facsimile
T.563 (1996) Corrigendum 1	06-1998	
T.563 (1996) Amendment 3	04-1999	
T.564	03-1993	Gateway characteristics for videotex interworking
T.571	09-1992	Terminal characteristics for the telematic file transfer within the teletex service
T.611	11-1994	Programming Communication Interface (PCI) APPLI/COM for facsimile Group 3, facsimile Group 4, teletex, telex, E-mail and file transfer services
T.800	08-2002	Information technology – JPEG 2000 image coding system: Core coding system

T.800 (2002) Amendment 1	09-2005	Profiles for digital cinema applications	
T.800 (2002) Corrigendum 1	01-2007		
T.801	08-2002	Information technology – JPEG 2000 image coding system: Extensions	
T.801 (2002) Corrigendum 3	01-2005		
T.801 (2002) Amendment 2	05-2005	Extended capabilities marker segment	
T.801 (2002) Corrigendum 4	05-2006		
T.802	01-2005	Information technology – JPEG 2000 image coding system: Motion JPEG 2000	
T.803	11-2002	Information technology – JPEG 2000 image coding system: Conformance testing	Available only in MS Word.
T.804	08-2002	Information technology – JPEG 2000 image coding system: Reference software	Available only in MS Word.
T.807	05-2006	Information technology – JPEG 2000 image coding system: Secure JPEG 2000	
T.808	01-2005	Information technology – JPEG 2000 image coding system: Interactivity tools, APIs and protocols	
T.808 (2005) Amendment 1	05-2006	APIs, metadata and editing	
T.808 (2005) Corrigendum 1	01-2007		
T.810	05-2006	Information technology – JPEG 2000 image coding system: Wireless	
T.851	09-2005	ITU-T T.81 (JPEG-1)-based still-image coding using an alternative arithmetic coder	
T.851 (2005) Corrigendum 1	05-2006		
T.870	03-2002	Information technology – Lossless and near-lossless compression of continuous-tone still images: Extensions	Available only in MS Word.
T.Sup1	11-2004	Conformance testing requirements for Recommendations of the T.170-series	

Recommendation count: 369

Series U : Telegraph switching

Number	*Approval Date*	*Recommendation Title*	*Status*
U.1	03-1993	Signalling conditions to be applied in the international telex service	
U.2	11-1988	Standardization of dials and dial pulse generators for the international telex service	
U.3	11-1988	Arrangements in switching equipment to minimize the effects of false calling signals	
U.4	11-1988	Exchange of information regarding signals destined to be used over international circuits concerned with switched teleprinter networks	
U.5	11-1988	Requirements to be met by regenerative repeaters in international connections	
U.6	11-1988	Prevention of fraudulent transit traffic in the fully automatic international telex service	
U.7	03-1993	Numbering schemes for automatic switching networks	
U.8	11-1988	Hypothetical reference connections for telex and gentex networks	
U.10	03-1993	Equipment of an international telex position	
U.11	03-1993	Telex and gentex signalling on intercontinental circuits used for intercontinental automatic transit traffic (type C signalling)	
U.12	03-1993	Terminal and transit control signalling system for telex and similar services on international circuits (type D signalling)	
U.15	03-1993	Interworking rules for international signalling systems according to Recommendations U.1, U.11 and U.12	
U.20	11-1988	Telex and gentex signalling on radio channels (synchronous 7-unit systems affording error correction by automatic repetition)	
U.21	11-1988	Operator recall on a telex call set up on a radiotelegraph circuit	
U.22	11-1988	Signals indicating delay in transmission on calls set up by means of synchronous systems with automatic error correction by repetition	
U.23	11-1988	Use of radiotelegraph circuits with ARQ equipment for fully automatic telex calls charged on the basis of elapsed time	
U.24	11-1988	Requirements for telex and gentex operation to be met by synchronous multiplex equipment described in Recommendation R.44	
U.25	11-1988	Requirements for telex and gentex operation to be met by code- and speed-dependent TDM systems conforming to Recommendation R.101	
U.30	11-1988	Signalling conditions for use in the international gentex network	
U.31	11-1988	Prevention of connection to faulty stations and/or station lines in the gentex service	
U.40	03-1993	Reactions by automatic terminals connected to the telex network in the event of ineffective call attempts or signalling incidents	

U.41	11-1988	Changed address interception and call redirection in the telex service
U.43	11-1988	Follow-on calls
U.44	11-1988	Multi-address calls in real time for broadcast purposes in the international telex service
U.45	03-1993	Response to the not-ready condition of the telex terminal
U.46	03-1993	Interruption of automatic transmission and flow control in the international telex service
U.60	11-1988	General requirements to be met in interfacing the international telex network with maritime satellite systems
U.61	03-1993	Detailed requirements to be met in interfacing the international telex network with maritime satellite systems
U.62	03-1993	General requirements to be met in interfacing the international telex network with the fully automated maritime VHF/UHF radio system
U.63	11-1988	General requirements to be met in interfacing the international telex network with the maritime "direct printing" system
U.70	11-1988	Telex service signals for telex to teletex interworking
U.74	11-1988	Extraction of telex selection information from a calling telex answerback
U.75	03-1993	Automatic called telex answerback check
U.80	03-1993	International telex store and forward access from a telex subscriber
U.81	10-1996	International telex store-and-forward – Delivery to a telex subscriber
U.82	11-1988	International telex store and forward – Interconnection of telex store and forward units
U.101	03-1993	Signalling systems for the Intex service (types E and F signalling)
U.102	07-1996	Intex and similar services – Network requirements to effect interworking between terminals operating at different speeds
U.140	11-1988	Definitions of essential technical terms relating to telegraph switching and signalling
U.200	03-1993	The international telex service – General technical requirements for interworking
U.201	03-1993	Interworking between the teletex service and the international telex service
U.202	03-1993	Technical requirements to be met in providing the international telex service within an integrated services digital network
U.203	03-1993	Technical requirements to be met when providing real-time bothway communications between terminals of the international telex service and data terminal equipments on a PSPDN or via the PSTN
U.204	03-1993	Interworking between the international telex service and the public interpersonal messaging service

U.205	03-1993	Store-and-retrieve facility for the delivery of messages from a terminal of the international telex service to a data terminal equipment which connects to a packet-switched public data network over the public switched telephone network
U.206	03-1993	Technical requirements for interworking between the international telex service and the videotex service
U.207	03-1993	Technical requirements to be met for the transfer of messages between terminals of the international telex service and Group 3 facsimile terminals connected to the PSTN
U.208	10-1996	The international telex service – Interworking with the INMARSAT C system using one-stage selection
U.210	03-1993	Intex service network requirements to effect interworking with the international telex service
U.220	03-1993	The international telex service – Technical requirements for a status enquiry function in an interworking scenario

Recommendation count: 113

Series V : Data communication over the telephone network

Number	*Approval Date*	*Recommendation Title*	*Status*
V.1	11-1988	Equivalence between binary notation symbols and the significant conditions of a two-condition code	
V.2	11-1988	Power levels for data transmission over telephone lines	
V.4	11-1988	General structure of signals of International Alphabet No. 5 code for character oriented data transmission over public telephone networks	
V.5	11-1988	Standardization of data signalling rates for synchronous data transmission in the general switched telephone network	
V.6	11-1988	Standardization of data signalling rates for synchronous data transmission on leased telephone-type circuits	
V.7	11-1988	Definitions of terms concerning data communication over the telephone network	
V.8	11-2000	Procedures for starting sessions of data transmission over the public switched telephone network	
V.8bis	11-2000	Procedures for the identification and selection of common modes of operation between data circuit-terminating equipments (DCEs) and between data terminal equipments (DTEs) over the public switched telephone network and on leased point-to-point telephone-t	
V.10	03-1993	Electrical characteristics for unbalanced double-current interchange circuits operating at data signalling rates nominally up to 100 kbit/s	
V.11	10-1996	Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s	
V.12	08-1995	Electrical characteristics for balanced double-current interchange circuits for interfaces with data signalling rates up to 52 Mbit/s	
V.13	03-1993	Simulated carrier control	
V.14	03-1993	Transmission of start-stop characters over synchronous bearer channels	
V.14 (1993) Corrigendum 1	09-1998		
V.15	11-1988	Use of acoustic coupling for data transmission	
V.16	11-1988	Medical analogue data transmission modems	
V.17	02-1991	A 2-wire modem for facsimile applications with rates up to 14 400 bit/s	
V.17 (1991) Corrigendum 1	09-1998		
V.18	11-2000	Operational and interworking requirements for DCEs operating in the text telephone mode	
V.18 (2000) Amendment 1	11-2002	Harmonization with ANSI TIA/EIA-825 (2000) text phones	
V.19	11-1988	Modems for parallel data transmission using telephone signalling frequencies	
V.20	11-1988	Parallel data transmission modems standardized for universal use in the general switched telephone network	

V.21	11-1988	300 bits per second duplex modem standardized for use in the general switched telephone network
V.22	11-1988	1200 bits per second duplex modem standardized for use in the general switched telephone network and on point-to-point 2-wire leased telephone-type circuits
V.22bis	11-1988	2400 bits per second duplex modem using the frequency division technique standardized for use on the general switched telephone network and on point-to-point 2-wire leased telephone-type circuits
V.23	11-1988	600/1200-baud modem standardized for use in the general switched telephone network
V.24	02-2000	List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)
V.25	10-1996	Automatic answering equipment and general procedures for automatic calling equipment on the general switched telephone network including procedures for disabling of echo control devices for both manually and automatically established calls
V.25 (1996) Corrigendum 1	07-2001	
V.25bis	10-1996	Synchronous and asynchronous automatic dialling procedures on switched networks
V.26	11-1988	2400 bits per second modem standardized for use on 4-wire leased telephone-type circuits
V.26bis	11-1988	2400/1200 bits per second modem standardized for use in the general switched telephone network
V.26ter	11-1988	2400 bits per second duplex modem using the echo cancellation technique standardized for use on the general switched telephone network and on point-to-point 2-wire leased telephone-type circuits
V.27	11-1988	4800 bits per second modem with manual equalizer standardized for use on leased telephone-type circuits
V.27bis	11-1988	4800/2400 bits per second modem with automatic equalizer standardized for use on leased telephone-type circuits
V.27ter	11-1988	4800/2400 bits per second modem standardized for use in the general switched telephone network
V.28	03-1993	Electrical characteristics for unbalanced double-current interchange circuits
V.29	11-1988	9600 bits per second modem standardized for use on point-to-point 4-wire leased telephone-type circuits
V.31	11-1988	Electrical characteristics for single-current interchange circuits controlled by contact closure
V.31bis	11-1988	Electrical characteristics for single-current interchange circuits using optocouplers
V.32	03-1993	A family of 2-wire, duplex modems operating at data signalling rates of up to 9600 bit/s for use on the general switched telephone network and on leased telephone-type circuits
V.32bis	02-1991	A duplex modem operating at data signalling rates of up to 14 400 bit/s for use on the general switched telephone network and on leased point-to-point 2-wire telephone-type circuits
V.33	11-1988	14 400 bits per second modem standardized for use on point-to-point 4-wire leased telephone-type circuits
V.34	02-1998	A modem operating at data signalling rates of up to 33 600 bit/s for use on the general switched telephone network and on leased point-to-point 2-wire telephone-type circuits

V.35	10-1984	Data transmission at 48 kbit/s using 60-108 kHz group band circuits
V.36	11-1988	Modems for synchronous data transmission using 60-108 kHz group band circuits
V.37	11-1988	Synchronous data transmission at a data signalling rate higher than 72 kbit/s using 60-108 kHz group band circuits
V.38	10-1996	A 48/56/64 kbit/s data circuit-terminating equipment standardized for use on digital point-to-point leased circuits
V.40	11-1988	Error indication with electromechanical equipment
V.41	11-1988	Code-independent error-control system
V.42	03-2002	Error-correcting procedures for DCEs using asynchronous-to-synchronous conversion
V.42 (2002) Corrigendum 1	07-2003	
V.42bis	01-1990	Data compression procedures for data circuit-terminating equipment (DCE) using error correction procedures
V.43	02-1998	Data flow control
V.44	11-2000	Data compression procedures
V.44 (2000) Corrigendum 1	03-2002	
V.50	11-1988	Standard limits for transmission quality of data transmission
M.729	11-1988	Organization of the maintenance of international public switched telephone circuits used for data transmission
V.53	11-1988	Limits for the maintenance of telephone-type circuits used for data transmission
V.54	11-1988	Loop test devices for modems
O.71	11-1988	Impulsive noise measuring equipment for telephone-type circuits
V.56	11-1988	Comparative tests of modems for use over telephone-type circuits
V.56bis	08-1995	Network transmission model for evaluating modem performance over 2-wire voice grade connections
V.56ter	08-1996	Test procedure for evaluation of 2-wire 4 kHz voiceband duplex modems
V.58	09-1994	Management information model for V-Series DCEs
V.59	11-2000	Managed objects for diagnostic information of public switched telephone network connected V-series modem DCEs
V.59 (2000) Corrigendum 1	07-2001	
V.59 (2000) Corrigendum 2	03-2002	
V.61	08-1996	A simultaneous voice plus data modem, operating at a voice plus data signalling rate of 4800 bit/s, with optional automatic switching to data-only signalling rates of up to 14 400 bit/s, for use on the General Switched Telephone Network and on leased poin
V.61 (1996) Corrigendum 1	01-2005	

V.70	08-1996	Procedures for the simultaneous transmission of data and digitally encoded voice signals over the GSTN, or over 2-wire leased point-to-point telephone type circuits	
V.70 (1996) Corrigendum 1	01-2005		
V.75	08-1996	DSVD terminal control procedures	
V.75 (1996) Corrigendum 1	01-2005		
V.75 Appendix II	02-1998	Session establishment using V.75/H.245 procedures	
V.76	08-1996	Generic multiplexer using V.42 LAPM-based procedures	
V.76 (1996) Corrigendum 1	01-2005		
V.80	08-1996	In-band DCE control and synchronous data modes for asynchronous DTE	
V.80 (1996) Amendment 1	07-2001	Additional data signalling rate codes in support of cellular systems	
V.90	09-1998	A digital modem and analogue modem pair for use on the Public Switched Telephone Network (PSTN) at data signalling rates of up to 56 000 bit/s downstream and up to 33 600 bit/s upstream	
V.91	05-1999	A digital modem operating at data signalling rates of up to 64 000 bit/s for use on a 4-wire circuit switched connection and on leased point-to-point 4-wire digital circuits	
V.91 (1999) Corrigendum 1	07-2001		
V.92	11-2000	Enhancements to Recommendation V.90	
V.92 (2000) Amendment 1	07-2001	Update of Tables 18, 19, 31, 32, Figure 20 and Clauses 8.6.6, 8.7.6, 9.10.1, and 9.11	
V.92 (2000) Amendment 2	03-2002	New interaction facilities for error-correcting procedures	
V.92 (2000) Corrigendum 1	07-2003		
V.100	11-1988	Interconnection between public data networks (PDNs) and the public switched telephone networks (PSTN)	
V.110	02-2000	Support by an ISDN of data terminal equipments with V-series type interfaces	
V.120	10-1996	Support by an ISDN of data terminal equipment with V-series type interfaces with provision for statistical multiplexing	
V.120 (1996) Corrigendum 1	05-1999		
V.130	08-1995	ISDN terminal adaptor framework	
V.140	01-2005	Procedures for establishing communication between two multiprotocol audiovisual terminals using digital channels at a multiple of 64 or 56 kbit/s	
V.150.0	01-2003	Modem-over-IP networks: Foundation	
V.150.1	01-2003	Modem-over-IP networks: Procedures for the end-to-end connection of V-series DCEs	
V.150.1 (2003) Corrigendum 1	07-2003		Pre-published.

V.150.1 (2003) Corrigendum 2	03-2004		Pre-published.
V.150.1 (2003) Amendment 1	01-2005	Modification to SSE reason identifier codes to support voice band data and text relay	
V.150.1 (2003) Amendment 2	05-2006	ToIP and new SPRT data types support	
V.151	05-2006	Procedures for the end-to-end connection of analogue PSTN text telephones over an IP network utilizing text relay	Pre-published.
V.152	01-2005	Procedures for supporting voice-band data over IP networks	
V.152 (2005) Corrigendum 1	09-2005		
V.152 (2005) Corrigendum 2	05-2006		
V.230	11-1988	General data communications interface layer 1 specification	
V.250	07-2003	Serial asynchronous automatic dialling and control	
V.250 Supplement 1	06-2001	Various extensions to V.250 basic command set	
V.251	08-1996	Procedure for DTE-controlled call negotiation	
V.251 (1996) Erratum 1	10-2003		
V.252	02-1998	Procedure for control of V.70 and H.324 terminals by a DTE	
V.253	02-1998	Control of voice-related functions in a DCE by an asynchronous DTE	
V.300	07-1999	A 128 (144) kbit/s data circuit-terminating equipment standardized for use on digital point-to-point leased circuits	

Recommendation count: 203

Series X : Data communication over the telephone network

Number	*Approval Date*	*Recommendation Title*	*Status*
X.1	03-2000	International user classes of service in, and categories of access to, public data networks and Integrated Services Digital Networks (ISDNs)	
X.2	03-2000	International data transmission services and optional user facilities in public data networks and ISDNs	
X.3	03-2000	Packet Assembly/Disassembly facility (PAD) in a public data network	
X.4	11-1988	General structure of signals of International Alphabet No. 5 code for character oriented data transmission over public data networks	
X.5	10-1996	Facsimile Packet Assembly/Disassembly facility (FPAD) in a public data network	
X.6	08-1997	Multicast service definition	
X.6 (1997) Amendment 1	03-2000	Frame relay PVC multicast service definition	
X.7	04-2004	Technical characteristics of data transmission services	
X.8	07-1994	Multi-aspect PAD (MAP) framework and service definition	
X.10	03-1993	Categories of access for Data Terminal Equipment (DTE) to public data transmission services	
X.20	11-1988	Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for start-stop transmission services on public data networks	
X.20bis	11-1988	Use on public data networks of Data Terminal Equipment (DTE) which is designed for interfacing to asynchronous duplex V-Series modems	
X.21	09-1992	Interface between Data Terminal Equipment and Data Circuit-terminating Equipment for synchronous operation on public data networks	
X.21bis	11-1988	Use on public data networks of Data Terminal Equipment (DTE) which is designed for interfacing to synchronous V-Series modems	
X.22	11-1988	Multiplex DTE/DCE interface for user classes 3-6	
X.24	11-1988	List of definitions for interchange circuits between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) on public data networks	
X.25	10-1996	Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit	
X.25 (1996) Corrigendum 1	09-1998		
V.10	03-1993	Electrical characteristics for unbalanced double-current interchange circuits operating at data signalling rates nominally up to 100 kbit/s	
V.11	10-1996	Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s	

X.28	12-1997	DTE/DCE interface for a start-stop mode Data Terminal Equipment accessing the Packet Assembly/Disassembly facility (PAD) in a public data network situated in the same country
X.28 (1997) Amendment 1	03-2000	Extensions of PAD parameter settings and PAD service signals
X.29	12-1997	Procedures for the exchange of control information and user data between a Packet Assembly/Disassembly (PAD) facility and a packet mode DTE or another PAD
X.30	03-1993	Support of X.21, X.21 bis and X.20 bis based Data Terminal Equipments (DTEs) by an Integrated Services Digital Network (ISDN)
X.31	11-1995	Support of packet mode terminal equipment by an ISDN
X.32	10-1996	Interface between Data terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and accessing a Packet-Switched Public Data Network through a public switched telephone network or an Integrated Servic
X.33	10-1996	Access to packet-switched data transmission services via frame relaying data transmission services
X.34	10-1996	Access to packet-switched data transmission services via B-ISDN
X.34 (1996) Corrigendum 1	03-2000	
X.35	11-1993	Interface between a PSPDN and a private PSDN which is based on X.25 procedures and enhancements to define a gateway function that is provided in the PSPDN
X.36	02-2003	Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for public data networks providing frame relay data transmission service by dedicated circuit
X.37	04-1995	Encapsulation in X.25 packets of various protocols including frame relay
X.38	10-1996	G3 facsimile equipment/DCE interface for G3 facsimile equipment accessing the Facsimile Packet Assembly/Disassembly facility (FPAD) in a public data network situated in the same country
X.39	10-1996	Procedures for the exchange of control information and user data between a Facsimile Packet Assembly/Disassembly (FPAD) facility and a packet mode Data Terminal Equipment (DTE) or another FPAD
X.40	11-1988	Standardization of frequency-shift modulated transmission systems for the provision of telegraph and data channels by frequency division of a group
X.42	10-2003	Procedures and methods for accessing a public data network from a DTE operating under control of a generalized polling protocol
X.45	10-1996	Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks, designed for efficiency at higher speeds
X.46	09-1998	Access to FRDTS via B-ISDN
X.48	10-1996	Procedures for the provision of a basic multicast service for data terminal equipments (DTEs) using Recommendation X.25
X.49	10-1996	Procedures for the provision of an extended multicast service for data terminal equipments (DTEs) using Recommendation X.25
X.50	11-1988	Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks

X.50bis	11-1988	Fundamental parameters of a 48-kbit/s user data signalling rate transmission scheme for the international interface between synchronous data networks
X.51	11-1988	Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks using 10-bit envelope structure
X.51bis	11-1988	Fundamental parameters of a 48-kbit/s user data signalling rate transmission scheme for the international interface between synchronous data networks using 10-bit envelope structure
X.52	11-1988	Method of encoding anisochronous signals into a synchronous user bearer
X.53	03-1993	Numbering of channels on international multiplex links at 64 kbit/s
X.54	11-1988	Allocation of channels on international multiplex links at 64 kbit/s
X.55	11-1988	Interface between synchronous data networks using a 6 + 2 envelope structure and single channel per carrier (SCPC) satellite channels
X.56	11-1988	Interface between synchronous data networks using an 8 + 2 envelope structure and single channel per carrier (SCPC) satellite channels
X.57	11-1988	Method of transmitting a single lower speed data channel on a 64 kbit/s data stream
X.58	11-1988	Fundamental parameters of a multiplexing scheme for the international interface between synchronous non-switched data networks using no envelope structure
X.60	11-1988	Common channel signalling for circuit-switched data applications
Q.741/X.61	11-1988	Signalling System No. 7 – Data user part
X.70	11-1988	Terminal and transit control signalling system for start-stop services on international circuits between anisochronous data networks
X.71	11-1988	Decentralized terminal and transit control signalling system on international circuits between synchronous data networks
X.75	10-1996	Packet-switched signalling system between public networks providing data transmission services
X.75 (1996) Corrigendum 1	09-1998	
X.76	02-2003	Network-to-network interface between public networks providing PVC and/or SVC frame relay data transmission service
X.77	08-1997	Interworking between PSPDNs via B-ISDN
X.77 (1997) Corrigendum 1	03-2000	
X.78	06-1999	Interworking procedures between networks providing frame relay data transmission services via B-ISDN
X.78 (1999) Corrigendum 1	03-2000	
X.80	11-1988	Interworking of interexchange signalling systems for circuit-switched data services
X.81	11-1988	Interworking between an ISDN circuit-switched and a circuit-switched public data network (CSPDN)
X.82	11-1988	Detailed arrangements for interworking between CSPDNs and PSPDNs based on Recommendation T.70
X.84	03-2004	Support of frame relay services over MPLS core networks
X.85/Y.1321	03-2001	IP over SDH using LAPS

X.85/Y.1321 (2001) Amendment 1	04-2004	Bit-oriented method for LAPS	
X.85/Y.1321 (2001) Corrigendum 1	06-2005		
X.86/Y.1323	02-2001	Ethernet over LAPS	
X.86/Y.1323 (2001) Amendment 1	04-2002	Using Ethernet flow control as rate limiting	
X.87/Y.1324	10-2003	Multiple services ring based on RPR	
X.92	11-1988	Hypothetical reference connections for public synchronous data networks	
X.96	03-2000	Call progress signals in public data networks	
X.110	04-2002	International routing principles and routing plan for Public Data Networks	
X.111	02-2003	Principles for the routing of international frame relay traffic	
X.115	04-1995	Definition of address translation capability in public data networks	
X.115 (1995) Amendment 1	10-1996	Refinements	
X.116	10-1996	Address translation registration and resolution protocol	
X.121	10-2000	International numbering plan for public data networks	
E.166/X.122	03-1998	Numbering plan interworking for the E.164 and X.121 numbering plans	
X.123	10-1996	Mapping between escape codes and TOA/NPI for E.164/X.121 numbering plan interworking during the transition period	
X.124	06-1999	Arrangements for the interworking of the E.164 and X.121 numbering plans for frame relay and ATM networks	
X.125	09-1998	Procedure for the notification of the assignment of international network identification codes for public frame relay data networks and ATM networks numbered under the E.164 numbering plan	
X.130	11-1988	Call processing delays in public data networks when providing international synchronous circuit-switched data services	
X.131	11-1988	Call blocking in public data networks when providing international synchronous circuit-switched data services	
X.134	08-1997	Portion boundaries and packet-layer reference events: basis for defining packet-switched performance parameters	
X.135	08-1997	Speed of service (delay and throughput) performance values for public data networks when providing international packet-switched services	
X.135 Suppl. 1	08-1997	Some test results from specific national and international portions	Not available, contact sales@itu.int.
X.136	08-1997	Accuracy and dependability performance values for public data networks when providing international packet-switched services	
X.137	08-1997	Availability performance values for public data networks when providing international packet-switched services	
X.138	08-1997	Measurement of performance values for public data networks when providing international packet-switched services	

X.139	08-1997	Echo, drop, generator and test DTEs for measurement of performance values in public data networks when providing international packet-switched services	
X.140	09-1992	General quality of service parameters for communication via public data networks	
X.141	11-1988	General principles for the detection and correction of errors in public data networks	
X.141 (1988) Corrigendum 1	02-1990		Available only in PDF.
X.142	10-2003	Quality of service metrics for characterizing Frame Relay/ATM service interworking performance	
X.144	10-2003	User information transfer performance parameters for public frame relay data networks	
X.145	10-2003	Connection establishment and disengagement performance parameters for public Frame Relay data networks providing SVC services	
X.146	10-2000	Performance objectives and quality of service classes applicable to frame relay	
X.147	10-2003	Frame Relay network availability	
X.147 (2003) Amendment 1	04-2004	Specification of availability objective values	
X.148	02-2003	Procedures for the measurement of the performance of public data networks providing the international frame relay service	
X.149	10-2003	Performance of IP networks when supported by public Frame Relay data networks	
X.150	11-1988	Principles of maintenance testing for public data networks using Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) test loops	
X.151	10-2003	Frame Relay operations and maintenance – Principles and functions	
X.151 (2003) Erratum 1	03-2004		
X.160	10-1996	Architecture for customer network management service for public data networks	
X.161	08-1997	Definition of customer network management services for public data networks	
X.162	03-2000	Definition of management information for customer network management service for public data networks to be used with the CNMc interface	
X.163	04-1995	Definition of management information for customer network management service for public data networks to be used with the CNMe interface	
X.170	06-1999	Network-network management architecture for data networks	
X.171	03-2000	Network-network management services for data networks	
X.180	11-1988	Administrative arrangements for international closed user groups (CUGs)	
X.181	11-1988	Administrative arrangements for the provision of international permanent virtual circuits (PVCs)	

X.200	07-1994	Information technology – Open Systems Interconnection – Basic Reference Model: The basic model
X.207	11-1993	Information technology – Open Systems Interconnection – Application layer structure
X.208	11-1988	Specification of Abstract Syntax Notation One (ASN.1)
X.209	11-1988	Specification of Basic Encoding Rules for Abstract Syntax Notation One (ASN.1)
X.210	11-1993	Information technology – Open Systems Interconnection – Basic Reference Model: Conventions for the definition of OSI services
X.211	11-1995	Information technology – Open Systems Interconnection – Physical service definition
X.212	11-1995	Information technology – Open Systems Interconnection – Data Link service definition
X.213	10-2001	Information technology – Open Systems Interconnection – Network service definition
X.214	11-1995	Information technology – Open Systems Interconnection -Transport service definition
X.215	11-1995	Information technology – Open Systems Interconnection – Session service definition
X.215 (1995) Amendment 1	08-1997	Efficiency enhancements
X.215 (1995) Amendment 2	12-1997	Nested connections functional unit
X.215 (1995) Technical Cor. 1	03-2000	
X.216	07-1994	Information technology – Open Systems Interconnection – Presentation service definition
X.216 (1994) Amendment 1	08-1997	Efficiency enhancements
X.216 (1994) Amendment 2	12-1997	Nested connections functional unit
X.217	04-1995	Information technology – Open Systems Interconnection – Service definition for the Association Control Service Element
X.217 (1995) Amendment 1	10-1996	Support of authentication mechanisms for the connectionless mode
X.217 (1995) Amendment 2	08-1997	Fast-associate mechanism
X.217bis	09-1998	Information technology – Open Systems Interconnection – Service definition for the Application Service Object Association Control Service Element
X.218	03-1993	Reliable Transfer: Model and service definition
X.219	11-1988	Remote Operations: Model, notation and service definition
X.220	03-1993	Use of X.200-Series protocols in CCITT applications
X.222	04-1995	Use of X.25 LAPB-compatible Data Link procedures to provide the OSI connection-mode Data Link service

X.222 (1995) Amendment 1	10-1996	Frame relay mapping
X.223	11-1993	Use of X.25 to provide the OSI connection-mode Network service for ITU-T applications
X.223 (1993) Amendment 1	10-1996	Transit delay and other refinements
X.224	11-1995	Information technology – Open Systems Interconnection – Protocol for providing the connection-mode transport service
X.224 (1995) Amendment 1	08-1997	Relaxation of class conformance requirements and expedited data service feature negotiation
X.225	11-1995	Information technology – Open Systems Interconnection – Connection-oriented Session protocol: Protocol specification
X.225 (1995) Amendment 1	08-1997	Efficiency enhancements
X.225 (1995) Amendment 2	12-1997	Nested connections functional unit
X.225 (1995) Technical Cor. 1	03-2000	
X.226	07-1994	Information technology – Open Systems Interconnection – Connection-oriented Presentation protocol: Protocol specification
X.226 (1994) Amendment 1	08-1997	Efficiency enhancements
X.226 (1994) Amendment 2	12-1997	Nested connections functional unit
X.227	04-1995	Information technology – Open Systems Interconnection – Connection-oriented protocol for the Association Control Service Element: Protocol specification
X.227 (1995) Amendment 1	10-1996	Incorporation of extensibility markers
X.227 (1995) Amendment 2	08-1997	Fast-associate mechanism
X.227bis	09-1998	Information technology – Open Systems Interconnection – Connection-mode protocol for the Application Service Object Association Control Service Element
X.228	11-1988	Reliable Transfer: Protocol specification
X.228 (1988) Corrigendum 1	03-2000	
X.229	11-1988	Remote Operations: Protocol specification
X.233	08-1997	Information technology – Protocol for providing the connectionless-mode network service: Protocol specification
X.234	07-1994	Information technology – Protocol for providing the OSI connectionless-mode transport service
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X.790 (1995) Amendment 1	10-1996	Implementation conformance statement proformas	
X.790 (1995) Corrigendum 1	03-1999		
X.790 (1995) Corrigendum 2	03-2001		
X.791	10-1996	Profile for trouble management function for ITU-T applications	
X.792	03-1999	Configuration audit support function for ITU-T applications	
X.792 (1999) Corrigendum 1	08-2001		
X.800	03-1991	Security architecture for Open Systems Interconnection for CCITT applications	
X.800 (1991) Amendment 1	10-1996	Layer Two Security Service and Mechanisms for LANs	
X.802	04-1995	Information technology – Lower layers security model	
X.803	07-1994	Information technology – Open Systems Interconnection – Upper layers security model	
X.805	10-2003	Security architecture for systems providing end-to-end communications	
X.810	11-1995	Information technology – Open Systems Interconnection – Security frameworks for open systems: Overview	
X.811	04-1995	Information technology – Open Systems Interconnection – Security frameworks for open systems: Authentication framework	
X.812	11-1995	Information technology – Open Systems Interconnection – Security frameworks for open systems: Access control framework	
X.813	10-1996	Information technology – Open Systems Interconnection – Security frameworks for open systems: Non-repudiation framework	
X.814	11-1995	Information technology – Open Systems Interconnection – Security frameworks for open systems: Confidentiality framework	
X.815	11-1995	Information technology – Open Systems Interconnection – Security frameworks for open systems: Integrity framework	
X.816	11-1995	Information technology – Open Systems Interconnection – Security frameworks for open systems: Security audit and alarms framework	

X.830	04-1995	Information technology – Open Systems Interconnection – Generic upper layers security: Overview, models and notation
X.831	04-1995	Information technology – Open Systems Interconnection – Generic upper layers security: Security Exchange Service Element (SESE) service definition
X.832	04-1995	Information technology – Open Systems Interconnection – Generic upper layers security: Security Exchange Service Element (SESE) protocol specification
X.833	04-1995	Information technology – Open Systems Interconnection – Generic upper layers security: Protecting transfer syntax specification
X.834	10-1996	Information technology – Open Systems Interconnection – Generic Upper Layers Security: Security Exchange Service Element (SESE) Protocol Implementation Conformance Statement (PICS) proforma
X.835	10-1996	Information technology – Open Systems Interconnection – Generic Upper Layers Security: Protecting transfer syntax Protocol Implementation Conformance Statement (PICS) proforma
X.841	10-2000	Information technology – Security techniques – Security information objects for access control
X.842	10-2000	Information technology – Security techniques – Guidelines for the use and management of trusted third party services
X.843	10-2000	Information technology – Security techniques – Specification of TTP services to support the application of digital signatures
X.851	12-1997	Information technology – Open Systems Interconnection – Service definition for the Commitment, Concurrency and Recovery service element
X.852	12-1997	Information technology – Open Systems Interconnection – Protocol for the Commitment, Concurrency and Recovery service element: Protocol specification
X.853	11-1995	Information technology – Open Systems Interconnection – Protocol for the Commitment, Concurrency and Recovery service element: Protocol Implementation Conformance Statement (PICS) proforma
X.860	12-1997	Open Systems Interconnection – Distributed Transaction Processing: Model
X.861	12-1997	Open Systems Interconnection – Distributed Transaction Processing: Service definition
X.862	12-1997	Open Systems Interconnection – Distributed Transaction Processing: Protocol specification
X.863	07-1994	Information technology – Open Systems Interconnection – Distributed Transaction Processing: Protocol Implementation Conformance Statement (PICS) proforma
X.880	07-1994	Information technology – Remote Operations: Concepts, model and notation
X.880 (1994) Technical Cor. 1	07-1995	
X.880 (1994) Amendment 1	11-1995	Built-in operations
X.881	07-1994	Information technology – Remote Operations: OSI realizations – Remote Operations Service Element (ROSE) service definition

X.881 (1994) Amendment 1	11-1995	Mapping to A-UNIT-DATA service and built-in operations	
X.882	07-1994	Information technology – Remote Operations: OSI realizations – Remote Operations Service Element (ROSE) protocol specification	
X.882 (1994) Technical Cor. 1	07-1995		
X.882 (1994) Amendment 1	11-1995	Mapping to A-UNIT-DATA service and built-in operations	
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X.892	05-2005	Information technology – Generic applications of ASN.1: Fast Web Services	
X.893	05-2007	Information technology – Generic applications of ASN.1: Fast infoset security	Pre-published.
X.901	08-1997	Information technology – Open Distributed Processing – Reference Model: Overview	
X.902	11-1995	Information technology – Open Distributed Processing – Reference Model: Foundations	
X.903	11-1995	Information technology – Open Distributed Processing – Reference Model: Architecture	
X.904	12-1997	Information technology – Open Distributed Processing – Reference Model: Architectural Semantics	
X.904 (1997) Amendment 1	03-2000	Computational formalization	
X.910	09-1998	Information technology – Open Distributed Processing – Naming framework	
X.911	05-2005	Information technology – Open distributed processing – Reference model – Enterprise language	
X.920	12-1997	Information technology – Open Distributed Processing – Interface Definition Language	
X.930	09-1998	Information technology – Open Distributed Processing – Interface references and binding	
X.931	06-1999	Information technology – Open Distributed Processing – Protocol support for computational interactions	
X.950	08-1997	Information technology – Open Distributed Processing – Trading Function: Specification	
X.952	12-1997	Information technology – Open Distributed Processing – Trading function: Provision of trading function using OSI Directory service	
X.952 (1997) Corrigendum 1	07-2005		
X.960	06-1999	Information technology – Open Distributed Processing – Type repository function	
X.960 Erratum 1	10-2002		
X.1035	02-2007	Password-authenticated key exchange (PAK) protocol	Pre-published.
X.1051	07-2004	Information security management system – Requirements for telecommunications (ISMS-T)	

X.1081	04-2004	The telebiometric multimodal model – A framework for the specification of security and safety aspects of telebiometrics	
X.1081 (2004) Corrigendum 1	02-2007		
X.1111	02-2007	Framework of security technologies for home network	Pre-published.
X.1121	04-2004	Framework of security technologies for mobile end-to-end data communications	
X.1122	04-2004	Guideline for implementing secure mobile systems based on PKI	
X.1141	06-2006	Security Assertion Markup Language (SAML 2.0)	
X.1142	06-2006	eXtensible Access Control Markup Language (XACML 2.0)	

Recommendation count: 1012

Series Y : Data networks, open system communications and security

Number	*Approval Date*	*Recommendation Title*	*Status*
Y.100	06-1998	General overview of the Global Information Infrastructure standards development	
Y.101	03-2000	Global Information Infrastructure terminology: Terms and definitions	
Y.110	06-1998	Global Information Infrastructure principles and framework architecture	
Y.120	06-1998	Global Information Infrastructure scenario methodology	
Y.120 (1998) Corrigendum 1	11-2000		
Y.120 Annex A	02-1999	Examples of use	
Y.130	03-2000	Information communication architecture	
Y.140	11-2000	Global Information Infrastructure (GII): Reference points for interconnection framework	
Y.140.1	03-2004	Guideline for attributes and requirements for interconnection between public telecommunication network operators and service providers involved in provision of telecommunication services	
Y.1001	11-2000	IP framework – A framework for convergence of telecommunications network and IP network technologies	
Y.1221	03-2002	Traffic control and congestion control in IP-based networks	
Y.1221 (2002) Amendment 1	03-2004	Extensions to transfer capabilities	
Y.1221 (2002) Amendment 2	11-2005	Further extension to transfer capabilities	
Y.1231	11-2000	IP Access Network Architecture	
Y.1241	03-2001	Support of IP-based services using IP transfer capabilities	
G.769/Y.1242	06-2004	Circuit multiplication equipment optimized for IP-based networks	
Y.1251	08-2002	General architectural model for interworking	
Y.1261	12-2002	Service requirements and architecture for voice services over Multi-Protocol Label Switching	
Y.1261 (2002) Erratum 1	02-2004		
Y.1271	10-2004	Framework(s) on network requirements and capabilities to support emergency telecommunications over evolving circuit-switched and packet-switched networks	
Y.1281	09-2003	Mobile IP services over MPLS	
Y.1291	05-2004	An architectural framework for support of Quality of Service in packet networks	

G.871/Y.1301	10-2000	Framework of Optical Transport Network Recommendations	
G.7041/Y.1303	08-2005	Generic framing procedure (GFP)	
G.7041/Y.1303 (2005) Amendment 1	03-2006		
G.7041/Y.1303 (2005) Corrigendum 1	12-2006		
G.7041/Y.1303 (2005) Amendment 2	07-2007		Pre-published.
G.8080/Y.1304	06-2006	Architecture for the automatically switched optical network (ASON)	
G.8080/Y.1304 (2006) Erratum 1	04-2007		
G.7042/Y.1305	03-2006	Link capacity adjustment scheme (LCAS) for virtual concatenated signals	
G.8010/Y.1306	02-2004	Architecture of Ethernet layer networks	
G.8010/Y.1306 Amendment 1	05-2006		Pre-published.
G.8011/Y.1307	08-2004	Ethernet over Transport – Ethernet services framework	
G.8011/Y.1307 (2004) Corrigendum 1	06-2005		
G.8011/Y.1307 (2004) Amendment 1	08-2005		
G.8011.1/Y.1307.1	08-2004	Ethernet private line service	
G.8011.1/Y.1307.1 (2004) Corrigendum 1	06-2005		
G.8011.2/Y.1307.2	09-2005	Ethernet virtual private line service	
G.8012/Y.1308	08-2004	Ethernet UNI and Ethernet NNI	
G.8012/Y.1308 (2004) Amendment 1	05-2006		
Y.1310	03-2004	Transport of IP over ATM in public networks	
Y.1311	03-2002	Network-based VPNs – Generic architecture and service requirements	
Y.1311.1	07-2001	Network-based IP VPN over MPLS architecture	
Y.1312	09-2003	Layer 1 Virtual Private Network generic requirements and architecture elements	
Y.1313	07-2004	Layer 1 Virtual Private Network service and network architectures	
Y.1314	10-2005	Virtual private network functional decomposition	
Y.1315	09-2006	QoS support for VPN services – Framework and characteristics	Pre-published.
X.85/Y.1321	03-2001	IP over SDH using LAPS	

X.85/Y.1321 (2001) Amendment 1	04-2004	Bit-oriented method for LAPS	
X.85/Y.1321 (2001) Corrigendum 1	06-2005		
G.707/Y.1322	01-2007	Network node interface for the synchronous digital hierarchy (SDH)	Pre-published.
G.707/Y.1322 (2007) Amendment 1	07-2007		Pre-published.
X.86/Y.1323	02-2001	Ethernet over LAPS	
X.86/Y.1323 (2001) Amendment 1	04-2002	Using Ethernet flow control as rate limiting	
X.87/Y.1324	10-2003	Multiple services ring based on RPR	
G.709/Y.1331	03-2003	Interfaces for the Optical Transport Network (OTN)	
G.709/Y.1331 (2003) Amend.1	12-2003		Not available, contact sales@itu.int.
G.709/Y.1331 (2003) Corrigendum 1	12-2006		Pre-published.
G.8040/Y.1340	09-2005	GFP frame mapping into Plesiochronous Digital Hierarchy (PDH)	
G.8021/Y.1341	08-2004	Characteristics of Ethernet transport network equipment functional blocks	
G.8021/Y.1341 (2004) Amendment 1	06-2006		Pre-published.
G.8031/Y.1342	06-2006	Ethernet Protection Switching	
G.7043/Y.1343	07-2004	Virtual concatenation of plesiochronous digital hierarchy (PDH) signals	
G.7043/Y.1343 (2004) Amendment 1	01-2005		
G.7043/Y.1343 (2004) Corrigendum 1	12-2006		
G.780/Y.1351	07-2004	Terms and definitions for synchronous digital hierarchy (SDH) networks	
G.780/Y.1351 (2004) Amendment 1	06-2005		
G.870/Y.1352	06-2004	Terms and definitions for optical transport networks (OTN)	
G.870/Y.1352 (2004) Amendment 1	06-2005		
G.8081/Y.1353	06-2004	Terms and definitions for Automatically Switched Optical Networks (ASON)	
G.8081/Y.1353 (2004) Amendment 1	06-2006		

G.8081/Y.1353 (2004) Amend.2	07-2007		Not available, contact sales@itu.int.
G.8001/Y.1354	06-2006	Terms and definitions for Ethernet frames over Transport (EoT)	
G.8001/Y.1354 (2006) Amendment 1	07-2007		Pre-published.
G.8101	12-2006	Terms and definitions for transport MPLS	
G.8261/Y.1361	05-2006	Timing and synchronization aspects in packet networks	
G.8261/Y.1361 (2006) Corrigendum 1	12-2006		Pre-published.
G.8110/Y.1370	01-2005	MPLS layer network architecture	
G.8110.1/Y.1370.1	11-2006	Architecture of Transport MPLS (T-MPLS) layer network	
G.8110.1/Y.1370.1 (2006) Amend.1	07-2007		Not available, contact sales@itu.int.
G.8112/Y.1371	10-2006	Interfaces for the Transport MPLS (T-MPLS) hierarchy	
G.8112/Y.1371 (2006) Cor.1	01-2007		Not available, contact sales@itu.int.
G.8121/Y.1381	03-2006	Characteristics of Transport MPLS equipment functional blocks	
G.8121/Y.1361 (2006) Corrigendum 1	12-2006		
G.8131/Y.1382	02-2007	Linear protection switching for Transport MPLS (T-MPLS) networks	Pre-published.
G.8601/Y.1391	06-2006	Architecture of service management in multi-bearer, multi-carrier environment	
Y.1401	10-2000	General requirements for interworking with Internet protocol (IP)-based networks	
X.371/Y.1402	02-2001	General arrangements for interworking between Public Data Networks and the Internet	
Y.1411	02-2003	ATM-MPLS network interworking – Cell mode user plane interworking	
Y.1412	11-2003	ATM-MPLS network interworking – Frame mode user plane interworking	
Y.1413	03-2004	TDM-MPLS network interworking – User plane interworking	
Y.1413 Corrigendum 1	10-2005		
Y.1414	07-2004	Voice services – MPLS network interworking	
Y.1415	02-2005	Ethernet-MPLS network interworking – User plane interworking	
Y.1415 (2005) Amendment 1	04-2007	New Appendix II – Use of Ethernet-MPLS interworking for transport of IP/MPLS services	Pre-published.

G.799.1/Y.1451.1	06-2004	Functionality and interface specifications for GSTN transport network equipment for interconnecting GSTN and IP networks	
Y.1452	03-2006	Voice trunking over IP networks	
Y.1453	03-2006	TDM-IP interworking – User plane interworking	
Y.1454	12-2006	Tandem free operation (TFO)-IP network interworking – User plane interworking	
G.820/I.351/Y.1501	07-2004	Relationships among ISDN, IP-based network and physical layer performance Recommendations	
Y.1530	05-2004	Call processing performance for voice service in hybrid IP networks	
Y.1540	12-2002	Internet protocol data communication service – IP packet transfer and availability performance parameters	
Y.1540 (2002) Amendment 1	08-2003	New Appendix VIII: Background on IP service availability	
Y.1541	02-2006	Network performance objectives for IP-based services	
Y.1541 (2006) Amendment 1	06-2006	New Appendix X – An example showing how to calculate IPDV across multiple sections	
Y.1541 (2006) Amendment 2	01-2007	New appendix XI – Digital circuit (ISDN) emulation requirements on IP-based networks	
Y.1542	07-2006	Framework for achieving end-to-end IP performance objectives	
Y.1560	09-2003	Parameters for TCP connection performance in the presence of middleboxes	
Y.1561	05-2004	Performance and availability parameters for MPLS networks	
Y.1562	03-2007	Framework for higher layer protocol performance parameters and their measurement	Pre-published.
G.7710/Y.1701	11-2001	Common equipment management function requirements	
G.7712/Y.1703	03-2003	Architecture and specification of data communication network	
G.7713/Y.1704	05-2006	Distributed Call and Connection Management (DCM)	
G.7713.1/Y.1704.1	03-2003	Distributed Call and Connection Management (DCM) based on PNNI	
G.7713.2/Y.1704.2	03-2003	Distributed Call and Connection Management: Signalling mechanism using GMPLS RSVP-TE	
G.7713.3/Y.1704.3	03-2003	Distributed Call and Connection Management: Signalling mechanism using GMPLS CR-LDP	
G.7714/Y.1705	08-2005	Generalized automatic discovery for transport entities	
G.7714.1/Y.1705.1	04-2003	Protocol for automatic discovery in SDH and OTN networks	
G.7714.1/Y.1705.1 (2003) Amendment 1	02-2006	New Appendix VI – Usage of the different discovery mechanisms	
G.7715/Y.1706	06-2002	Architecture and requirements for routing in the automatically switched optical networks	
G.7715/Y.1706 (2002) Amendment 1	02-2007		

G.7715.1/Y.1706.1	02-2004	ASON routing architecture and requirements for link state protocols	
G.7715.2/Y.1706.2	02-2007	ASON routing architecture and requirements for remote route query	Pre-published.
G.7718/Y.1709	02-2005	Framework for ASON management	
G.7718.1/Y.1709.1	12-2006	Protocol-neutral management information model for the control plane view	Pre-published.
Y.1710	11-2002	Requirements for Operation & Maintenance functionality in MPLS networks	
Y.1711	02-2004	Operation & Maintenance mechanism for MPLS networks	
Y.1711 (2004) Corrigendum 1	02-2005		
Y.1711 Amendment 1	10-2005	New function type codes	
Y.1712	01-2004	OAM functionality for ATM-MPLS interworking	
Y.1713	03-2004	Misbranching detection for MPLS networks	
Y.1714	01-2007	MPLS management and OAM framework	Pre-published.
Y.1720	12-2006	Protection switching for MPLS networks	Pre-published.
Y.1730	01-2004	Requirements for OAM functions in Ethernet-based networks and Ethernet services	
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Y.1731 (2006) Erratum 1	12-2006		
Y.2001	12-2004	General overview of NGN	
Y.2011	10-2004	General principles and general reference model for Next Generation Networks	
Y.2012	09-2006	Functional requirements and architecture of the NGN release 1	
Y.2012 (2006) Supplement 1	07-2006	Session/border control (S/BC) functions	
Y.2013	12-2006	Converged services framework functional requirements and architecture	Pre-published.
Y.2021	09-2006	IMS for Next Generation Networks	
Y.2031	09-2006	PSTN/ISDN emulation architecture	
Y.2091	03-2007	Terms and definitions for Next Generation Networks	Pre-published.
Y.2111	09-2006	Resource and admission control functions in Next Generation Networks	
Y.2171	09-2006	Admission control priority levels in Next Generation Networks	
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Y.2201	04-2007	NGN release 1 requirements	Pre-published.

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Y.2262	12-2006	PSTN/ISDN emulation and simulation	Not available, contact sales@itu.int.
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Y.2271 (2006) Erratum 1	03-2007		
M.3060/Y.2401	03-2006	Principles for the Management of Next Generation Networks	
Y.2601	12-2006	Fundamental characteristics and requirements of future packet based networks	
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Y.2901	12-2006	The carrier grade open environment reference model	Pre-published.
Y.2902	12-2006	Carrier grade open environment components	
Y.2000SerSup1	07-2006	NGN release 1 scope	Pre-published.

Recommendation count: 272

Series Z : Languages and general software aspects for telecommunication systems

Number	*Approval Date*	*Recommendation Title*	*Status*
Z.100	08-2002	Specification and Description Language (SDL)	
Z.100 (2002) Amendment 1	10-2003	Backwards compatibility and compliance	
Z.100 (2002) Corrigendum 1	08-2004		
Z.100 Annex F1	11-2000	SDL formal definition: General overview	
Z.100 Annex F2	11-2000	SDL formal definition: Static semantics	Available only in PDF.
Z.100 Annex F3	11-2000	SDL formal definition: Dynamic semantics	
Z.100 Supplement 1	05-1997	SDL+ methodology: use of MSC and SDL (with ASN.1)	
Z.104	10-2004	Encoding of SDL data	
Z.105	07-2003	SDL combined with ASN.1 modules (SDL/ASN.1)	
Z.106	08-2002	Common interchange format for SDL	
Z.107	11-1999	SDL with embedded ASN.1	
Z.109	06-2007	SDL-2000 combined with UML	Pre-published.
Z.110	11-2000	Criteria for use of formal description techniques by ITU-T	
Z.119	02-2007	Guidelines for UML profile design	Pre-published.
Z.120	04-2004	Message sequence chart (MSC)	Pre-published.
Z.120 Annex B	04-1998	Formal semantics of message sequence charts	Available only in PDF.
Z.121	02-2003	Specification and Description Language (SDL) data binding to Message Sequence Charts (MSC)	
Z.130	07-2003	Extended Object Definition Language (eODL): Techniques for distributed software component development – Conceptual foundation, notations and technology mappings	Pre-published.
Z.130 (2003) Amendment 1	06-2006	New Annex E – eODL to CIDL mapping	
Z.140	03-2006	Testing and Test Control Notation version 3 (TTCN-3): Core language	
Z.141	03-2006	Testing and Test Control Notation version 3 (TTCN-3): Tabular presentation format (TFT)	
Z.142	03-2006	Testing and Test Control Notation version 3 (TTCN-3): Graphical presentation format (GFT)	

Z.143	03-2006	Testing and Test Control Notation version 3 (TTCN-3): Operational semantics
Z.144	03-2006	Testing and Test Control Notation version 3 (TTCN-3): Runtime interface (TRI)
Z.145	03-2006	Testing and Test Control Notation version 3 (TTCN-3): Control interface (TCI)
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Z.341	11-1988	Glossary of terms

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Z.450	10-2003	Quality aspects of protocol-related Recommendations	
Z.500	05-1997	Framework on formal methods in conformance testing	
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Recommendation count: 129

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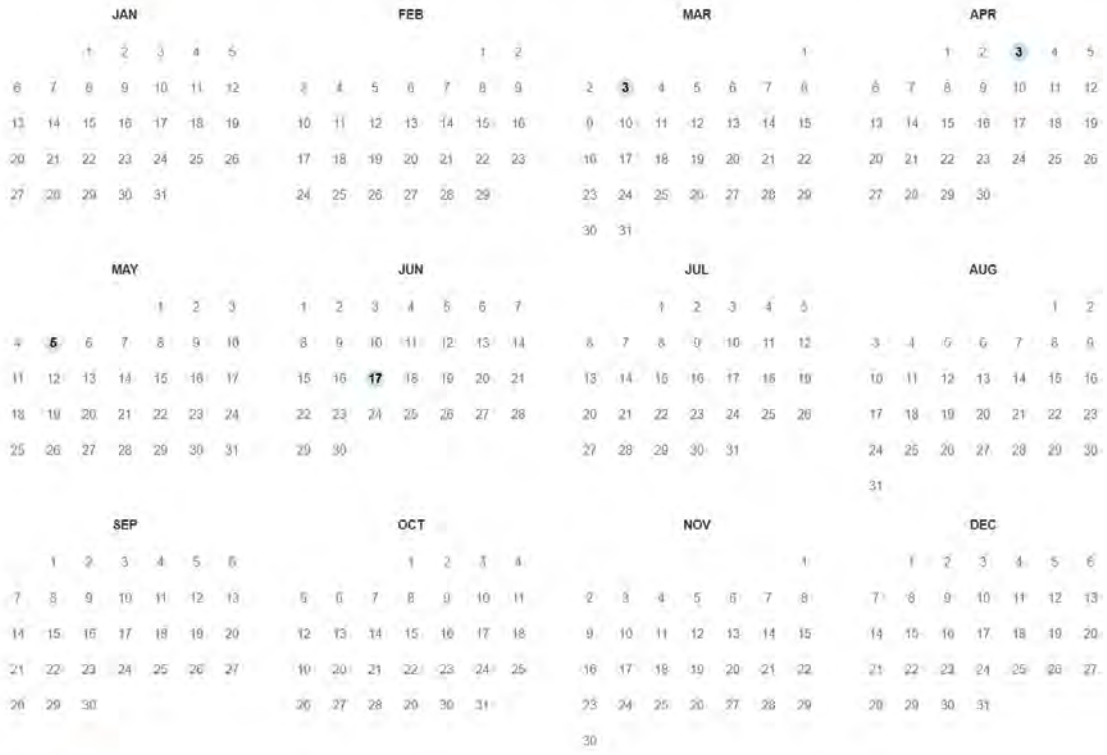
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Table of contents : March edition
Table of contents : June edition
Table of contents : September edition

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APPENDIX H26406

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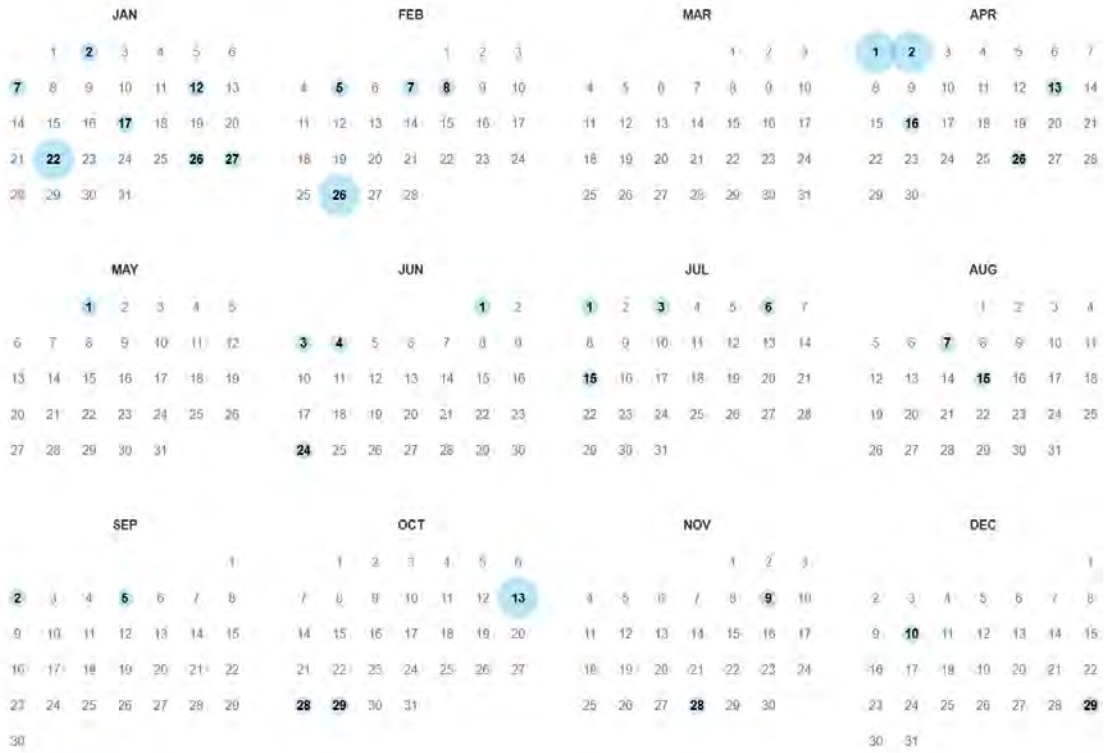
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APPENDIX H26407

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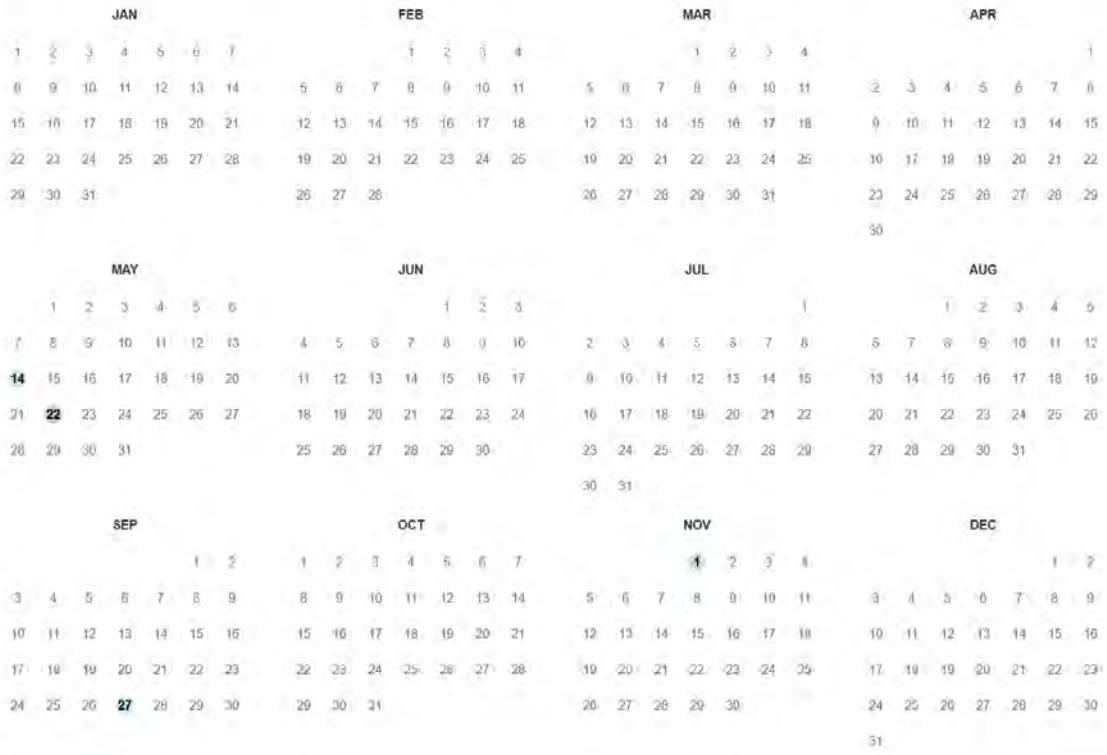
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>> Study Group 16 : Multimedia terminals, systems and applications

Results from previous meetings: 2005-07 | 2004-11 | 2004-01 | 2003-05 | 2002-10

Meeting Results
Geneva, 3 - 13 April 2006

Executive Summary of the meeting

Major Plenary accomplishments:

- Consented Recommendations: 34 at this meeting
  - Consent of H.324 Annex K was postponed for a special WP2/16 Plenary to be held 13 June 2006 (see TSB Collective 4/16)
- Recommendations Decided/Determined/Approved: none at this meeting
- Recommendations deleted or proposed for deletion: none
- Other texts approved: errata (1), appendices (0), supplements (3), technical papers (0), and implementors' guides (7)
- For updates to the SG 16 management team, see below
- List of interim meetings pre-approved: see related link
- Final text of outgoing Liaison Statements: see related link (TIES account needed)

The meeting had 145 attendees during the meeting period (compared to 152 at the last meeting). The final list of participants is available in TD 263 (P)

Map of meeting reports & Liaison Statements (as seen by the SG 16 Plenary)

	Plen	WP1	WP2	WP3
Meeting Report	TD 230R2(P) Q20: TD 231(P) Q26: TD 232R1+ 267+ 269+ 270(P)	TD 233R2 (P)	TD 234R2 (P)	TD 235R1 (P) + TD 266 (P)
Liaison Statements	Q20: TD 264R1 (P) Q26: TD 268R1 (P) Others: TD 272R1+ 273R1+ 277R1(P)	TD 236R1 (P)	TD 237R1 (P)	TD 238R1 (P)
Work Programme	-	TD 239 (P)	TD 240R1 (P)	TD 241 (P)

Summary of Questions' Results

Question 1/16 Summary
Question 1 reviewed several matters in relation with H.324/M, in particular, contributions proposing call setup acceleration techniques which led to the successful creation of a new Annex K/H.324. This annex specifies a media oriented acceleration negotiation technique for H.324/M terminals. Along other enhancements, a Reduced-Complexity Decoding Operation (RCDO) for H.264 Baseline Profile Bitstreams was added to H.241 as a new Annex B. It specifies RCDO, a reduced-complexity decoding process to be applied to H.264 Baseline profile bitstreams when such use has been negotiated using Rec. H.241. Question 1 prepared two Recommendations and two Corrigenda for Consent (H.222.0 Cor. 5, H.241, H.324 Cor. 1, and H.324 Annex K). (Note: Consent of H.324 Annex K was postponed, see COM16-R10 for details).

Question 2/16 Summary
Question 2 had a very successful meeting, working to put a number of new and revised Recommendations forward for consent. It was agreed at this meeting to consent revised versions of H.323, H.225.0, H.245, and H.246. We also completed work on two new Recommendations: H.460.21 ("Message Broadcast for H.323 Systems") and H.249 ("Extended User Input Indications"). We also approved a revised H.323 Implementers Guide and the H-series Supplement 4.

Question 3/16 Summary
Q.3/16 met for 11 quarters to review some 110 documents. Q.3/16 continued work on a number of existing work items which has resulted in seven Recommendations for Consent: H.248.19 Amendment 1, H.248.23 Corrigendum 1, H.248.38, H.248.39, H.248.41, H.248.42 and H.248.45. In addition to these Recommendations Q.3 prepared 5 documents for approval: H-Series Supplement 2 "Packages Guide", H-Series Supplement 6 "Decomposed Gateways - Control Load Quantum - Busy Hour Context Attempts (BHCoA) and Busy Hour Session Attempts (BHSA)", H.248 Sub-Series Implementors' Guide, H.248.1 version 1 Implementors' Guide and the H.248.1 version 2 Implementors' Guide . Eight new work items were agreed for: H.248.2 Amendment 1, H.248.9 Amendment 1, H.248.25 Amendment 1, H.248.28 Amendment 1, H.248.30 Amendment 1, H.248.CCC "Connection Capability Control Package", H.248.SCR "Statistic Conditional Reporting Package" and H.248.QHR "RTCP HR QoS Statistics Packages". The group agreed to create an H.248.1 Living List containing desirable functionality that would require a new version of the H.248 protocol. Four Liaison Statements were generated to ITU-T Study Group 11 and ETSI TISPAN and 3GPP.
The Rapporteur would like to thank the contributors to the Q.3 work and especially the editors for their work in preparing Recommendations.

Question 4/16 Summary
This meeting revised H.350 Sub-series Implementors' Guide clarifying the use of commPrivate attribute in H.350. It also identified several areas where enhancements of H.350 Sub-series are needed. It is expected that H.350 Sub-series will be revised at the next meeting with these corrections and enhancements.

Question 5/16 Summary
Question 5 made good progress on H.proxy, which was the primary focus of the meeting. The experts reached several important agreements, trying to clarify the expectations for this Recommendation and nature of contributions expected at the next meeting. We expect further input at the upcoming meetings, with a goal of putting the text forward for consent at the November 2006 Study Group 16 Meeting.

Question 6/16 Summary
Q.6/16 is also sometimes referred to as "VCEG" (Video Coding Experts Group). Some of the work of Q.6/16 is also conducted jointly with ISO/IEC JTC 1/SC 29/WG 11 (MPEG) in an organization known as "the JVT" (Joint Video Team). A collocated meeting of the JVT was held during the first week of this SG 16 meeting. The JVT work was concentrated primarily on the development of extensions of Rec. H.264 to support scalable video coding (SVC) and coding of video with a 4:4:4 chroma format.

The primary goals for Q.6/16 at this meeting of SG 16 were to review the progress of Q.6 and JVT work, to reach AAP Consent on those work items that have reached sufficient maturity, and to plan future work. Q.6 items for AAP Consent at this meeting included 1) a Draft Technical Corrigendum to Rec. H.262 to correct IDCT accuracy requirements, 2) an Amendment to Rec. H.264 to support additional colour spaces and to remove the specification of the existing High 4:4:4 profile, and 3) a Draft New Rec. H.VBCM to specify syntax and semantics for video back channel messages for conveyance of status information and requests from a video receiver to a video sender. The goals of the meeting were achieved to the satisfaction of Q.6. The Question plans two interim Rapporteurs meetings.

Question 9/16 Summary
The Terms of Reference (ToRs) for the EV-VBR codec (annex Q9.A) were clarified and the schedule for standardization has been updated (annex Q9.B). Selection Methods have been discussed and a prioritization of the ToRs has been developed. From this prioritized list of requirements, two new measures of candidate performance have been developed (annex Q9.D) and will be

used to aid the selection of the baseline codec. The current number of candidate codecs for the baseline selection is six; however this may reduce if further collaborations are formed (deadline 31 May 2006). The selection test conditions have been reviewed and modified (annex Q9.C) based upon this number and a liaison statement has been compiled to provide SG12 with the necessary information for them to draft the test plan for the selection of the baseline codec, hopefully in time for approval at their June meeting. An initial framework for the ToRs of the Super-Wideband modes of the codec has been created (annex Q9.E). The Question is planning an interim Rapporteurs meeting in June 2006.

Question 10/16 Summary
The group completed a new extension to ITU-T G.729 dubbed G.729EV , revisions of ITU-T G.723.1 and of G.728 Annex J. The group also revised the Implementors' Guides for G.728 and G.729. An Erratum to G.729 main body text was also prepared. Following ETSI TC DECT request, the group agreed to launch the standardisation of a Packet Loss Concealment (PLC) algorithm for G.722. Terms of Reference and time schedule have been drafted; they will be finalised by correspondence in liaison with ETSI TC DECT. The foreseen approval date is November 2006 (G.722 Appendix III). The standardization a floating point version of G.722.1C (future Annex D) has resumed and is foreseen for Consent in November 2006. G.729EV optimization/Characterization phase step 1 is completed. Characterization phase step 2 has been launched and it will be completed at next SG16 Plenary meeting. Software tools that need to be adapted to SG16 speech and audio coding ongoing standardization works will be updated. Q10/16 reviewed a proposal of a new work item on an embedded variable bit rate extension to G.722.2; it will be further discussed at the next meetings based on written input documents. Q10/16 produced outgoing Liaison Statements to SG12 (on G.191 update, G.729EV, G.722 PLC, G.722.1 D), to ETSI TC DECT (on G.722 PLC) and on G.722.2 EV (to 3GPP, 3GPP2 and ISO/MPEG).

The work will progress by correspondence and will be reviewed at the next Q10/16 meeting, planned in early June 2006 as an interim meeting.

Question 11/16 Summary
The group had as a goal to complete the work on a draft new Recommendation that defines Procedures for the end-to-end connection of analogue PSTN text telephones over an IP network utilizing text relay (V.151). A second goal was to complete the text of a new Amendment to V.150.1 that supports V.151 and also adds new SPRT data types. On completion of discussing several Delayed contributions it was agreed by the group to create a new corrigendum to V.152 to add clarification and correct editorial errors. The Question plans to hold one interim meeting.

Question 14/16 Summary
The group had as a goal to review and address maintenance issues against the T-series Recommendations within its sphere of responsibility. Several Delayed contributions were presented against T.38. These were reviewed and it was agreed not to submit a new version of T.38 for consent at this meeting. Rather, it was agreed to collate the accepted changes to T.38 into a single document that would be a living list of baseline text. Contributions to future meetings addressing or commenting on this baseline text are requested. The Question plans to hold one interim meeting.

Question 15/16 Summary
At this meeting, Q15/16 finalized the draft Corrigendum 1 to Recommendation G.767 for consent. Advance was also made in the work for the enhancement of G.769. Two contributions were reviewed, one to report the quality evaluation results to emphasize the merit of channel multiplexing scheme in IP-CME, and another to propose the method for the end-to-end QoS parameters notification for NGN terminals. Regarding the work on drafting I.733, the group agreed to postpone the decision whether terminate drafting work or not, since submission of contributions at expected interim meeting was suggested. The Question plans to hold one interim meeting.

Question 16/16 Summary
Further progress was made on drafting text for revised ITU-T Rec. G.168 (Echo Cancellers) and new ITU-T Rec. G.160 (Voice Enhancement Devices). G.168 is planned for Consent in November 2006. G.160 was planned for Consent at this meeting but it was agreed that the text was not sufficiently stable. Instead, a work plan was developed to address the issues for Consent of G.160 at a later date. One liaison statement was sent to SG12requesting the development of a new objective test method for evaluating the voice quality of noise reduction functions. One interim meeting is proposed for 30 August to 5 September 2006.

Question 17/16 Summary
At this meeting, Q.17 reviewed three incoming LSs and produced two outgoing LSs. Three delayed contributions were discussed. The question agreed to version 1.4 of the draft G.IP2IP, and the living list of G. 799.1/Y.1451.1 was updated. The Question is planning one interim meeting 30 August - 5 September 2006.

Question 18/16 Summary
The purpose of the meeting was to advance the work on draft new Recommendation Q.115.2 "Logic for the control of Voice Enhancement Devices/Functions", draft new Recommendation G.mdcspne "Mechanism for dynamic coordination of SPNE", draft revised Recommendation G.161 "Interaction aspects of signal processing network equipment" for consent in 2006 and draft new Recommendation G.UCPSPNE about "SPNE mechanisms/auxiliary functions" for consent in 2007.
It was agreed to add new Terms and definitions of Network Signal Processing into all relevant Recommendations related to SPNE and to inform the TSB in order to revise the current definitions in the data base SANCHO. The definitions can be found in section 3.4.4 Discussions, TD 115(WP1/16).
It was agreed to request for one experts meeting before the next SG 16 meeting to progress the work on G.161_2006, Q.115.2, G.mdcspne for the consent date November 2006 and the new Recommendation G.UCPSPNE for the consent date 2007.

Question 20/16 Summary
Q20/16 reviewed the MEDIACOM project description. Within the MEDIACOM project a number of specific actions for coordination have been decided. Q20/16 updated the action plan for developing countries and countries with economies in transition to include the latest development of the WTDC. Q20/16 again stressed that its implementation is very much dependant on the appointment of a liaison officer to these countries. Q20/16 asks for volunteers. Q20/16 also reviewed the action plan on MM technical facilities to support Early Warning information Messages. Regarding NGN, Q20/16 decided to propose to start the preparation of a workshop on MM in NGN together with SGs 9, 11, 12, 13 and 19 to be held beginning of 2007.

Question 21/16 Summary
Question 21/16 has progressed work on "Multimedia over NGN" by giving an educational point of view of the project H.325, adding some QoS and interoperability considerations as far as terminals are concerned. It was decided to keep the H.saarch draft as a good base to define a multimedia architecture (particularly dealing with A/V services) independent from any technology. Thus the requirements described in should be useful to define a relevant NGN framework jointly with SG13. It was proposed to define also an IPTV recommendation project (e.g. H.612) and to work on the topic with the IPTV FG. A first contribution to this document was discussed, taking into account IP streaming services. Finally, it was also decided to work on home networking issues within H.saarch and H.612 contexts. Many SDOs were considered as relevant as far as the development of a new IPTV recommendation is concerned (ATIS, DVB, HGI, ...), according to the presentations from the IPTV consultation. It was especially decided to cooperate with the DSL Forum (above all) so as to make a relevant IPTV Recommendation.

Question 22/16 Summary
At this meeting,Q.22 met for 4 quarters, and for 3 out of the 4 Q.22 held joint session with Q.21. There are two LS and 7 delayed contributions reviewed. We covered the issues in different areas including IPTV and IP streaming,NRFID, project "H.325" and IP videotelephony. For the IPTV area, documents including 3 delayed contributions from China were presented and discussed with a status report produced (TD 270/WP2 rev1) as the output of an editorial team. As for NRFID, one contribution from Japan together with a brief presentation from University of North Carolina were presented followed by an extended discussion. It was agreed that it is an important direction for SG16 and its impacts on multimedia services in the NGN framework should be studied, therefore further contributions are solicited. Two contributions concerning project "H.325" were reviewed. Interesting problems such as decentralized architecture, peer-to-peer and end-to-end security were discussed. Problems were identified and listed, but there seems to be a solution which we expect to see in subsequent contributions. Two LSs from DSL Forum were considered and possible cooperation opportunities with DSL Forum were discovered. The Rapporteur would like to thank all the contributors to the Q.22 work and is looking forward to their continued participation and support.

Question 23/16 Summary
At this meeting, Q.23 forwarded for Consent four texts related to JPEG-2000, a Corrigendum for Rec. T.851, and Draft new ITU-T T.55 | ISO/IEC 10646 "Information technology - Universal Multiple-Octet Coded Character Set (UCS)" and Amendment 1 to that new Rec., as common text with ISO/IEC. Q.23 also progressed work on the Multimedia Convergence Codec (MMCC), gamma correction, and a possible new "Sound Activity Detector". A new version of the Multimedia Coding Summary Database (MCSD) was produced. Q.23 generated LS regarding speech codecs in draft revised J.161, signal level definitions for transcoding between narrowband and wideband audio codecs, latency and the NGN, JPEG-related topics, and Unicode-related topics. The Question is planning an interim Rapporteurs meeting in June 2006.

Question 24/16 Summary
Question 24/16 has made good progress in the work on draft new Recommendation H.361 (ex H.mmqos, entitled "End-to-End QoS and Service Priority Signaling in H.323 Systems"), and the document has been moved forward for consent according to the comments provided at the meeting. In addition, Question 24/16 has discussed possible new work items regarding the speech quality and end-to-end QoS control based on QoS feedback using existing protocols.

Question 25/16 Summary
Q.25 achieved significant progress on draft Recommendation H.460.spn "Security Protocol Negotiation capability"; this draft is scheduled for consent at the next meeting. Further there were fruitful discussions around the activity of federated secure Internet conferencing, that topic may be studied in the context of vision H.325.

Question 26/16 Summary
The work in Q26 continued on the development of the draft Recommendation on accessibility guidelines. It is planned to seek consent at the next meeting of SG16. The accessibility checklist,

created for the NGN work in ITU, was revised and is now considered to be complete. It will be made more widely available after further experience with its use. During the meeting a successful joint meeting with Q3/2 was held to explore ways of collaborating between the two groups and avoiding any potential duplication of work. Contributions are needed on accessibility guidelines, amendments to V.18 and service descriptions for text communications. Members of the group will continue to take part in workshops and other events. A project was started to prepare for the joint UNESCO/ITU accessibility event planned to be held in early 2007. It was agreed to request that accessibility documents be made available at no charge from the ITU web site.

Question 27/16 Summary
The deletion of the Question was proposed, based on the fact that for several meetings the Question has received no contributions, there is no Rapporteur. It was agreed that any work on this question should be redistributed as needed among other SG 16 Questions (e.g. Q.1, Q.2 for MM Systems) and that the general aspects would be dealt with under Q.20/16. This has been agreed by the meeting.

Question 28/16 Summary
Q 28/16 presented the activities carried out since last SG16 meeting. An updated draft roadmap about standardization on e-health is presented although very few inputs have been received from experts. An initial version shall be ready by June whereas it has been agreed to arrange a workshop specifically focused on the discussion of the roadmap around November 06.
It was reported also the work carried out under the E-health Standardisation Coordination Group (eHSCG) and the Healthcare Technology Task force (HTTF), mainly oriented to coordination among SDOs and promotional activities.
The need of external experts was also appointed as one of the reasons for the reduced number of contributions although there are very high expectative on health and standards.

Question 29/16 Summary
In the context of NGN GSI Question 29/16 has started a close co-operation with Questions Q.6/13 as well as Questions Q.2 and Q.5/19 on mobility-related issues for NGN. This co-operation has helped Q.29/16 to proceed with work on H.mmsm (Service Mobility for new Multimedia Service Architecture). A new draft 0.4 revision of an associated technical paper was presented. The content of the paper is consolidated with concerned Questions in other study groups mentioned above.

The issue of including presence service to H.323 based systems were brought up. There have been several offline discussions behind the scenes in between the last recent study group meetings. Q.29/16 meeting agreed that one should use the given motivation and invite interested groups to send inputs to this topic.

Recommendations Consented by SG 16 on the closing Plenary

Consented Recommendations for AAP posting	Documents*	AAP/LC**
Revised ITU-T Rec. G.723.1 "Dual rate speech coder for multimedia communications transmitting at 5.3 and 6.3 kbit/s"	TD 258/Plen	AAP 35
New ITU-T Rec. G.728 Amd.1 "Revised Annex J"	TD 257/Plen	AAP 35
New ITU-T Rec. G.729.1 (ex G.729EV) "An 8-32 kbit/s scalable wideband coder bitstream interoperable with G.729"	TD 260/Plen	AAP 35
New ITU-T Rec. G.767 Cor.1 "Digital circuit multiplication equipment using 16 kbit/s LD-CELP, digital speech interpolation and facsimisle demodulation /remodulation (10/98)"	TD 247/Plen	AAP 35
New ITU-T Rec. H.222.0 | ISO/IEC 13818-1 Cor.5 "Information Technology - Generic Coding of Moving Pictures And Associated Audio Information: Systems: Corrections identified during integration of third edition"	TD 214/Plen	AAP 35
Revised ITU-T Rec. H.225.0v6 "Call signalling protocols and media stream packetization for packet-based multimedia communication systems"	TD 275R1/Plen	AAP 35
Revised ITU-T Rec. H.241 "Extended video procedures and control signals for H.300 series terminals"	TD 212/Plen	AAP 35
Revised ITU-T Rec. H.245 "Control protocol for multimedia communication"	TD 265/Plen	AAP 35
Revised ITU-T Rec. H.246 "Interworking of H-Series multimedia terminals with H-Series multimedia terminals and voice/voiceband terminals on GSTN and ISDN"	TD 215/Plen	AAP 35
New ITU-T Rec. H.248.19 Amd.1, "Decomposed multipoint control unit, audio, video and data conferencing packages: New Text Overlay Package and Border and Background Package"	TD 220/Plen	AAP 35
New ITU-T Rec. H.248.23 Cor.1, "Enhanced Alerting packages"	TD 243/Plen	AAP 35
New ITU-T Rec. H.248.38 "Base Context Package"	TD 248/Plen	AAP 35
New ITU-T Rec. H.248.39 "H.248 SDP Parameter Identification and Wildcarding"	TD 250/Plen	AAP 35
New ITU-T Rec. H.248.41 "IP Domain Connection Package"	TD 217/Plen	AAP 35
New ITU-T Rec. H.248.42 "DCME Interworking Package"	TD 245/Plen	AAP 35
New ITU-T Rec. H.248.45 "MGC Information Package"	TD 222R1/Plen	AAP 35
New ITU-T Rec. H.249 (ex-H.Keys) "Extended User Input Indications"	TD 219/Plen	AAP 35
New ITU-T Rec. H.262 | ISO/IEC 13818-2 (MPEG-2 Video) Technical Cor.2 "Information technology - Generic coding of moving pictures and associated audio information: Video"	TD 229/Plen	AAP 35
New ITU-T Rec. H.264 Amd.1 "Support of additional colour spaces and removal of the High 4:4:4 Profile"	TD 228/Plen	AAP 36
New ITU-T Rec. H.271 (ex-H.VBCM) "Video back channel messages for conveyance of status information and requests from a video receiver to a video sender"	TD 227R1/Plen	AAP 35
New ITU-T Rec. H.323v6 "Packet-based multimedia communications systems"	TD 274/Plen	AAP 36
New ITU-T Rec. H.324 Cor.1 "Clarification in Annex A"	TD 249/Plen	AAP 35
New ITU-T Rec. H.361 (ex-H.mmqos) "End-to-End Quality of Service (QoS) and Service Priority Signalling in H.323 Systems	TD 262/Plen	AAP 35
New ITU-T Rec. H.460.21 (ex-H.460.mb) "Message Broadcast for H.323 Systems"	TD 253/Plen	AAP 35
New ITU-T Rec. T.55 | ISO/IEC 10646 "Information technology - Universal Multiple-Octet Coded Character Set	TD 213/Plen	TBD
New ITU-T Rec. T.55 | ISO/IEC 10646 Amd.1 "Glagolitic, Coptic, Georgian and other characters"	TD 213/Plen	TBD
New ITU-T Rec. T.801 | ISO/IEC 15444-2 Cor.4 "Information technology - JPEG 2000 Image coding system: Extensions"	TD 208/Plen	AAP 35
New ITU-T Rec. T.807 | ISO/IEC 15444-8 "Information technology - JPEG 2000 image coding system: Secure JPEG 2000"	TD 209/Plen	AAP 35
New ITU-T Rec.T.808 (01/2005) | ISO/IEC 15444-9:2005 Amd.1 "Information technology - JPEG 2000 image coding system: Interactivity tools, APIs and protocols, Amd.1: APIs, metadata, and editing"	TD 210/Plen	AAP 35
New ITU-T Rec. T. 810 | ISO/IEC 15444-11 "Information technology - JPEG 2000 image coding system: Wireless"	TD 211/Plen	AAP 35
New ITU-T Rec. T.851 Cor.1 "ITU-T T.81 (JPEG 1)-based still-image coding using an alternative arithmetic coder"	TD 261/Plen	AAP 35
New ITU-T Rec. V.150.1 Amd.2 "ToIP and new SPRT Data Types support"	TD 252R1/Plen	AAP 35
New ITU-T Rec. V.151. "procedures for end-to-end connection of analogue PSTN text telephones over an IP network utilizing text relay"	TD 218/Plen	AAP 35
New ITU-T Rec. V.152 Cor.2 "Procedures for supporting Voice-band over IP Networks	TD 251R1/Plen	AAP 35

Notes: *: some texts are subject to editorial cleanup before posting. Hence, the version posted may differ slightly from the TD indicated.

**: expected AAP Announcement for Last Call

Recommendations Approved by SG 16 on the closing Plenary

None at this meeting.

Recommendations Decided by SG 16 on the closing Plenary

None at this meeting.

Other texts approved by SG 16

Errata	Document
New ITU-T Rec. G.729 Erratum 1	TD 254(P)

Supplements	Document
Revised H-Series Sup.2 "H.248 Sub-Series: Packages Guide Release 8"	TD 221R1(P)
Revised H-Series Sup.4 "Repository of generic parameters for ITU-T Recommendations H.460.x sub-series"	TD 259(P)
New H-Series Sup.6 "Decomposed Gateways - Control Load Quantum"	TD 246(P)

Implementors' Guides	Document
Revised G.728 Implementors' Guide	TD 255(P)
Revised G.729 Implementors' Guide	TD 256(P)
Revised H.248 Sub-series Implementors' Guide	TD 226(P)
Revised H.248 Version 2 Implementors' Guide	TD 225(P)
Revised H.248 Version 1 Implementors' Guide	TD 224(P)
Revised H.323-Series Implementors' Guide	TD 276(P)
Revised H.350 Sub-series Implementors' Guide	TD 223(P)

Note: no Technical Papers were approved at this meeting.

Texts deleted or proposed for deletion by SG 16

None.

Updates in the SG 16 management team and Rapporteurs

(Click here for the complete list of SG 16 Rapporteurs)

Resignations:

- Mr Hiroyuki Ohno (NIICT, Japan) as Rapporteur for Q.27/16

New Appointments:

- Mr Pierre-André Probst as Liaison Officer to FG IPTV

Open positions:

- Rapporteur for Q.20/16 (MediaCom Project, allocated to the Plenary)
- Rapporteur for Q.26/16 (Accessibility to Multimedia Systems and Services, allocated to the Plenary)
- EWM Coordinator
- Liaison Officer to 3GPPs, OMA

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APPENDIX H26408

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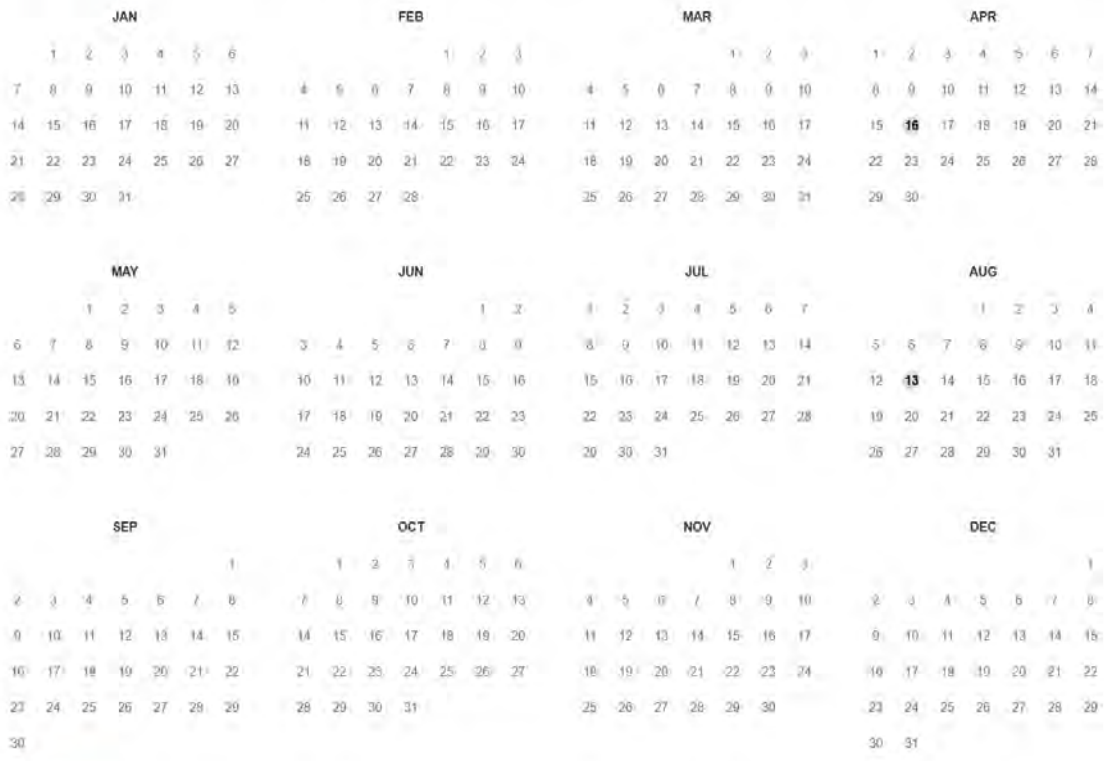
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ITU-T SG 16 Meeting Results (Study Period 2005 - 2008)

>> Study Group 16 : Multimedia terminals, systems and applications

Results from previous meetings: 2006-04 | 2005-07 | 2004-11 | 2004-01 | 2003-05 | 2002-10

Meeting Results
Geneva, 14 - 24 November 2006

Executive Summary of the meeting

Major Plenary accomplishments:

- Consented Recommendations: 33 at this meeting.

- NOTE: As decided in the closing SG 16 Plenary, G.729.1 Amd.1 was split in two amendments, whereby the new Annex B (floating point spec) is moved into Amd.2 and Amd.1 contains the balance of text initially submitted for Consent by WP3/16. Further, it was agreed that the Last Call for G.729.1 Amendment 2 will be delayed to mid-January in order to allow extended review of accompanying floating point C code by the SG 16 experts.
- Recommendations Decided/Determined/Approved: none at this meeting
- Recommendations deleted or proposed for deletion: none
- Other texts approved: errata (0), appendices (2), supplements (2), technical papers (3), and implementors' guides (4)
- Changes in SG 16 Question set:
  - New Q8/16 on generic sound activity detection - Pending final approval at the next SG 16 meeting after endorsement by TSAG, SG 16 will start immediately working in this field under the leadership of Mr Paul Coverdale (Canada) - see text
  - Revised Q6/16 on visual coding - In addition to the video coding studies, Q6/16 now is also responsible for still-image coding activities - see text
- For updates to the SG 16 management team, see below
- List of interim meetings pre-approved: see related link
- Final text of outgoing Liaison Statements: see related link (TIES account needed)

The meeting had 132 attendees during the meeting period (compared to 145 at the last meeting). The final list of participants is available in TD 357 (P)

Map of meeting reports & Liaison Statements (as seen by the SG 16 Plenary)

	Plen	WP1	WP2	WP3
Meeting Report	TD 330 (P) Q20: TD 331R2 (P) Q26: TD 332R1 (P)	TD 333R1 (P)	TD 334R1 (P)	TD 335R1 (P)
Liaison Statements	Q20: TD 362 (P) Q26: TD 359 (P)	TD 336 (P)	TD 337R1 (P)	TD 338R1 (P)
Work programme	Q26: TD 332R1 (P)	TD 339 (P)	TD 340R1 (P)	TD 341R1 (P)

Summary of Questions' Results

Question 1/16 Summary
Question 1 reviewed several matters in relation with H.324/M, in particular, contributions proposing corrections and clarifications to the call setup acceleration techniques from Annex K/H.324. Along other enhancements, a new Recommendation H.272, defining procedures and values for video gamma compensation in multimedia systems, such as videoconferencing and video telephony, was created, and several Recommendations of the T.120-series were revised. Question 1 proposed four Recommendations, one Amendment and one Corrigendum for Consent (H.272, H.222.0 Amd.1, H.324 Cor.2, T.120, T.123, and T.124) and one Implementors' Guide for Approval (T.120 Sub-series).

Question 2/16 Summary
Question 2 successfully completed work on revised Recommendation H.460.4 and new Amendments to H.246 and H.225.0. The experts also completed work on a revised H.323 System Implementors' Guide that documented editorial errors found in H.245 and H.460.18.

Question 3/16 Summary
Q3/16 met for 12 quarters to review some 90 documents. Q3/16 continued work on a number of existing work items which has resulted in 8 Recommendations for Consent: H.248.2 Amendment 1, Revised H.248.25, Revised H.248.28, Revised H.248.30, H.248.40, H.248.44, H.248.46 and H.248.47. In addition to these Recommendations Q3 prepared 4 documents for Approval: Release 9 of the H-Series Supplement 2 "*Packages Guide*", new H-Series Supplement 5 "*Guidelines for Resource Management of Resources for H.248 RTP Terminations*", the revised H.248 Sub-Series Implementors' Guide, and the H.248.1 Version 2 Implementors' Guide. Q3 prepared seven liaison statements.
The Rapporteur would like to thank the contributors to the Q3 work and especially the editors for their work in preparing Recommendations.

Question 4/16 Summary
Question 4/16 completed draft H.350.7 *"Directory Services Architecture for XMPP"* for Consent that allows an organization to directory-enable and manage XMPP (Extensible Messaging and Presence Protocol) resources in the same way that other multimedia protocols (e.g. H.320, H.323, SIP) are managed in H.350. We also started a new work on H.350.8 *"Resource Registry"* to represent not only people but also resources such as conference rooms, classrooms, medical facilities and virtual organizations in a directory. H.350 Use Guide was considered for ITU-T publication but its implementation is yet to be materialized.

Question 5/16 Summary
Question 5 made progress on the development of Recommendation H.proxy during this meeting. A number of contributions on the subject are expected for the next Rapporteur's meeting, with an objective of consenting the text at the next SG16 meeting. The experts completed work on the revised Technical Paper "*Firewall and NAT Traversal Problems in H.323 Systems*", progressed work on Technical Paper "*Harmonization of multiple mechanisms for H.323 NAT/FW traversal*", and agreed on editorial corrections for H.460.18 (incorporated in the H.323 System Implementors' Guide).

Question 6/16 Summary
Q6/16 is also sometimes referred to as "VCEG" (Video Coding Experts Group). A substantial portion of the work of Q6/16 is also conducted jointly with ISO/IEC JTC 1/SC 29/WG 11 (MPEG) in an organization known as "the JVT" (Joint Video Team). The ongoing JVT work is currently concentrated on the maintenance and development of extensions for Rec. H.264 (a Twin Text Recommendation with ISO/IEC 14496-10) including enhanced support for professional applications, scalable video coding (SVC), multi-view video coding (MVC) and supplemental enhancement information (SEI).
The primary goals for Q6/16 at this meeting of SG 16 were to review the progress of Q6 and JVT work, to reach AAP Consent on those work items that have reached sufficient maturity, and to plan future work. Additionally, it was agreed to task Q6/16 with handling still image coding issues, previously in Q23/16, and for such a revised text of Q6/16 was prepared. At this meeting, Q6/16 already handled the majority of the still-image coding work. The goals of the meeting were achieved to the satisfaction of Q6/16.
Q6/16 produced four items for AAP Consent: 1) a draft new Amendment to Rec. H.262 (Common Text with ISO/IEC 13818-2) to enhance colour space support, 2) a draft new Amendment to Rec. H.264 (Twin Text with ISO/IEC 14496-10) to define all-Intra and 4:4:4 profiles primarily intended for professional video applications, 3) a draft new Corrigendum to Rec. T.800 (Common Text with ISO/IEC 15444-1), and 4) a draft new Corrigendum to Rec. T.808 (ISO/IEC 15444-9). The first two of these items were video coding topics conducted with a close relationship to ISO/IEC JTC 1/SC 29/WG 11 (MPEG) and the latter two of these items were JPEG 2000 image coding conducted with a close relationship to ISO/IEC JTC 1/SC 29/WG 1 (JPEG/JBIG).

Question 9/16 Summary
The Test Plan for the Baseline Selection Testing was reviewed and modified with the consent of the Q7/12 Rapporteur. The Processing Test Plan for the Baseline Selection Testing was reviewed and approved.
The Terms of Reference for the Super-Wideband and Stereo modes of the EV-VBR Codec were updated and approved.
A draft mandate, proposed by the Rapporteur, for the planned Focus Group was discussed and edited. The timescales for the remainder of the Q9/16 work was proposed by the Rapporteur and approved by the closing Work Party Plenary
Q9/16 drafted a detailed response to the most recent liaison statement from Q7/12 SQEG addressing all of their concerns and open questions. A copy of the revised Test Plan, Processing Plan and Super-Wideband Stereo Terms of Reference were attached to this liaison reply.

Question 10/16 Summary
The group approved submission for Consent under AAP: Revised Rec. G.729 (main body, Annexes A, B, C, C+, D, E, F, G, H, I and J including C-source Codes and test vectors) as G.729 Release 2, new Amendment 1 to G.729.1 (*"New Annex A on G.729.1 usage in H.245, plus corrections to the main body and updated test vectors"*), new Amendment 2 to G.729.1 (*"New Annex B on a reference floating-point implementation for G.729.1"*), new Corrigendum to G.722.2 (corrections of G.722.2 Annex C defects). Two new Appendices to G.722 that propose PLC algorithms for applications prone to packet losses have been submitted for Approval at this meeting.
G.729.1 Characterization phase step 2 has been completed. The group agreed to launch the standardisation of low complexity full band extension to G.722.1 for wireline conversational applications, DTX/CNG scheme for G.729.1. For these work items, Terms of Reference and time schedule have been drafted. No consensus was reached to move for Consent under AAP the proposed G.729.1 Amendment and/or Annex to extend the low delay mode operation up to 14 kbit/s.
Question 10/16 produced outgoing Liaison Statements to SG 12 (on speech and audio coding matters), to ETSI TC DECT (on G.722 PLC), to SG11 (on Q.3401), to ISO/IEC MPEG (on G.722.1 full band extension and on G.729.1 super-wideband extension).
The work will progress by correspondence and will be reviewed at the two next Q10/16 meetings, planned in January and March 2007 as interim meetings.

Question 11/16 Summary
The goal for Q11/16 was to consider contributions on the work items of V.150.1, V.151 and V.152. With respect to V.151 text for a new Annex was considered and progressed. The group agreed to define two new Annexes for V.152 addressing a new Data Signal Detector and silence suppression scheme and a mechanism to allow the re-enabling of echo cancellers on detecting V.21 HDLC Flags. The group agreed to start a new work on a Recommendation for defining inter-working functions between Relay and VBD. The initial work will be a study on the subject matter with priority to a V.152 to T.38 inter-working function. The group has no documents for Approval or Consent at this meeting. The group is requesting a single interim Rapporteur's meeting for February/March 2007 timeframe.

Question 14/16 Summary
Proposed extension of silence period in T.30 in case of fallback from V.34 fax to normal fax was agreed to re-enable echo cancellers. New Amendment 1 to T.30 was agreed to be put forward for Consent at this meeting. It was agreed to put forward for Consent a revised version of T.38, which contains clarification of all call establishments, improvement of the compatibility between T.38 gateway and Group 3 facsimile and some other minor corrections. The Question plans no interim meetings before June 2007

Question 15/16 Summary
At this meeting, Question 15/16 advanced the work on drafting new Recommendation I.733 expecting to be put forward for Consent at July 2007 SG 16 meeting. Contribution proposing the additional text for I.733 was agreed to be included with a minor modification. One joint session with Q16, Q17, Q18 of WP1 and Q23 of WP3 was organized to identify the requirements for proposed new work on developing Generic Sound Activity Detector (GSAD) in WP3. The necessity of developing different types of GSAD was recognized, and it was basically agreed to advance the work in WP3. The Question plans to hold one interim meeting.

Question 16/16 Summary
Further progress was made on drafting text for revised ITU-T Rec. G.168 "Echo Cancellers" and new ITU-T Rec. G.160 "Voice Enhancement Devices". G.168 was put forward for Consent at this meeting. G.160 is planned for Consent in 2008. A joint meeting with Questions 11, 14 and 18 was held to discuss V.34 fax operation with echo cancellers. Another joint meeting with Questions 15, 17, 18 and 23 was held to discuss the requirements of a Generic Sound Activity Detector (GSAD). One liaison regarding proposed changes to ITU-T Rec. G.108.2 "*Transmission planning aspects of echo cancellers*" was sent to SG12. One interim meeting is proposed.

Question 17/16 Summary
At this meeting, Question 17/16 advanced the work on drafting new Recommendation G.IP2IP expecting to be put forward for Consent in 2008. Contributions proposing the addition and the modifications to draft G.IP2IP were discussed, and all the agreements were reflected in new draft text (V.1.6). One joint session with Q15, Q16, Q18 of WP1 and Q23 of WP3 was organized to identify the requirements for proposed new work on developing Generic Sound Activity Detector (GSAD) in WP3. The necessity of developing different types of GSAD was recognized, and it was basically agreed to advance the work in WP3. The Question plans to hold one interim meeting.

Question 18/16 Summary
It was decided to propose draft new Recommendation Q.115.2 *"Logic for the control of Voice Enhancement Devices/Functions"* and draft new Corrigendum 1 to Recommendation G.766.1 *"Managed objects for signal processing network elements"* for Consent at the closing SG16 Plenary. Further progress was made on drafting text for revised Recommendation G.161 *"Interaction aspects of signal processing network equipment"*, draft new Recommendation G.mdcspne *"Mechanism for dynamic coordination of SPNE"* and draft new Recommendation G.UCPSPNE about *"SPNE mechanisms/auxiliary functions"*. Discussions were held together with Q11, Q14 and Q16 about the interoperability of V.34fax operation with echo cancellers, and with Q15, Q16, Q17 and Q23 to discuss the development of a Generic Sound Activity Detector (GSAD). It was agreed to develop a new Recommendation on Signal Processing Network Equipment (G.SPNE). The Question is planning one interim meeting, and prepared one LS to SG 11 requesting to change a property ID in ITU-T Rec. Q.115.0. One interim meeting is proposed.

Question 20/16 Summary
Q20/16 reviewed the results of the ongoing activities on NGN, IPTV, NID, TDR/EW and GRID. As background information, two tutorials on IPTV and GRID have been organised. The need for specific actions for coordination and harmonization of the work performed on these topics has been discussed under the relevant SG 16 Questions.
In addition SG 16 initiated the organization of a workshop on "Multimedia in NGN". A first draft of the objectives with a proposal for the different sessions has been developed (see TD314/Plen). The Mediacom webpage has been updated and the latest development on TDR/EW included in a liaison statement to TSAG, ITU-T SG2 and PCP-TDR (TD362/Plen).

Question 21/16 Summary
Question 21/16 has progressed the work on "Multimedia over NGN" by giving some guidelines to the "H.325" project, but it's still not enough clear. The role of "H.325" within an NGN-IMS based network must particularly be clarified, as well as the gaps of the SIP protocol, if there are some. It was decided to keep the H.saarch draft as a starting point to further define a network-agnostic multimedia architecture (particularly dealing with A/V services). It is expected that the requirements described there will be useful to define a relevant NGN framework, jointly with SG13. It was proposed to define also an IPTV Recommendation project (e.g. H.612) and to work on the topic with the FG IPTV. A first version of this document should be written for the next Q21 meeting, starting from work items identified for Q21 by the FG IPTV, and including contributions from CATR on the subject. Finally, it was also decided to work on home networking issues within the H.saarch and H.612 contexts. A new subject H.GHNA was initiated to progress a generic home networking architecture with cooperation with SG15, HGI Forum, etc.

Question 22/16 Summary
Q22 met for five sessions and two of these sessions were held jointly with Q21. LS from JCA-NID, TSB and FG IPTV were reviewed and necessary responses were made. We had effective discussions covering networked ID, IPTV, videotelephony and visual surveillance. As for the networked ID area, it was decided to develop a set of Recommendations according to a roadmap with the first Recommendations expected in July 2007. Videotelephony discussions produced a brief ad hoc group report to be used to guide further contributions. Q22 would like to thank all those who have actively participated in the Q22 meeting and look forward to their support at subsequent meetings.

Question 23/16 Summary
Q23 agreed to create a new SG16 Question to address the standardization of a generic sound activity detector (G.SAD). In coordination with Q6/16, two corrigenda to the T.800 series (JPEG-2000) were submitted for approval under AAP as common text with ISO. Q23 reviewed progress of the multimedia convergence codec, and agreed to concentrate on defining the high level application areas before continuing to develop detailed terms of reference (ToR). The meeting updated the media coding database based on input from MPEG, 3GPP2 and 3GPP. Finally, Q23 agreed to postpone the approval of T.55 (Unicode) as a stand-alone ITU-T Recommendation, pending a decision from ISO/IEC regarding whether Unicode can be maintained as ITU-T | ISO/IEC common text.

Question 24/16 Summary
Question 24 discussed the contents of draft new Recommendations H.361 Annexes A, B, and C, and it was agreed to submit the presented documents as contributions for the next Rapporteur meeting after reflecting the comments received at the meeting. In addition, Question 24 discussed possible new work items on end-to-end QoS in multimedia systems, e.g., media codec negotiation for minimizing the number of transcodings and codec bit rates control based on QoS feedback.

Question 25/16 Summary
Q25 finalized and proposes for Consent by the SG16 meeting new draft Recommendation H.460.22 "*Negotiation of Security Protocols to Protect H.225.0 Call Signalling Message*".

Question 26/16 Summary
Q26/16 completed its work on the Accessibility Guidelines (now Recommendation F.790) and the Telecommunications Accessibility Checklist. These documents were approved. We reviewed the outputs of SG 13 on NGN and FG IPTV for their accessibility aspects and sent liaisons to those groups. Liaisons were sent to several other groups updating them on our work. We welcomed the creation of Question 20/1 in ITU-D on accessibility and agreed to collaborate where possible. We also welcomed the creation of an accessibility flyer by the TSB.

Question 28/16 Summary
Q28/16 presented the activities carried out since last SG16 meeting. The first version of a roadmap about standardization on e-health was submitted for approval as an ITU-T SG 16 Technical Paper. This roadmap will be publicized and distributed among different SGs. It was reported also that very little work has been carried out under the E-health Standardisation Coordination Group (eHSCG) and the Healthcare Technology Task Force (HTTF), mainly oriented to coordination among SDOs and promotional activities. As no volunteers appeared, it was decided to stop working on a new Recommendation about "*Framework for e-health applications in emergency situations*".

Question 29/16 Summary
In the context of NGN-GSI, Q29/16 has continued its cooperation with Question Q6/13 as well as Questions Q2 and Q5/19 on mobility-related issues for NGN. This cooperation supports Q29/16 to progress its work on the technical paper TP.MMSM (*Service Mobility for new Multimedia Service Architecture*). A new draft 0.7 of the technical paper was presented. For consolidation of the content, the definitions of "vertical" and "horizontal" have to be adapted to the definitions, given by Q.1706. Due to lack of contributions the "Presence" work item was cancelled.

Recommendations Consented by SG 16 on the closing Plenary

Description	Documents*	AAP /LC**
ITU-T Rec. F.790 (ex V.guidelines) "*Telecommunications accessibility guidelines for older persons and persons with disabilities*" (New)	TD 355(P)	50
ITU-T Rec. G.168 "*Digital Network Echo Cancellers*" (Rev.)	TD 323(P)	50

ITU-T Rec. G.722.2 Corrigendum 2 "*Corrections to C source code in Annex C*" (New)	TD 361(P)	50
ITU-T Rec. G.729 "*Coding of speech at 8 kbit/s using conjugate-structure algebraic-code-excited linear-prediction (CS-ACELP)*" (Rev.)	TD 305(P)	50
ITU-T Rec. G.729.1 Amendment 1 "*New Annex A on G.729.1 usage in H.245, plus corrections to the main body and updated test vectors*" (New) - See note	TD 360(P) minus Annex B	50
ITU-T Rec. G.729.1 Amendment 2 "*New Annex B on a reference floating-point implementation for G.729.1*" (New) - See note	Only Annex B in TD 360(P)	51
ITU-T Rec. G.776.1 Corrigendum 1 "*Managed objects for signal processing network elements*" (New)	TD 328(P)	50
ITU-T Rec. H.222.0 | ISO/IEC 13818-1 Amendment 1 "*Transport of MPEG-4 streaming text and MPEG-4 lossless audio over MPEG-2 systems*" (New)	TD 308(P)	50
ITU-T Rec. H.225.0 Amendment 1 "*Updating Connected Party Information after Third Party Pause and Re-Routing & Clarification to Echo Control Procedures*" (New)	TD 315(P)	50
ITU-T Rec. H.246 Amendment 1 "*Mapping of user priority level and country/international network of call origination between H.225 and ISUP*" (New)	TD 329(P)	50
ITU-T Rec. H.248.2 Amendment 1 "*Discriminated call type enhancement*" (New)	TD 319R1(P)	50
ITU-T Rec. H.248.25 "*Basic CAS packages*" (Rev.)	TD 352(P)	50
ITU-T Rec. H.248.28 " *International CAS packages*" (Rev.)	TD 353(P)	50
ITU-T Rec. H.248.30 "*RTCP extended performance metrics packages*" (Rev.)	TD 354(P)	50
ITU-T Rec. H.248.40 "*Application Data Inactivity Detection Package*" (New)	TD 312(P)	50
ITU-T Rec. H.248.44 (ex H.248.MLPP) "*Multi-level precedence and pre-emption package*" (New)	TD 326(P)	50
ITU-T Rec. H.248.46 "*Connection Capability Control Package*" (New)	TD 320(P)	50
ITU-T Rec. H.248.47 "*Statistic Conditional Reporting Package*" (New)	TD 321(P)	50
ITU-T Rec. H.262 | ISO/IEC 13818-2 (2000 edition) Amendment 2 "*Video: Support for colour spaces*" (New)	TD 348(P)	50
ITU-T Rec. H.264 Amendment 2 "*All-Intra and High 4:4:4 Predictive profiles*" (New)	TD 349(P)	50
ITU-T Rec. H.272 (ex H.Gamma) "*Procedures and values for video gamma compensation in multimedia systems*" (New)	TD 346R1(P)	50
ITU-T Rec. H.324 Corrigendum 2 "*Terminal for low bit-rate multimedia communication: Corrections to Annex K*" (New)	TD 325(P)	50
ITU-T Rec. H.350.7 "*Directory Services Architecture for XMPP*" (New)	TD 327(P)	50
ITU-T Rec. H.460.4 "*Call priority designation and country/international network of call origination identification for H.323 priority calls*" (Rev.)	TD 317(P)	50
ITU-T Rec. H.460.22 (ex H.460.spn) "*Negotiation of Security Protocols to Protect H.225.0 Call Signalling Message*" (New)	TD 342R2(P)	50
ITU-T Rec. Q.115.2 "*Logic for the control of Voice Enhancement Devices/Functions*" (New)	TD 303R1(P)	50
ITU-T Rec. T.30 Amendment 1 "*Extension of silence period during fallback from V.34*" (New)	TD 301(P)	50
ITU-T Rec. T.38 "*Procedures for real-time Group 3 facsimile communication over IP networks*" (Rev.)	TD 302(P)	50
ITU-T Rec. T.120 "*Data protocols for multimedia conferencing*" (Rev.)	TD 298(P)	50
ITU-T Rec. T.123 "*Network-specific data protocol stacks for multimedia conferencing*" (Rev.)	TD 299(P)	50
ITU-T Rec. T.124 "*Generic Conference Control*" (Rev.)	TD 300R1(P)	50
ITU-T Rec. T.800 | ISO/IEC 15444-1 Corrigendum 1 "*Information technology - JPEG 2000 image coding system: Core coding system*" (New)	TD 343(P)	50
ITU-T Rec. T.808 | ISO/IEC 15444-9 Corrigendum 1 "*Information technology - JPEG 2000 image coding system: Interactivity tools, APIs and protocols*" (New)	TD 347(P)	50

Notes:
*: some texts are subject to editorial cleanup before posting. Hence, the version posted may differ slightly from the TD indicated.
**: expected AAP Announcement for Last Call

Recommendations Approved by SG 16 on the closing Plenary
None at this meeting.

Recommendations Decided by SG 16 on the closing Plenary
None at this meeting.

Other texts approved by SG 16

Implementors' Guides	Document
ITU-T Rec. H.248 Sub-series Implementors' Guide (Rev.)	TD 344(P)
ITU-T Rec. H.248.1 Version 2 Implementors' Guide (Rev.)	TD 345(P)
ITU-T H.323 System Implementors' Guide (Rev.)	TD 358(P)
ITU-T Rec. T.120 Series Implementors' Guide (Rev.)	TD 297(P)

Supplements	Document
ITU-T H-Series Sup.2 "*H.248 sub-series packages guide - Release 9*" (Rev.)	TD 316(P)
ITU-T H-Series Sup.5 (ex RTPXtalk) "*Gateway Control Protocol: Guidelines for Resource Management of Resources for H.248 RTP Terminations*" (New)	TD 322(P)

Appendices	Document
ITU-T Rec. G.722 Appendices III and IV on Packet Loss Concealment algorithms (New)	TD 356(P)

Technical Papers	Document
ITU-T Technical Paper TP.FNTP "*Firewall and NAT Traversal Problems in H.323 Systems*" (Rev.)	TD 311(P)
ITU-T Technical Paper TP.RTM "*Roadmap for Telemedicine*" (New)	TD 318(P)
ITU-T Technical Paper TP.TACL "*Telecommunications Accessibility Checklist*" (New)	TD 350(P)

Texts deleted or proposed for deletion by SG 16
None.

Updates in the SG 16 management team and Rapporteurs
(Click here for the complete list of SG 16 Rapporteurs)

Resignations:

- Mr Istvan Sebestyen, Vice-chairman SG 16 and Chair of WP 2/16
- Rapporteur for Q17/16 (Mr Tõnu Trump, Ericsson)
- Rapporteur for Q21/16 (Mr Bastien Lamer, France Telecom)
- Rapporteur for Q23/16 (Mr Dave Lindbergh, Polycom)
- Rapporteur for Q25/16 (Mr Martin Euchner, Siemens Networks)

New Appointments:

- Mr Paul Jones (Cisco, USA), as Rapporteur for Q26/16 (*Accessibility to Multimedia Systems and Services*, allocated to Plenary)
- Messrs Pierre-André Probst and Noah Luo as Liaison Officers to the ITU-T JCA-NID
- Mr Gary Sullivan as Liaison Officer to ISO/IEC JTC1 SC29 and its WG1 (in addition to WG11)

Open positions:

- Rapporteur for Q17/16 (*Voice gateway equipment*, WP1/16)
- Rapporteur for Q20/16 (*MediaCom Project*, allocated to the Plenary)
- Rapporteur for Q21/16 (*Multimedia Architecture*, WP2/16)
- Rapporteur for Q23/16 (*Media Coding*, WP3/16)
- Rapporteur for Q25/16 (*Multimedia Security in Next-Generation Networks*, WP2/16)
- Liaison Officer to ITU-T SG 9, 17; ETSI TISPAN; ISO TC215; 3GPPs, OMA and W3C
- EWM Coordinator

Draft new Question 8/16 - Generic Sound Activity Detection
(new Question)

1. **Motivation**

Voice Activity Detection (VAD) is widely used in telecommunications networks as a means of differentiating between wanted and unwanted in-band audio signals, for example to obtain trunking efficiency in circuit multiplication equipment; to ensure correct operation of echo control and other signal enhancement devices etc.

The proposal for Generic Sound Activity Detection (GSAD) is motivated by two problems.

1. With rapid changes in the telecommunication network environment, more and more multimedia services are being provided. Although the network is evolving from a voice to a multimedia network, most VAD algorithms are still mainly designed to handle voice signals and can not work properly in the presence of rich audio signals, which include voice, music, background environmental noise, information tones etc.
2. Historically, VAD algorithms have been developed separately for individual network elements and applications, and there are currently numerous VAD algorithms. However, they are based on different principles, which make it difficult to provide common performance enhancements across all VAD's.

Therefore it is beneficial to develop a Generic Sound (rather than Voice) Activity Detector, which can be applied across a range of applications. The benefits from a standardised GSAD are:

- Enhanced performance to deal with new types of in-band audio signals
- Reduced development time and cost for new equipment requiring sound activity detection, eg codecs, circuit multiplication equipment, echo control, signal enhancement devices, VoIP gateways, terminal adapters etc.
- Opportunity for use in existing speech and audio coders which do not include VAD

2. **Study items**

Study items to be considered include, but are not limited to:

- Definition and classification of applications and associated performance requirements for generic sound activity detection;
- Definition of algorithm(s) suitable for generic sound activity detection meeting the applications and performance requirements;
- Definition of the test conditions and evaluation procedures to be applied in selecting between candidate algorithms on the basis of objective and subjective performance, in conjunction with SG 12;
- Selection and specification of procedures to be used in verifying the implementation of selected algorithm or algorithms.

3. **Tasks**

Tasks include, but are not limited to:

- Develop Terms of Reference for GSAD algorithms for different applications
- In conjunction with SG12, develop new Recommendations on testing methodologies
- Solicit proposals and conduct selection test(s) for candidate algorithms to meet these Terms of Reference
- Develop new Recommendation(s) based on the outcome of these selection test(s)

4. **Relationships**

Recommendations:

- G.700-series speech and audio coding Recommendations
- G.76X-series circuit multiplication Recommendations
- G.799.X-series voice over IP gateway Recommendations
- G.16X-series speech enhancement Recommendations

Questions:

- Q9, 10, 23/16 on speech coding;
- Q11, 15, 16, 17, 18/16 on network signal processing.

Study Groups:

- ITU-T SG 2 to identify other potential user applications;
- ITU-T SG 9 on applications within home networking;
- ITU-T SG 11 on signalling requirements and protocols;
- ITU-T SG 12 on voice quality evaluation of specified algorithms;
- ITU-T SG 13 on the NGN Project;
- ITU-T SG 19 on speech coding in IMT2000 and beyond;
- ITU-R SG 8 to ensure compatibility with mobile transmission system constraints.

Other Bodies:

- ETSI (TISPAN);
- TIA;
- IETF;
- 3GPP, 3GPP2.

Draft revised text for Question 6/16 - ~~Video~~ Visual coding

Title: Question 6/16 - ~~Video~~ Visual coding
(Continuation of Question 6/16)

1. **Motivation**

The goal of this Question is to produce Recommendations for video visual signal coding methods appropriate for conversational (e.g. videoconferencing and video telephony) and non-conversational (e.g., streaming, broadcast, file download, media storage/playback, or digital cinema) audio/visual services. Visual signal coding includes the coding of:

- video sequences

- still image
- graphics
- stereoscopic and multi-view visual information
- light fields and volumetric imagery
- computer displays
- medical imaging

This Question will focus on the maintenance and extension of existing video and still-image coding Recommendations, and laying the ground for new Recommendations using advanced techniques to significantly improve the trade-offs between bit rate, quality, delay, and algorithm complexity. Video, still-image, and other visual coding standards will be developed with sufficient flexibility to accommodate a diverse number of transport types (Internet, LAN, Mobile, ISDN, GSTN, H.222.0, NGN, etc.).

2. Study Items

- New coding methods in order to achieve the following objectives:
  - improvements in compression efficiency;
  - robust operation in error/loss-prone environments (e.g. non-guaranteed-bandwidth packet networks or mobile wireless communication);
  - reduction of real-time delay;
  - reduction of channel acquisition time and random access latency;
  - reduction of complexity;
- Organization of the compressed data format to support packetization and streaming;
- Methods to allow streams to be easily mixed by MCUs or terminals;
- Techniques to permit networks or terminals to adjust the bit rate of video streams efficiently;
- Techniques for object coding and multiview operation;
- Techniques for efficient compressed-digital to compressed-digital processing (including transcoding).
- The impact of colorimetry, video quality assessment, and quality control requirements on video codec development.
- Computer graphics compression.
- Security aspects that directly affect video and still-image coding including watermarking techniques.

3. Tasks

Tasks include, but are not limited to:

- Maintenance of existing H-series video coding Recommendations, including H.120, H.261, H.262 | ISO/IEC 13818-2, H.263 and H.264 | ISO/IEC 14496-10;
- Extensions to H.264: 2004-2008;
- Conformance and reference software development for H.264;
- Complete requirements definition and begin detailed algorithm design for H.265;
- Final Rec. H.265: expected 20089-2010 (given sufficient progress in contribution technology);.
- Maintain and extend existing Recommendations regarding still image coding, including Recommendations T.80, T.81, T.82, T.83, T.84, T.85, T.86, T.87, T.88, T.89, T.800, T.801, T.803, T.804, T.851, and T.870.

4. Relationships

Recommendations:

- H.300-series Systems Recommendations;
- H.222.0;
- H.241;
- H.245;
- H.248;
- T.80-series, T.800-series.

Questions:

- 20(A), 21(B), 22(C), 23(E), 24(F), 25(G), 26(H), 28(J), 1, 2, 4 of SG 16.

Study Groups:

- SGs 9, 11, 12, 13;
- ITU-R SG 6 (in particular, Working Party 6M)

Other bodies:

- ISO/IEC JTC 1/SC 29 (MPEG and JPEG/JBIG) for harmonization of advanced coding objectives;
- IETF, DVB, ATSC, ARIB, 3GPP, 3GPP-2, SMPTE, IMTC, OMA, W3C

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APPENDIX H26409

International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

H.264

(03/2005)

SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Infrastructure of audiovisual services – Coding of moving video

Advanced video coding for generic audiovisual services

ITU-T Recommendation H.264

ITU-T H-SERIES RECOMMENDATIONS

AUDIOVISUAL AND MULTIMEDIA SYSTEMS

CHARACTERISTICS OF VISUAL TELEPHONE SYSTEMS	H.100–H.199
INFRASTRUCTURE OF AUDIOVISUAL SERVICES	
General	H.200–H.219
Transmission multiplexing and synchronization	H.220–H.229
Systems aspects	H.230–H.239
Communication procedures	H.240–H.259
Coding of moving video	**H.260–H.279**
Related systems aspects	H.280–H.299
Systems and terminal equipment for audiovisual services	H.300–H.349
Directory services architecture for audiovisual and multimedia services	H.350–H.359
Quality of service architecture for audiovisual and multimedia services	H.360–H.369
Supplementary services for multimedia	H.450–H.499
MOBILITY AND COLLABORATION PROCEDURES	
Overview of Mobility and Collaboration, definitions, protocols and procedures	H.500–H.509
Mobility for H-Series multimedia systems and services	H.510–H.519
Mobile multimedia collaboration applications and services	H.520–H.529
Security for mobile multimedia systems and services	H.530–H.539
Security for mobile multimedia collaboration applications and services	H.540–H.549
Mobility interworking procedures	H.550–H.559
Mobile multimedia collaboration inter-working procedures	H.560–H.569
BROADBAND AND TRIPLE-PLAY MULTIMEDIA SERVICES	
Broadband multimedia services over VDSL	H.610–H.619

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation H.264

Advanced video coding for generic audiovisual services

Summary

This Recommendation | International Standard represents an evolution of the existing video coding standards (H.261, H.262, and H.263) and it was developed in response to the growing need for higher compression of moving pictures for various applications such as videoconferencing, digital storage media, television broadcasting, Internet streaming, and communication. It is also designed to enable the use of the coded video representation in a flexible manner for a wide variety of network environments. The use of this Recommendation | International Standard allows motion video to be manipulated as a form of computer data and to be stored on various storage media, transmitted and received over existing and future networks and distributed on existing and future broadcasting channels.

The revision approved 2005-03 contains modifications of the video coding standard to add four new profiles, referred to as the High, High 10, High 4:2:2, and High 4:4:4 profiles, to improve video quality capability and to extend the range of applications addressed by the standard (for example, by including support for a greater range of picture sample precision and higher-resolution chroma formats). Additionally, a definition of new types of supplemental data has been specified to further broaden the applicability of the video coding standard. Finally, a number of corrections to errors in the published text have been included. This revision, in addition to enhancing video coding capability, will serve to maintain technical alignment with the corresponding jointly-developed ISO/IEC 14496-10 standard.

Corrigendum 1 to ITU-T Rec. H.264 corrected and updated various minor aspects to bring the ITU-T version of the text up to date relative to the April 2005 output status approved as a new edition of the corresponding jointly-developed and technically-aligned text ISO/IEC 14496-10. It additionally fixes a number of minor errors and needs for clarification and defines three previously-reserved sample aspect ratio indicators.

This edition includes the text approved 2005-03 and its Corrigendum 1 approved 2005-09.

Source

ITU-T Recommendation H.264 was approved on 1 March 2005 by ITU-T Study Group 16 (2005-2008) under the ITU-T Recommendation A.8 procedure. It includes modifications introduced by H.264 (2005) Cor.1 approved on 13 September 2005 by ITU-T Study Group 16 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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CONTENTS

Page

Foreword ..... **xiv**

0 Introduction **1**
0.1 Prologue *1*
0.2 Purpose *1*
0.3 Applications *1*
0.4 Publication and versions of this specification *1*
0.5 Profiles and levels *2*
0.6 Overview of the design characteristics *2*
0.6.1 Predictive coding 3
0.6.2 Coding of progressive and interlaced video 3
0.6.3 Picture partitioning into macroblocks and smaller partitions 3
0.6.4 Spatial redundancy reduction 3
0.7 How to read this specification *3*

1 Scope **4**

2 Normative references **4**

3 Definitions **4**

4 Abbreviations **12**

5 Conventions **12**
5.1 Arithmetic operators *13*
5.2 Logical operators *13*
5.3 Relational operators *13*
5.4 Bit-wise operators *13*
5.5 Assignment operators *14*
5.6 Range notation *14*
5.7 Mathematical functions *14*
5.8 Variables, syntax elements, and tables *15*
5.9 Text description of logical operations *16*
5.10 Processes *17*

6 Source, coded, decoded and output data formats, scanning processes, and neighbouring relationships **17**
6.1 Bitstream formats *17*
6.2 Source, decoded, and output picture formats *17*
6.3 Spatial subdivision of pictures and slices *22*
6.4 Inverse scanning processes and derivation processes for neighbours *23*
6.4.1 Inverse macroblock scanning process 23
6.4.2 Inverse macroblock partition and sub-macroblock partition scanning process 24
6.4.2.1 Inverse macroblock partition scanning process 25
6.4.2.2 Inverse sub-macroblock partition scanning process 25
6.4.3 Inverse 4x4 luma block scanning process 26
6.4.4 Inverse 8x8 luma block scanning process 26
6.4.5 Derivation process of the availability for macroblock addresses 26
6.4.6 Derivation process for neighbouring macroblock addresses and their availability 27
6.4.7 Derivation process for neighbouring macroblock addresses and their availability in MBAFF frames 27
6.4.8 Derivation processes for neighbouring macroblocks, blocks, and partitions 28
6.4.8.1 Derivation process for neighbouring macroblocks 29
6.4.8.2 Derivation process for neighbouring 8x8 luma block 29
6.4.8.3 Derivation process for neighbouring 4x4 luma blocks 30
6.4.8.4 Derivation process for neighbouring 4x4 chroma blocks 30
6.4.8.5 Derivation process for neighbouring partitions 31
6.4.9 Derivation process for neighbouring locations 33
6.4.9.1 Specification for neighbouring locations in fields and non-MBAFF frames 33
6.4.9.2 Specification for neighbouring locations in MBAFF frames 34

7 Syntax and semantics **36**
7.1 Method of describing syntax in tabular form *36*
7.2 Specification of syntax functions, categories, and descriptors *37*
7.3 Syntax in tabular form *38*
7.3.1 NAL unit syntax 38
7.3.2 Raw byte sequence payloads and RBSP trailing bits syntax 39
7.3.2.1 Sequence parameter set RBSP syntax 39

7.3.2.1.1 Scaling list syntax 40
7.3.2.1.2 Sequence parameter set extension RBSP syntax 40
7.3.2.2 Picture parameter set RBSP syntax 41
7.3.2.3 Supplemental enhancement information RBSP syntax 42
7.3.2.3.1 Supplemental enhancement information message syntax 42
7.3.2.4 Access unit delimiter RBSP syntax 43
7.3.2.5 End of sequence RBSP syntax 43
7.3.2.6 End of stream RBSP syntax 43
7.3.2.7 Filler data RBSP syntax 43
7.3.2.8 Slice layer without partitioning RBSP syntax 43
7.3.2.9 Slice data partition RBSP syntax 43
7.3.2.9.1 Slice data partition A RBSP syntax 43
7.3.2.9.2 Slice data partition B RBSP syntax 44
7.3.2.9.3 Slice data partition C RBSP syntax 44
7.3.2.10 RBSP slice trailing bits syntax 44
7.3.2.11 RBSP trailing bits syntax 44
7.3.3 Slice header syntax 45
7.3.3.1 Reference picture list reordering syntax 46
7.3.3.2 Prediction weight table syntax 47
7.3.3.3 Decoded reference picture marking syntax 48
7.3.4 Slice data syntax 49
7.3.5 Macroblock layer syntax 50
7.3.5.1 Macroblock prediction syntax 51
7.3.5.2 Sub-macroblock prediction syntax 52
7.3.5.3 Residual data syntax 53
7.3.5.3.1 Residual block CAVLC syntax 54
7.3.5.3.2 Residual block CABAC syntax 55
7.4 Semantics 56
7.4.1 NAL unit semantics 56
7.4.1.1 Encapsulation of an SODB within an RBSP (informative) 58
7.4.1.2 Order of NAL units and association to coded pictures, access units, and video sequences 59
7.4.1.2.1 Order of sequence and picture parameter set RBSPs and their activation 59
7.4.1.2.2 Order of access units and association to coded video sequences 60
7.4.1.2.3 Order of NAL units and coded pictures and association to access units 60
7.4.1.2.4 Detection of the first VCL NAL unit of a primary coded picture 62
7.4.1.2.5 Order of VCL NAL units and association to coded pictures 63
7.4.2 Raw byte sequence payloads and RBSP trailing bits semantics 63
7.4.2.1 Sequence parameter set RBSP semantics 63
7.4.2.1.1 Scaling list semantics 68
7.4.2.1.2 Sequence parameter set extension RBSP semantics 69
7.4.2.2 Picture parameter set RBSP semantics 70
7.4.2.3 Supplemental enhancement information RBSP semantics 73
7.4.2.3.1 Supplemental enhancement information message semantics 73
7.4.2.4 Access unit delimiter RBSP semantics 73
7.4.2.5 End of sequence RBSP semantics 73
7.4.2.6 End of stream RBSP semantics 73
7.4.2.7 Filler data RBSP semantics 73
7.4.2.8 Slice layer without partitioning RBSP semantics 73
7.4.2.9 Slice data partition RBSP semantics 74
7.4.2.9.1 Slice data partition A RBSP semantics 74
7.4.2.9.2 Slice data partition B RBSP semantics 74
7.4.2.9.3 Slice data partition C RBSP semantics 74
7.4.2.10 RBSP slice trailing bits semantics 74
7.4.2.11 RBSP trailing bits semantics 75
7.4.3 Slice header semantics 75
7.4.3.1 Reference picture list reordering semantics 80
7.4.3.2 Prediction weight table semantics 81
7.4.3.3 Decoded reference picture marking semantics 82
7.4.4 Slice data semantics 85
7.4.5 Macroblock layer semantics 85
7.4.5.1 Macroblock prediction semantics 92
7.4.5.2 Sub-macroblock prediction semantics 93
7.4.5.3 Residual data semantics 95

7.4.5.3.1 Residual block CAVLC semantics 96
7.4.5.3.2 Residual block CABAC semantics 96
8 Decoding process 96
8.1 NAL unit decoding process 97
8.2 Slice decoding process 98
8.2.1 Decoding process for picture order count 98
8.2.1.1 Decoding process for picture order count type 0 99
8.2.1.2 Decoding process for picture order count type 1 100
8.2.1.3 Decoding process for picture order count type 2 101
8.2.2 Decoding process for macroblock to slice group map 102
8.2.2.1 Specification for interleaved slice group map type 103
8.2.2.2 Specification for dispersed slice group map type 103
8.2.2.3 Specification for foreground with left-over slice group map type 104
8.2.2.4 Specification for box-out slice group map types 104
8.2.2.5 Specification for raster scan slice group map types 105
8.2.2.6 Specification for wipe slice group map types 105
8.2.2.7 Specification for explicit slice group map type 105
8.2.2.8 Specification for conversion of map unit to slice group map to macroblock to slice group map 105
8.2.3 Decoding process for slice data partitioning 105
8.2.4 Decoding process for reference picture lists construction 106
8.2.4.1 Decoding process for picture numbers 107
8.2.4.2 Initialisation process for reference picture lists 107
8.2.4.2.1 Initialisation process for the reference picture list for P and SP slices in frames 108
8.2.4.2.2 Initialisation process for the reference picture list for P and SP slices in fields 108
8.2.4.2.3 Initialisation process for reference picture lists for B slices in frames 109
8.2.4.2.4 Initialisation process for reference picture lists for B slices in fields 109
8.2.4.2.5 Initialisation process for reference picture lists in fields 110
8.2.4.3 Reordering process for reference picture lists 110
8.2.4.3.1 Reordering process of reference picture lists for short-term reference pictures 111
8.2.4.3.2 Reordering process of reference picture lists for long-term reference pictures 112
8.2.5 Decoded reference picture marking process 112
8.2.5.1 Sequence of operations for decoded reference picture marking process 113
8.2.5.2 Decoding process for gaps in frame_num 113
8.2.5.3 Sliding window decoded reference picture marking process 114
8.2.5.4 Adaptive memory control decoded reference picture marking process 114
8.2.5.4.1 Marking process of a short-term reference picture as “unused for reference” 114
8.2.5.4.2 Marking process of a long-term reference picture as “unused for reference” 115
8.2.5.4.3 Assignment process of a LongTermFrameIdx to a short-term reference picture 115
8.2.5.4.4 Decoding process for MaxLongTermFrameIdx 115
8.2.5.4.5 Marking process of all reference pictures as “unused for reference” and setting MaxLongTermFrameIdx to “no long-term frame indices” 115
8.2.5.4.6 Process for assigning a long-term frame index to the current picture 116
8.3 Intra prediction process 116
8.3.1 Intra_4x4 prediction process for luma samples 117
8.3.1.1 Derivation process for the Intra4x4PredMode 117
8.3.1.2 Intra_4x4 sample prediction 119
8.3.1.2.1 Specification of Intra_4x4_Vertical prediction mode 119
8.3.1.2.2 Specification of Intra_4x4_Horizontal prediction mode 119
8.3.1.2.3 Specification of Intra_4x4_DC prediction mode 120
8.3.1.2.4 Specification of Intra_4x4_Diagonal_Down_Left prediction mode 120
8.3.1.2.5 Specification of Intra_4x4_Diagonal_Down_Right prediction mode 120
8.3.1.2.6 Specification of Intra_4x4_Vertical_Right prediction mode 121
8.3.1.2.7 Specification of Intra_4x4_Horizontal_Down prediction mode 121
8.3.1.2.8 Specification of Intra_4x4_Vertical_Left prediction mode 122
8.3.1.2.9 Specification of Intra_4x4_Horizontal_Up prediction mode 122
8.3.2 Intra_8x8 prediction process for luma samples 122
8.3.2.1 Derivation process for Intra8x8PredMode 123
8.3.2.2 Intra_8x8 sample prediction 124
8.3.2.2.1 Reference sample filtering process for Intra_8x8 sample prediction 125
8.3.2.2.2 Specification of Intra_8x8_Vertical prediction mode 126
8.3.2.2.3 Specification of Intra_8x8_Horizontal prediction mode 126
8.3.2.2.4 Specification of Intra_8x8_DC prediction mode 127
8.3.2.2.5 Specification of Intra_8x8_Diagonal_Down_Left prediction mode 127

8.3.2.2.6 Specification of Intra_8x8_Diagonal_Down_Right prediction mode 127
8.3.2.2.7 Specification of Intra_8x8_Vertical_Right prediction mode 128
8.3.2.2.8 Specification of Intra_8x8_Horizontal_Down prediction mode 128
8.3.2.2.9 Specification of Intra_8x8_Vertical_Left prediction mode 129
8.3.2.2.10 Specification of Intra_8x8_Horizontal_Up prediction mode 129
8.3.3 Intra_16x16 prediction process for luma samples 129
8.3.3.1 Specification of Intra_16x16_Vertical prediction mode 130
8.3.3.2 Specification of Intra_16x16_Horizontal prediction mode 130
8.3.3.3 Specification of Intra_16x16_DC prediction mode 130
8.3.3.4 Specification of Intra_16x16_Plane prediction mode 131
8.3.4 Intra prediction process for chroma samples 131
8.3.4.1 Specification of Intra_Chroma_DC prediction mode 132
8.3.4.2 Specification of Intra_Chroma_Horizontal prediction mode 134
8.3.4.3 Specification of Intra_Chroma_Vertical prediction mode 134
8.3.4.4 Specification of Intra_Chroma_Plane prediction mode 134
8.3.5 Sample construction process for I_PCM macroblocks 134
8.4 Inter prediction process 135
8.4.1 Derivation process for motion vector components and reference indices 137
8.4.1.1 Derivation process for luma motion vectors for skipped macroblocks in P and SP slices 138
8.4.1.2 Derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8 139
8.4.1.2.1 Derivation process for the co-located 4x4 sub-macroblock partitions 139
8.4.1.2.2 Derivation process for spatial direct luma motion vector and reference index prediction mode 142
8.4.1.2.3 Derivation process for temporal direct luma motion vector and reference index prediction mode 144
8.4.1.3 Derivation process for luma motion vector prediction 146
8.4.1.3.1 Derivation process for median luma motion vector prediction 147
8.4.1.3.2 Derivation process for motion data of neighbouring partitions 148
8.4.1.4 Derivation process for chroma motion vectors 149
8.4.2 Decoding process for Inter prediction samples 149
8.4.2.1 Reference picture selection process 150
8.4.2.2 Fractional sample interpolation process 151
8.4.2.2.1 Luma sample interpolation process 152
8.4.2.2.2 Chroma sample interpolation process 155
8.4.2.3 Weighted sample prediction process 156
8.4.2.3.1 Default weighted sample prediction process 156
8.4.2.3.2 Weighted sample prediction process 157
8.5 Transform coefficient decoding process and picture construction process prior to deblocking filter process. 159
8.5.1 Specification of transform decoding process for 4x4 luma residual blocks 160
8.5.2 Specification of transform decoding process for luma samples of Intra_16x16 macroblock prediction mode 160
8.5.3 Specification of transform decoding process for 8x8 luma residual blocks 161
8.5.4 Specification of transform decoding process for chroma samples 162
8.5.5 Inverse scanning process for transform coefficients 164
8.5.6 Inverse scanning process for 8x8 luma transform coefficients 164
8.5.7 Derivation process for the chroma quantisation parameters and scaling function 166
8.5.8 Scaling and transformation process for luma DC transform coefficients for Intra_16x16 macroblock type 168
8.5.9 Scaling and transformation process for chroma DC transform coefficients 169
8.5.10 Scaling and transformation process for residual 4x4 blocks 171
8.5.11 Scaling and transformation process for residual 8x8 luma blocks 173
8.5.12 Picture construction process prior to deblocking filter process 176
8.5.13 Residual colour transform process 177
8.6 Decoding process for P macroblocks in SP slices or SI macroblocks 178
8.6.1 SP decoding process for non-switching pictures 178
8.6.1.1 Luma transform coefficient decoding process 178
8.6.1.2 Chroma transform coefficient decoding process 179
8.6.2 SP and SI slice decoding process for switching pictures 181
8.6.2.1 Luma transform coefficient decoding process 181
8.6.2.2 Chroma transform coefficient decoding process 181
8.7 Deblocking filter process 182
8.7.1 Filtering process for block edges 186
8.7.2 Filtering process for a set of samples across a horizontal or vertical block edge 188
8.7.2.1 Derivation process for the luma content dependent boundary filtering strength 188
8.7.2.2 Derivation process for the thresholds for each block edge 190
8.7.2.3 Filtering process for edges with bS less than 4 191

8.7.2.4 Filtering process for edges for bS equal to 4 ... 193
9 Parsing process ... 194
9.1 Parsing process for Exp-Golomb codes ... 194
9.1.1 Mapping process for signed Exp-Golomb codes ... 195
9.1.2 Mapping process for coded block pattern ... 196
9.2 CAVLC parsing process for transform coefficient levels ... 198
9.2.1 Parsing process for total number of transform coefficient levels and trailing ones ... 199
9.2.2 Parsing process for level information ... 201
9.2.2.1 Parsing process for level_prefix ... 202
9.2.3 Parsing process for run information ... 203
9.2.4 Combining level and run information ... 206
9.3 CABAC parsing process for slice data ... 206
9.3.1 Initialisation process ... 207
9.3.1.1 Initialisation process for context variables ... 208
9.3.1.2 Initialisation process for the arithmetic decoding engine ... 218
9.3.2 Binarization process ... 219
9.3.2.1 Unary (U) binarization process ... 221
9.3.2.2 Truncated unary (TU) binarization process ... 221
9.3.2.3 Concatenated unary/ k-th order Exp-Golomb (UEGk) binarization process ... 222
9.3.2.4 Fixed-length (FL) binarization process ... 222
9.3.2.5 Binarization process for macroblock type and sub-macroblock type ... 222
9.3.2.6 Binarization process for coded block pattern ... 225
9.3.2.7 Binarization process for mb_qp_delta ... 225
9.3.3 Decoding process flow ... 225
9.3.3.1 Derivation process for ctxIdx ... 226
9.3.3.1.1 Assignment process of ctxIdxInc using neighbouring syntax elements ... 228
9.3.3.1.1.1 Derivation process of ctxIdxInc for the syntax element mb_skip_flag ... 228
9.3.3.1.1.2 Derivation process of ctxIdxInc for the syntax element mb_field_decoding_flag ... 228
9.3.3.1.1.3 Derivation process of ctxIdxInc for the syntax element mb_type ... 229
9.3.3.1.1.4 Derivation process of ctxIdxInc for the syntax element coded_block_pattern ... 229
9.3.3.1.1.5 Derivation process of ctxIdxInc for the syntax element mb_qp_delta ... 230
9.3.3.1.1.6 Derivation process of ctxIdxInc for the syntax elements ref_idx_l0 and ref_idx_l1 ... 230
9.3.3.1.1.7 Derivation process of ctxIdxInc for the syntax elements mvd_l0 and mvd_l1 ... 231
9.3.3.1.1.8 Derivation process of ctxIdxInc for the syntax element intra_chroma_pred_mode ... 232
9.3.3.1.1.9 Derivation process of ctxIdxInc for the syntax element coded_block_flag ... 233
9.3.3.1.1.10 Derivation process of ctxIdxInc for the syntax element transform_size_8x8_flag ... 234
9.3.3.1.2 Assignment process of ctxIdxInc using prior decoded bin values ... 234
9.3.3.1.3 Assignment process of ctxIdxInc for syntax elements significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1 ... 235
9.3.3.2 Arithmetic decoding process ... 237
9.3.3.2.1 Arithmetic decoding process for a binary decision ... 238
9.3.3.2.1.1 State transition process ... 239
9.3.3.2.2 Renormalization process in the arithmetic decoding engine ... 241
9.3.3.2.3 Bypass decoding process for binary decisions ... 242
9.3.3.2.4 Decoding process for binary decisions before termination ... 242
9.3.4 Arithmetic encoding process (informative) ... 243
9.3.4.1 Initialisation process for the arithmetic encoding engine (informative) ... 243
9.3.4.2 Encoding process for a binary decision (informative) ... 243
9.3.4.3 Renormalization process in the arithmetic encoding engine (informative) ... 244
9.3.4.4 Bypass encoding process for binary decisions (informative) ... 246
9.3.4.5 Encoding process for a binary decision before termination (informative) ... 246
9.3.4.6 Byte stuffing process (informative) ... 247
Annex A Profiles and levels ... 249
A.1 Requirements on video decoder capability ... 249
A.2 Profiles ... 249
A.2.1 Baseline profile ... 249
A.2.2 Main profile ... 250
A.2.3 Extended profile ... 250
A.2.4 High profile ... 250
A.2.5 High 10 profile ... 251
A.2.6 High 4:2:2 profile ... 251
A.2.7 High 4:4:4 profile ... 252

A.3 Levels ... *252*
A.3.1 Level limits common to the Baseline, Main, and Extended profiles ... 252
A.3.2 Level limits common to the High, High 10, High 4:2:2, and High 4:4:4 profiles ... 254
A.3.3 Profile-specific level limits ... 255
A.3.3.1 Baseline profile limits ... 256
A.3.3.2 Main, High, High 10, High 4:2:2, or High 4:4:4 profile limits ... 257
A.3.3.3 Extended Profile Limits ... 258
A.3.4 Effect of level limits on frame rate (informative) ... 259
Annex B Byte stream format ... 262
B.1 Byte stream NAL unit syntax and semantics ... *262*
B.1.1 Byte stream NAL unit syntax ... 262
B.1.2 Byte stream NAL unit semantics ... 262
B.2 Byte stream NAL unit decoding process ... *262*
B.3 Decoder byte-alignment recovery (informative) ... *263*
Annex C Hypothetical reference decoder ... 264
C.1 Operation of coded picture buffer (CPB) ... *266*
C.1.1 Timing of bitstream arrival ... 266
C.1.2 Timing of coded picture removal ... 267
C.2 Operation of the decoded picture buffer (DPB) ... *268*
C.2.1 Decoding of gaps in frame_num and storage of "non-existing" frames ... 268
C.2.2 Picture decoding and output ... 268
C.2.3 Removal of pictures from the DPB before possible insertion of the current picture ... 268
C.2.4 Current decoded picture marking and storage ... 269
C.2.4.1 Marking and storage of a reference decoded picture into the DPB ... 269
C.2.4.2 Storage of a non-reference picture into the DPB ... 269
C.3 Bitstream conformance ... *269*
C.4 Decoder conformance ... *271*
C.4.1 Operation of the output order DPB ... 272
C.4.2 Decoding of gaps in frame_num and storage of "non-existing" pictures ... 272
C.4.3 Picture decoding ... 272
C.4.4 Removal of pictures from the DPB before possible insertion of the current picture ... 272
C.4.5 Current decoded picture marking and storage ... 272
C.4.5.1 Storage and marking of a reference decoded picture into the DPB ... 272
C.4.5.2 Storage and marking of a non-reference decoded picture into the DPB ... 273
C.4.5.3 "Bumping" process ... 273
Annex D Supplemental enhancement information ... 275
D.1 SEI payload syntax ... *276*
D.1.1 Buffering period SEI message syntax ... 277
D.1.2 Picture timing SEI message syntax ... 277
D.1.3 Pan-scan rectangle SEI message syntax ... 278
D.1.4 Filler payload SEI message syntax ... 278
D.1.5 User data registered by ITU-T Recommendation T.35 SEI message syntax ... 279
D.1.6 User data unregistered SEI message syntax ... 279
D.1.7 Recovery point SEI message syntax ... 279
D.1.8 Decoded reference picture marking repetition SEI message syntax ... 279
D.1.9 Spare picture SEI message syntax ... 280
D.1.10 Scene information SEI message syntax ... 280
D.1.11 Sub-sequence information SEI message syntax ... 281
D.1.12 Sub-sequence layer characteristics SEI message syntax ... 281
D.1.13 Sub-sequence characteristics SEI message syntax ... 281
D.1.14 Full-frame freeze SEI message syntax ... 282
D.1.15 Full-frame freeze release SEI message syntax ... 282
D.1.16 Full-frame snapshot SEI message syntax ... 282
D.1.17 Progressive refinement segment start SEI message syntax ... 282
D.1.18 Progressive refinement segment end SEI message syntax ... 282
D.1.19 Motion-constrained slice group set SEI message syntax ... 282
D.1.20 Film grain characteristics SEI message syntax ... 283
D.1.21 Deblocking filter display preference SEI message syntax ... 283
D.1.22 Stereo video information SEI message syntax ... 284
D.1.23 Reserved SEI message syntax ... 284
D.2 SEI payload semantics ... *284*
D.2.1 Buffering period SEI message semantics ... 284

D.2.2 Picture timing SEI message semantics 285
D.2.3 Pan-scan rectangle SEI message semantics 288
D.2.4 Filler payload SEI message semantics 290
D.2.5 User data registered by ITU-T Recommendation T.35 SEI message semantics 290
D.2.6 User data unregistered SEI message semantics 290
D.2.7 Recovery point SEI message semantics 290
D.2.8 Decoded reference picture marking repetition SEI message semantics 291
D.2.9 Spare picture SEI message semantics 292
D.2.10 Scene information SEI message semantics 293
D.2.11 Sub-sequence information SEI message semantics 295
D.2.12 Sub-sequence layer characteristics SEI message semantics 296
D.2.13 Sub-sequence characteristics SEI message semantics 297
D.2.14 Full-frame freeze SEI message semantics 299
D.2.15 Full-frame freeze release SEI message semantics 299
D.2.16 Full-frame snapshot SEI message semantics 299
D.2.17 Progressive refinement segment start SEI message semantics 299
D.2.18 Progressive refinement segment end SEI message semantics 300
D.2.19 Motion-constrained slice group set SEI message semantics 300
D.2.20 Film grain characteristics SEI message semantics 301
D.2.21 Deblocking filter display preference SEI message semantics 306
D.2.22 Stereo video information SEI message semantics 308
D.2.23 Reserved SEI message semantics 309
Annex E Video usability information 310
E.1 VUI syntax 311
E.1.1 VUI parameters syntax 311
E.1.2 HRD parameters syntax 312
E.2 VUI semantics 312
E.2.1 VUI parameters semantics 312
E.2.2 HRD parameters semantics 323

LIST OF FIGURES

Figure 6-1 – Nominal vertical and horizontal locations of 4:2:0 luma and chroma samples in a frame 19
Figure 6-2 – Nominal vertical and horizontal sampling locations of 4:2:0 samples in top and bottom fields. 20
Figure 6-3 – Nominal vertical and horizontal locations of 4:2:2 luma and chroma samples in a frame 20
Figure 6-4 – Nominal vertical and horizontal sampling locations of 4:2:2 samples top and bottom fields 21
Figure 6-5 – Nominal vertical and horizontal locations of 4:4:4 luma and chroma samples in a frame 21
Figure 6-6 – Nominal vertical and horizontal sampling locations of 4:4:4 samples top and bottom fields 22
Figure 6-7 – A picture with 11 by 9 macroblocks that is partitioned into two slices 23
Figure 6-8 – Partitioning of the decoded frame into macroblock pairs 23
Figure 6-9 – Macroblock partitions, sub-macroblock partitions, macroblock partition scans, and sub-macroblock partition scans 25
Figure 6-10 – Scan for 4x4 luma blocks 26
Figure 6-11 – Scan for 8x8 luma blocks 26
Figure 6-12 – Neighbouring macroblocks for a given macroblock 27
Figure 6-13 – Neighbouring macroblocks for a given macroblock in MBAFF frames 28
Figure 6-14 – Determination of the neighbouring macroblock, blocks, and partitions (informative) 29
Figure 7-1 – Structure of an access unit not containing any NAL units with nal_unit_type equal to 0, 7, 8, or in the range of 12 to 18, inclusive, or in the range of 20 to 31, inclusive. 62
Figure 8-1 – Intra_4x4 prediction mode directions (informative) 118
Figure 8-2 –Example for temporal direct-mode motion vector inference (informative) 146
Figure 8-3 – Directional segmentation prediction (informative) 147

Figure 8-4 – Integer samples (shaded blocks with upper-case letters) and fractional sample positions (un-shaded blocks with lower-case letters) for quarter sample luma interpolation 153

Figure 8-5 – Fractional sample position dependent variables in chroma interpolation and surrounding integer position samples A, B, C, and D 155

Figure 8-6 – Assignment of the indices of dcY to luma4x4BlkIdx 161

Figure 8-7 – Assignment of the indices of dcC to chroma4x4BlkIdx: (a) chroma_format_idc equal to 1, (b) chroma_format_idc equal to 2, (c) chroma_format_idc equal to 3 163

Figure 8-8 – 4x4 block scans. (a) Zig-zag scan. (b) Field scan (informative) 164

Figure 8-9 – 8x8 block scans. (a) 8x8 zig-zag scan. (b) 8x8 field scan (informative) 165

Figure 8-10 – Boundaries in a macroblock to be filtered 183

Figure 8-11 – Convention for describing samples across a 4x4 block horizontal or vertical boundary 187

Figure 9-1 – Illustration of CABAC parsing process for a syntax element SE (informative) 207

Figure 9-2 – Overview of the arithmetic decoding process for a single bin (informative) 238

Figure 9-3 – Flowchart for decoding a decision 239

Figure 9-4 – Flowchart of renormalization 241

Figure 9-5 – Flowchart of bypass decoding process 242

Figure 9-6 – Flowchart of decoding a decision before termination 243

Figure 9-7 – Flowchart for encoding a decision 244

Figure 9-8 – Flowchart of renormalization in the encoder 245

Figure 9-9 – Flowchart of PutBit(B) 245

Figure 9-10 – Flowchart of encoding bypass 246

Figure 9-11 – Flowchart of encoding a decision before termination 247

Figure 9-12 – Flowchart of flushing at termination 247

Figure C-1 – Structure of byte streams and NAL unit streams for HRD conformance checks 264

Figure C-2 – HRD buffer model 265

Figure E-1 – Location of chroma samples for top and bottom fields as a function of chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field 320

LIST OF TABLES

Table 6-1 –SubWidthC, and SubHeightC values derived from chroma_format_idc 18

Table 6-2 – Specification of input and output assignments for subclauses 6.4.8.1 to 6.4.8.5 29

Table 6-3 – Specification of mbAddrN 33

Table 6-4 - Specification of mbAddrN and yM 35

Table 7-1 – NAL unit type codes 57

Table 7-2 – Assignment of mnemonic names to scaling list indices and specification of fall-back rule 65

Table 7-3 – Specification of default scaling lists Default_4x4_Intra and Default_4x4_Inter 66

Table 7-4 – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter 66

Table 7-5 – Meaning of primary_pic_type 73

Table 7-6 – Name association to slice_type 75

Table 7-7 – reordering_of_pic_nums_idc operations for reordering of reference picture lists 81

Table 7-8 – Interpretation of adaptive_ref_pic_marking_mode_flag 83

Table 7-9 – Memory management control operation (memory_management_control_operation) values 84
Table 7-10 – Allowed collective macroblock types for slice_type 86
Table 7-11 – Macroblock types for I slices 87
Table 7-12 – Macroblock type with value 0 for SI slices 88
Table 7-13 – Macroblock type values 0 to 4 for P and SP slices 89
Table 7-14 – Macroblock type values 0 to 22 for B slices 90
Table 7-15 – Specification of CodedBlockPatternChroma values 92
Table 7-16 – Relationship between intra_chroma_pred_mode and spatial prediction modes 92
Table 7-17 – Sub-macroblock types in P macroblocks 93
Table 7-18 – Sub-macroblock types in B macroblocks 94
Table 8-1 – Refined slice group map type 102
Table 8-2 – Specification of Intra4x4PredMode[luma4x4BlkIdx] and associated names 117
Table 8-3 – Specification of Intra8x8PredMode[luma8x8BlkIdx] and associated names 123
Table 8-4 – Specification of Intra16x16PredMode and associated names 130
Table 8-5 – Specification of Intra chroma prediction modes and associated names 132
Table 8-6 – Specification of the variable colPic 140
Table 8-7 – Specification of PicCodingStruct(X) 140
Table 8-8 – Specification of mbAddrCol, yM, and vertMvScale 141
Table 8-9 – Assignment of prediction utilization flags 143
Table 8-10 – Derivation of the vertical component of the chroma vector in field coding mode 149
Table 8-11 – Differential full-sample luma locations 153
Table 8-12 – Assignment of the luma prediction sample predPartLX$_L$[x_L, y_L] 155
Table 8-13 – Specification of mapping of idx to c_{ij} for zig-zag and field scan 164
Table 8-14 – Specification of mapping of idx to c_{ij} for 8x8 zig-zag and 8x8 field scan 166
Table 8-15 – Specification of QP_C as a function of qP_I 167
Table 8-16 – Derivation of offset dependent threshold variables α' and β' from indexA and indexB 191
Table 8-17 – Value of variable t'_{C0} as a function of indexA and bS 192
Table 9-1 – Bit strings with “prefix” and “suffix” bits and assignment to codeNum ranges (informative) 194
Table 9-2 – Exp-Golomb bit strings and codeNum in explicit form and used as ue(v) (informative) 195
Table 9-3 – Assignment of syntax element to codeNum for signed Exp-Golomb coded syntax elements se(v) 196
Table 9-4 – Assignment of codeNum to values of coded_block_pattern for macroblock prediction modes 196
Table 9-5 – coeff_token mapping to TotalCoeff(coeff_token) and TrailingOnes(coeff_token) 200
Table 9-6 – Codeword table for level_prefix (informative) 203
Table 9-7 – total_zeros tables for 4x4 blocks with TotalCoeff(coeff_token) 1 to 7 204
Table 9-8 – total_zeros tables for 4x4 blocks with TotalCoeff(coeff_token) 8 to 15 205
Table 9-9 – total_zeros tables for chroma DC 2x2 and 2x4 blocks 205
Table 9-10 – Tables for run_before 206
Table 9-11 – Association of ctxIdx and syntax elements for each slice type in the initialisation process 208
Table 9-12 – Values of variables m and n for ctxIdx from 0 to 10 209
Table 9-13 – Values of variables m and n for ctxIdx from 11 to 23 210

Table 9-14 – Values of variables m and n for ctxIdx from 24 to 39 210
Table 9-15 – Values of variables m and n for ctxIdx from 40 to 53 210
Table 9-16 – Values of variables m and n for ctxIdx from 54 to 59, and 399 to 401 211
Table 9-17 – Values of variables m and n for ctxIdx from 60 to 69 211
Table 9-18 – Values of variables m and n for ctxIdx from 70 to 104 212
Table 9-19 – Values of variables m and n for ctxIdx from 105 to 165 213
Table 9-20 – Values of variables m and n for ctxIdx from 166 to 226 214
Table 9-21 – Values of variables m and n for ctxIdx from 227 to 275 215
Table 9-22 – Values of variables m and n for ctxIdx from 277 to 337 216
Table 9-23 – Values of variables m and n for ctxIdx from 338 to 398 217
Table 9-24 – Values of variables m and n for ctxIdx from 402 to 459 218
Table 9-25 – Syntax elements and associated types of binarization, maxBinIdxCtx, and ctxIdxOffset 220
Table 9-26 – Bin string of the unary binarization (informative) 221
Table 9-27 – Binarization for macroblock types in I slices 223
Table 9-28 – Binarization for macroblock types in P, SP, and B slices 224
Table 9-29 – Binarization for sub-macroblock types in P, SP, and B slices 225
Table 9-30 – Assignment of ctxIdxInc to binIdx for all ctxIdxOffset values except those related to the syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1 227
Table 9-31 – Assignment of ctxIdxBlockCatOffset to ctxBlockCat for syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1 228
Table 9-32 – Specification of ctxIdxInc for specific values of ctxIdxOffset and binIdx 235
Table 9-33 – Specification of ctxBlockCat for the different blocks 235
Table 9-34 – Mapping of scanning position to ctxIdxInc for ctxBlockCat == 5 236
Table 9-35 – Specification of rangeTabLPS depending on pStateIdx and qCodIRangeIdx 240
Table 9-36 – State transition table 241
Table A-1 – Level limits 254
Table A-2 – Specification of cpbBrVclFactor and cpbBrNalFactor 256
Table A-3 – Baseline profile level limits 257
Table A-4 – Main, High, High 10, High 4:2:2, or High 4:4:4 profile level limits 257
Table A-5 – Extended profile level limits 258
Table A-6 – Maximum frame rates (frames per second) for some example frame sizes 259
Table D-1 – Interpretation of pic_struct 286
Table D-2 – Mapping of ct_type to source picture scan 287
Table D-3 – Definition of counting_type values 287
Table D-4 – scene_transition_type values. 294
Table D-5 – model_id values 301
Table D-6 – blending_mode_id values 302
Table E-1 – Meaning of sample aspect ratio indicator 313
Table E-2 – Meaning of video_format 314
Table E-3 – Colour primaries 315

Table E-4 – Transfer characteristics 316
Table E-5 – Matrix coefficients 319
Table E-6 – Divisor for computation of $\Delta t_{fi,dpb}(n)$ 321

Foreword

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardising telecommunications on a world-wide basis. The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups that, in turn, produce Recommendations on these topics. The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1. In some areas of information technology that fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialised system for world-wide standardisation. National Bodies that are members of ISO and IEC participate in the development of International Standards through technical committees established by the respective organisation to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organisations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75% of the national bodies casting a vote.

This Recommendation | International Standard was prepared jointly by ITU-T SG 16 Q.6, also known as VCEG (Video Coding Experts Group), and by ISO/IEC JTC 1/SC 29/WG 11, also known as MPEG (Moving Picture Experts Group). VCEG was formed in 1997 to maintain prior ITU-T video coding standards and develop new video coding standard(s) appropriate for a wide range of conversational and non-conversational services. MPEG was formed in 1988 to establish standards for coding of moving pictures and associated audio for various applications such as digital storage media, distribution, and communication.

In this Recommendation | International Standard Annexes A through E contain normative requirements and are an integral part of this Recommendation | International Standard.

ITU-T Recommendation H.264

Advanced video coding for generic audiovisual services

0 Introduction

This clause does not form an integral part of this Recommendation | International Standard.

0.1 Prologue

This subclause does not form an integral part of this Recommendation | International Standard.

As the costs for both processing power and memory have reduced, network support for coded video data has diversified, and advances in video coding technology have progressed, the need has arisen for an industry standard for compressed video representation with substantially increased coding efficiency and enhanced robustness to network environments. Toward these ends the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG) formed a Joint Video Team (JVT) in 2001 for development of a new Recommendation | International Standard.

0.2 Purpose

This subclause does not form an integral part of this Recommendation | International Standard.

This Recommendation | International Standard was developed in response to the growing need for higher compression of moving pictures for various applications such as videoconferencing, digital storage media, television broadcasting, internet streaming, and communication. It is also designed to enable the use of the coded video representation in a flexible manner for a wide variety of network environments. The use of this Recommendation | International Standard allows motion video to be manipulated as a form of computer data and to be stored on various storage media, transmitted and received over existing and future networks and distributed on existing and future broadcasting channels.

0.3 Applications

This subclause does not form an integral part of this Recommendation | International Standard.

This Recommendation | International Standard is designed to cover a broad range of applications for video content including but not limited to the following:

CATV	Cable TV on optical networks, copper, etc.
DBS	Direct broadcast satellite video services
DSL	Digital subscriber line video services
DTTB	Digital terrestrial television broadcasting
ISM	Interactive storage media (optical disks, etc.)
MMM	Multimedia mailing
MSPN	Multimedia services over packet networks
RTC	Real-time conversational services (videoconferencing, videophone, etc.)
RVS	Remote video surveillance
SSM	Serial storage media (digital VTR, etc.)

0.4 Publication and versions of this specification

This subclause does not form an integral part of this Recommendation | International Standard.

This specification has been jointly developed by ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group. It is published as technically-aligned twin text in both organizations ITU-T and ISO/IEC.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 1 refers to the first (2003) approved version of this Recommendation | International Standard.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 2 refers to the integrated text containing the corrections specified in the first technical corrigendum.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 3 refers to the integrated text containing both the first technical corrigendum (2004) and the first amendment, which is referred to as the "Fidelity range extensions".

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 4 (the current specification) refers to the integrated text containing the first technical corrigendum (2004), the first amendment (the "Fidelity range extensions"), and an additional technical corrigendum (2005). In the ITU-T, the next published version after version 2 was version 4 (due to the completion of the drafting work for version 4 prior to the approval opportunity for a final version 3 text).

0.5 Profiles and levels

This subclause does not form an integral part of this Recommendation | International Standard.

This Recommendation | International Standard is designed to be generic in the sense that it serves a wide range of applications, bit rates, resolutions, qualities, and services. Applications should cover, among other things, digital storage media, television broadcasting and real-time communications. In the course of creating this Specification, various requirements from typical applications have been considered, necessary algorithmic elements have been developed, and these have been integrated into a single syntax. Hence, this Specification will facilitate video data interchange among different applications.

Considering the practicality of implementing the full syntax of this Specification, however, a limited number of subsets of the syntax are also stipulated by means of "profiles" and "levels". These and other related terms are formally defined in clause 3.

A "profile" is a subset of the entire bitstream syntax that is specified by this Recommendation | International Standard. Within the bounds imposed by the syntax of a given profile it is still possible to require a very large variation in the performance of encoders and decoders depending upon the values taken by syntax elements in the bitstream such as the specified size of the decoded pictures. In many applications, it is currently neither practical nor economic to implement a decoder capable of dealing with all hypothetical uses of the syntax within a particular profile.

In order to deal with this problem, "levels" are specified within each profile. A level is a specified set of constraints imposed on values of the syntax elements in the bitstream. These constraints may be simple limits on values. Alternatively they may take the form of constraints on arithmetic combinations of values (e.g. picture width multiplied by picture height multiplied by number of pictures decoded per second).

Coded video content conforming to this Recommendation | International Standard uses a common syntax. In order to achieve a subset of the complete syntax, flags, parameters, and other syntax elements are included in the bitstream that signal the presence or absence of syntactic elements that occur later in the bitstream.

0.6 Overview of the design characteristics

This subclause does not form an integral part of this Recommendation | International Standard.

The coded representation specified in the syntax is designed to enable a high compression capability for a desired image quality. With the exception of the transform bypass mode of operation for lossless coding in the High 4:4:4 profile and the I_PCM mode of operation in all profiles, the algorithm is typically not lossless, as the exact source sample values are typically not preserved through the encoding and decoding processes. A number of techniques may be used to achieve highly efficient compression. Encoding algorithms (not specified in this Recommendation | International Standard) may select between inter and intra coding for block-shaped regions of each picture. Inter coding uses motion vectors for block-based inter prediction to exploit temporal statistical dependencies between different pictures. Intra coding uses various spatial prediction modes to exploit spatial statistical dependencies in the source signal for a single picture. Motion vectors and intra prediction modes may be specified for a variety of block sizes in the picture. The prediction residual is then further compressed using a transform to remove spatial correlation inside the transform block before it is quantised, producing an irreversible process that typically discards less important visual information while forming a close approximation to the source samples. Finally, the motion vectors or intra prediction modes are combined with the quantised transform coefficient information and encoded using either variable length codes or arithmetic coding.

0.6.1 Predictive coding

This subclause does not form an integral part of this Recommendation | International Standard.

Because of the conflicting requirements of random access and highly efficient compression, two main coding types are specified. Intra coding is done without reference to other pictures. Intra coding may provide access points to the coded sequence where decoding can begin and continue correctly, but typically also shows only moderate compression efficiency. Inter coding (predictive or bi-predictive) is more efficient using inter prediction of each block of sample values from some previously decoded picture selected by the encoder. In contrast to some other video coding standards, pictures coded using bi-predictive inter prediction may also be used as references for inter coding of other pictures.

The application of the three coding types to pictures in a sequence is flexible, and the order of the decoding process is generally not the same as the order of the source picture capture process in the encoder or the output order from the decoder for display. The choice is left to the encoder and will depend on the requirements of the application. The decoding order is specified such that the decoding of pictures that use inter-picture prediction follows later in decoding order than other pictures that are referenced in the decoding process.

0.6.2 Coding of progressive and interlaced video

This subclause does not form an integral part of this Recommendation | International Standard.

This Recommendation | International Standard specifies a syntax and decoding process for video that originated in either progressive-scan or interlaced-scan form, which may be mixed together in the same sequence. The two fields of an interlaced frame are separated in capture time while the two fields of a progressive frame share the same capture time. Each field may be coded separately or the two fields may be coded together as a frame. Progressive frames are typically coded as a frame. For interlaced video, the encoder can choose between frame coding and field coding. Frame coding or field coding can be adaptively selected on a picture-by-picture basis and also on a more localized basis within a coded frame. Frame coding is typically preferred when the video scene contains significant detail with limited motion. Field coding typically works better when there is fast picture-to-picture motion.

0.6.3 Picture partitioning into macroblocks and smaller partitions

This subclause does not form an integral part of this Recommendation | International Standard.

As in previous video coding Recommendations and International Standards, a macroblock, consisting of a 16x16 block of luma samples and two corresponding blocks of chroma samples, is used as the basic processing unit of the video decoding process.

A macroblock can be further partitioned for inter prediction. The selection of the size of inter prediction partitions is a result of a trade-off between the coding gain provided by using motion compensation with smaller blocks and the quantity of data needed to represent the data for motion compensation. In this Recommendation | International Standard the inter prediction process can form segmentations for motion representation as small as 4x4 luma samples in size, using motion vector accuracy of one-quarter of the luma sample grid spacing displacement. The process for inter prediction of a sample block can also involve the selection of the picture to be used as the reference picture from a number of stored previously-decoded pictures. Motion vectors are encoded differentially with respect to predicted values formed from nearby encoded motion vectors.

Typically, the encoder calculates appropriate motion vectors and other data elements represented in the video data stream. This motion estimation process in the encoder and the selection of whether to use inter prediction for the representation of each region of the video content is not specified in this Recommendation | International Standard.

0.6.4 Spatial redundancy reduction

This subclause does not form an integral part of this Recommendation | International Standard.

Both source pictures and prediction residuals have high spatial redundancy. This Recommendation | International Standard is based on the use of a block-based transform method for spatial redundancy removal. After inter prediction from previously-decoded samples in other pictures or spatial-based prediction from previously-decoded samples within the current picture, the resulting prediction residual is split into 4x4 blocks. These are converted into the transform domain where they are quantised. After quantisation many of the transform coefficients are zero or have low amplitude and can thus be represented with a small amount of encoded data. The processes of transformation and quantisation in the encoder are not specified in this Recommendation | International Standard.

0.7 How to read this specification

This subclause does not form an integral part of this Recommendation | International Standard.

It is suggested that the reader starts with clause 1 (Scope) and moves on to clause 3 (Definitions). Clause 6 should be read for the geometrical relationship of the source, input, and output of the decoder. Clause 7 (Syntax and semantics) specifies the order to parse syntax elements from the bitstream. See subclauses 7.1-7.3 for syntactical order and see subclause 7.4 for semantics; i.e., the scope, restrictions, and conditions that are imposed on the syntax elements. The actual parsing for most syntax elements is specified in clause 9 (Parsing process). Finally, clause 8 (Decoding process) specifies how the syntax elements are mapped into decoded samples. Throughout reading this specification, the reader should refer to clauses 2 (Normative references), 4 (Abbreviations), and 5 (Conventions) as needed. Annexes A through E also form an integral part of this Recommendation | International Standard.

Annex A specifies seven profiles (Baseline, Main, Extended, High, High 10, High 4:2:2 and High 4:4:4), each being tailored to certain application domains, and defines the so-called levels of the profiles. Annex B specifies syntax and semantics of a byte stream format for delivery of coded video as an ordered stream of bytes. Annex C specifies the hypothetical reference decoder and its use to check bitstream and decoder conformance. Annex D specifies syntax and semantics for supplemental enhancement information message payloads. Finally, Annex E specifies syntax and semantics of the video usability information parameters of the sequence parameter set.

Throughout this specification, statements appearing with the preamble "NOTE -" are informative and are not an integral part of this Recommendation | International Standard.

1 Scope

This document specifies ITU-T Recommendation H.264 | ISO/IEC International Standard ISO/IEC 14496-10 video coding.

2 Normative references

The following Recommendations and International Standards contain provisions which, through reference in this text, constitute provisions of this Recommendation | International Standard. At the time of publication, the editions indicated were valid. All Recommendations and Standards are subject to revision, and parties to agreements based on this Recommendation | International Standard are encouraged to investigate the possibility of applying the most recent edition of the Recommendations and Standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards. The Telecommunication Standardization Bureau of the ITU maintains a list of currently valid ITU-T Recommendations.

- ITU-T Recommendation T.35 (2000), *Procedure for the allocation of ITU-T defined codes for non-standard facilities*.
- ISO/IEC 11578:1996, Annex A, *Universal Unique Identifier*.
- ISO/CIE 10527:1991, *Colorimetric Observers*.

3 Definitions

For the purposes of this Recommendation | International Standard, the following definitions apply.

3.1 **access unit**: A set of *NAL units* always containing exactly one *primary coded picture*. In addition to the *primary coded picture*, an access unit may also contain one or more *redundant coded pictures* or other *NAL units* not containing *slices* or *slice data partitions* of a *coded picture*. The decoding of an access unit always results in a *decoded picture*.

3.2 **AC transform coefficient**: Any *transform coefficient* for which the *frequency index* in one or both dimensions is non-zero.

3.3 **adaptive binary arithmetic decoding process**: An entropy *decoding process* that derives the values of *bins* from a *bitstream* produced by an *adaptive binary arithmetic encoding process*.

3.4 **adaptive binary arithmetic encoding process**: An entropy *encoding process*, not normatively specified in this Recommendation | International Standard, that codes a sequence of *bins* and produces a *bitstream* that can be decoded using the *adaptive binary arithmetic decoding process*.

3.5 **alpha blending**: A process not specified by this Recommendation | International Standard, in which an *auxiliary coded picture* is used in combination with a *primary coded picture* and with other data not specified by this Recommendation | International Standard in the *display process*. In an alpha blending process, the samples of an *auxiliary coded picture* are interpreted as indications of the degree of opacity (or, equivalently, the degrees of transparency) associated with the corresponding *luma* samples of the *primary coded picture*.

3.6 **arbitrary slice order**: A *decoding order* of *slices* in which the *macroblock address* of the first *macroblock* of some *slice* of a *picture* may be less than the *macroblock address* of the first *macroblock* of some other preceding *slice* of the same *coded picture*.

3.7 **auxiliary coded picture**: A *picture* that supplements the *primary coded picture* that may be used in combination with other data not specified by this Recommendation | International Standard in the *display process*. An auxiliary coded picture has the same syntactic and semantic restrictions as a monochrome *redundant coded picture*. An auxiliary coded picture must contain the same number of *macroblocks* as the *primary coded picture*. Auxiliary coded pictures have no normative effect on the *decoding process*. See also *primary coded picture* and *redundant coded picture*.

3.8 **B slice**: A *slice* that may be decoded using *intra prediction* from decoded samples within the same *slice* or *inter prediction* from previously-decoded *reference pictures*, using at most two *motion vectors* and *reference indices* to *predict* the sample values of each *block*.

3.9 **bin**: One bit of a *bin string*.

3.10 **binarization**: A set of *bin strings* for all possible values of a *syntax element*.

3.11 **binarization process**: A unique mapping process of all possible values of a *syntax element* onto a set of *bin strings*.

3.12 **bin string**: A string of *bins*. A bin string is an intermediate binary representation of values of *syntax elements* from the *binarization* of the *syntax element*.

3.13 **bi-predictive slice:** See *B slice***.**

3.14 **bitstream**: A sequence of bits that forms the representation of *coded pictures* and associated data forming one or more *coded video sequences*. Bitstream is a collective term used to refer either to a *NAL unit stream* or a *byte stream*.

3.15 **block**: An MxN (M-column by N-row) array of samples, or an MxN array of *transform coefficients*.

3.16 **bottom field**: One of two *fields* that comprise a *frame*. Each row of a *bottom field* is spatially located immediately below a corresponding row of a *top field*.

3.17 **bottom macroblock (of a macroblock pair)**: The *macroblock* within a *macroblock pair* that contains the samples in the bottom row of samples for the *macroblock pair*. For a *field macroblock pair*, the bottom macroblock represents the samples from the region of the *bottom field* of the *frame* that lie within the spatial region of the *macroblock pair*. For a *frame macroblock pair*, the bottom macroblock represents the samples of the *frame* that lie within the bottom half of the spatial region of the *macroblock pair*.

3.18 **broken link**: A location in a *bitstream* at which it is indicated that some subsequent *pictures* in *decoding order* may contain serious visual artefacts due to unspecified operations performed in the generation of the *bitstream*.

3.19 **byte**: A sequence of 8 bits, written and read with the most significant bit on the left and the least significant bit on the right. When represented in a sequence of data bits, the most significant bit of a byte is first.

3.20 **byte-aligned**: A position in a *bitstream* is byte-aligned when the position is an integer multiple of 8 bits from the position of the first bit in the *bitstream*. A bit or *byte* or *syntax element* is said to be byte-aligned when the position at which it appears in a *bitstream* is byte-aligned.

3.21 **byte stream**: An encapsulation of a *NAL unit stream* containing *start code prefixes* and *NAL units* as specified in Annex B.

3.22 **can**: A term used to refer to behaviour that is allowed, but not necessarily required.

3.23 **category**: A number associated with each *syntax element*. The category is used to specify the allocation of *syntax elements* to *NAL units* for *slice data partitioning*. It may also be used in a manner determined by the application to refer to classes of *syntax elements* in a manner not specified in this Recommendation | International Standard.

3.24 **chroma**: An adjective specifying that a sample array or single sample is representing one of the two colour difference signals related to the primary colours. The symbols used for a chroma array or sample are Cb and Cr.

NOTE – The term chroma is used rather than the term chrominance in order to avoid the implication of the use of linear light transfer characteristics that is often associated with the term chrominance.

3.25 **coded field**: A *coded representation* of a *field*.

3.26 **coded frame**: A *coded representation* of a *frame*.

3.27 **coded picture**: A *coded representation* of a *picture*. A coded picture may be either a *coded field* or a *coded frame*. Coded picture is a collective term referring to a *primary coded picture* or a *redundant coded picture*, but not to both together.

3.28 **coded picture buffer (CPB)**: A first-in first-out buffer containing *access units* in *decoding order* specified in the *hypothetical reference decoder* in Annex C.

3.29 **coded representation**: A data element as represented in its coded form.

3.30 **coded video sequence**: A sequence of *access units* that consists, in decoding order, of an *IDR access unit* followed by zero or more non-IDR *access units* including all subsequent *access units* up to but not including any subsequent *IDR access unit*.

3.31 **component**: An array or single sample from one of the three arrays (*luma* and two *chroma*) that make up a *field* or *frame*.

3.32 **complementary field pair:** A collective term for a *complementary reference field pair* or a *complementary non-reference field pair*.

3.33 **complementary non-reference field pair**: Two *non-reference fields* that are in consecutive *access units* in *decoding order* as two *coded fields* of opposite parity where the first *field* is not already a paired *field*.

3.34 **complementary reference field pair**: Two *reference fields* that are in consecutive *access units* in *decoding order* as two *coded fields* and share the same value of the frame_num *syntax element*, where the second *field* in *decoding order* is not an *IDR picture* and does not include a memory_management_control_operation *syntax element* equal to 5.

3.35 **context variable**: A variable specified for the *adaptive binary arithmetic decoding process* of a *bin* by an equation containing recently decoded *bins*.

3.36 **DC transform coefficient**: A *transform coefficient* for which the *frequency index* is zero in all dimensions.

3.37 **decoded picture**: A *decoded picture* is derived by decoding a *coded picture*. A *decoded picture* is either a decoded *frame*, or a decoded *field*. A decoded *field* is either a decoded *top field* or a decoded *bottom field*.

3.38 **decoded picture buffer (DPB)**: A buffer holding *decoded pictures* for reference, output reordering, or output delay specified for the *hypothetical reference decoder* in Annex C.

3.39 **decoder**: An embodiment of a *decoding process*.

3.40 **decoding order**: The order in which *syntax elements* are processed by the *decoding process*.

3.41 **decoding process**: The process specified in this Recommendation | International Standard that reads a *bitstream* and derives *decoded pictures* from it.

3.42 **direct prediction**: An *inter prediction* for a *block* for which no *motion vector* is decoded. Two direct *prediction* modes are specified that are referred to as spatial direct *prediction* and temporal *prediction* mode.

3.43 **display process**: A process not specified in this Recommendation | International Standard having, as its input, the cropped decoded *pictures* that are the output of the *decoding process*.

3.44 **decoder under test (DUT)**: A *decoder* that is tested for conformance to this Recommendation | International Standard by operating the *hypothetical stream scheduler* to deliver a conforming *bitstream* to the *decoder* and to the *hypothetical reference decoder* and comparing the values and timing of the output of the two *decoders*.

3.45 **emulation prevention byte**: A *byte* equal to 0x03 that may be present within a *NAL unit*. The presence of emulation prevention bytes ensures that no sequence of consecutive *byte-aligned bytes* in the *NAL unit* contains a *start code prefix*.

3.46 **encoder**: An embodiment of an *encoding process*.

3.47 **encoding process**: A process, not specified in this Recommendation | International Standard, that produces a *bitstream* conforming to this Recommendation | International Standard.

3.48 **field**: An assembly of alternate rows of a *frame*. A *frame* is composed of two *fields*, a *top field* and a *bottom field*.

3.49 **field macroblock**: A macroblock containing samples from a single *field*. All *macroblocks* of a *coded field* are field macroblocks. When *macroblock-adaptive frame/field decoding* is in use, some *macroblocks* of a *coded frame* may be field macroblocks.

3.50 **field macroblock pair**: A *macroblock pair* decoded as two *field macroblocks.*

3.51 **field scan**: A specific sequential ordering of *transform coefficients* that differs from the *zig-zag scan* by scanning columns more rapidly than rows. Field scan is used for *transform coefficients* in *field macroblocks.*

3.52 **flag**: A variable that can take one of the two possible values 0 and 1.

3.53 **frame**: A *frame* contains an array of *luma* samples and two corresponding arrays of *chroma* samples. A *frame* consists of two *fields*, a *top field* and a *bottom field.*

3.54 **frame macroblock**: A *macroblock* representing samples from the two *fields* of a *coded frame*. When *macroblock-adaptive frame/field decoding* is not in use, all macroblocks of a *coded frame* are frame macroblocks. When *macroblock-adaptive frame/field decoding* is in use, some macroblocks of a *coded frame* may be frame macroblocks.

3.55 **frame macroblock pair**: A *macroblock pair* decoded as two *frame macroblocks.*

3.56 **frequency index**: A one-dimensional or two-dimensional index associated with a *transform coefficient* prior to an *inverse transform* part of the *decoding process.*

3.57 **hypothetical reference decoder (HRD)**: A hypothetical *decoder* model that specifies constraints on the variability of conforming *NAL unit streams* or conforming *byte streams* that an encoding process may produce.

3.58 **hypothetical stream scheduler (HSS)**: A hypothetical delivery mechanism for the timing and data flow of the input of a *bitstream* into the *hypothetical reference decoder*. The HSS is used for checking the conformance of a *bitstream* or a *decoder*.

3.59 **I slice**: A *slice* that is not an *SI slice* that is decoded using *prediction* only from decoded samples within the same *slice*.

3.60 **informative**: A term used to refer to content provided in this Recommendation | International Standard that is not an integral part of this Recommendation | International Standard. Informative content does not establish any mandatory requirements for conformance to this Recommendation | International Standard.

3.61 **instantaneous decoding refresh (IDR) access unit**: An *access unit* in which the *primary coded picture* is an *IDR picture*.

3.62 **instantaneous decoding refresh (IDR) picture**: A *coded picture* in which all *slices* are *I* or *SI slices* that causes the *decoding process* to mark all *reference pictures* as "unused for reference" immediately after decoding the IDR picture. After the decoding of an IDR picture all following *coded pictures* in *decoding order* can be decoded without *inter prediction* from any *picture* decoded prior to the IDR picture. The first *picture* of each *coded video sequence* is an IDR picture.

3.63 **inter coding**: Coding of a *block, macroblock, slice*, or *picture* that uses *inter prediction*.

3.64 **inter prediction**: A *prediction* derived from decoded samples of *reference pictures* other than the current *decoded picture*.

3.65 **interpretation sample value**: A possibly-altered value corresponding to a decoded sample value of an *auxiliary coded picture* that may be generated for use in the *display process*. Interpretation sample values are not used in the *decoding process* and have no normative effect on the *decoding process*.

3.66 **intra coding**: Coding of a *block, macroblock, slice*, or *picture* that uses *intra prediction.*

3.67 **intra prediction**: A *prediction* derived from the decoded samples of the same decoded *slice*.

3.68 **intra slice**: See *I slice.*

3.69 **inverse transform**: A part of the *decoding process* by which a set of *transform coefficients* are converted into spatial-domain values, or by which a set of *transform coefficients* are converted into *DC transform coefficients*.

3.70 **layer**: One of a set of syntactical structures in a non-branching hierarchical relationship. Higher layers contain lower layers. The coding layers are the *coded video sequence*, *picture*, *slice*, and *macroblock* layers.

3.71 **level**: A defined set of constraints on the values that may be taken by the *syntax elements* and variables of this Recommendation | International Standard. The same set of levels is defined for all *profiles*, with most aspects of the definition of each level being in common across different *profiles.* Individual implementations may, within specified constraints, support a different level for each supported *profile*. In a different context, level is the value of a *transform coefficient* prior to *scaling.*

3.72 **list 0 (list 1) motion vector**: A *motion vector* associated with a *reference index* pointing into *reference picture list 0* (*list 1*).

3.73 **list 0 (list 1) prediction**: *Inter prediction* of the content of a *slice* using a *reference index* pointing into *reference picture list 0* (*list 1*).

3.74 **luma**: An adjective specifying that a sample array or single sample is representing the monochrome signal related to the primary colours. The symbol or subscript used for luma is Y or L.

NOTE – The term luma is used rather than the term luminance in order to avoid the implication of the use of linear light transfer characteristics that is often associated with the term luminance. The symbol L is sometimes used instead of the symbol Y to avoid confusion with the symbol y as used for vertical location.

3.75 **macroblock**: A 16x16 *block* of *luma* samples and two corresponding *blocks* of *chroma* samples. The division of a *slice* or a *macroblock pair* into macroblocks is a *partitioning*.

3.76 **macroblock-adaptive frame/field decoding**: A *decoding process* for *coded frames* in which some *macroblocks* may be decoded as *frame macroblocks* and others may be decoded as *field macroblocks.*

3.77 **macroblock address**: When *macroblock-adaptive frame/field decoding* is not in use, a macroblock address is the index of a macroblock in a *macroblock raster scan* of the *picture* starting with zero for the top-left *macroblock* in a *picture*. When *macroblock-adaptive frame/field decoding* is in use, the macroblock address of the *top macroblock* of a *macroblock pair* is two times the index of the *macroblock pair* in a *macroblock pair raster scan* of the *picture*, and the macroblock address of the *bottom macroblock* of a *macroblock pair* is the macroblock address of the corresponding *top macroblock* plus 1. The macroblock address of the *top macroblock* of each *macroblock pair* is an even number and the macroblock address of the *bottom macroblock* of each *macroblock pair* is an odd number.

3.78 **macroblock location**: The two-dimensional coordinates of a *macroblock* in a *picture* denoted by (x, y). For the top left *macroblock* of the *picture* (x, y) is equal to (0, 0). x is incremented by 1 for each *macroblock* column from left to right. When *macroblock-adaptive frame/field decoding* is not in use, y is incremented by 1 for each *macroblock* row from top to bottom. When *macroblock-adaptive frame/field decoding* is in use, y is incremented by 2 for each *macroblock pair* row from top to bottom, and is incremented by an additional 1 when a macroblock is a *bottom macroblock.*

3.79 **macroblock pair**: A pair of vertically contiguous *macroblocks* in a *frame* that is coupled for use in *macroblock-adaptive frame/field decoding*. The division of a *slice* into macroblock pairs is a *partitioning*.

3.80 **macroblock partition**: A *block* of *luma* samples and two corresponding *blocks* of *chroma* samples resulting from a *partitioning* of a *macroblock* for *inter prediction*.

3.81 **macroblock to slice group map**: A means of mapping *macroblocks* of a *picture* into *slice groups*. The macroblock to slice group map consists of a list of numbers, one for each coded *macroblock*, specifying the *slice group* to which each coded *macroblock* belongs.

3.82 **map unit to slice group map**: A means of mapping *slice group map units* of a *picture* into *slice groups*. The map unit to slice group map consists of a list of numbers, one for each *slice group map unit*, specifying the *slice group* to which each coded *slice group map unit* belongs.

3.83 **may**: A term used to refer to behaviour that is allowed, but not necessarily required. In some places where the optional nature of the described behaviour is intended to be emphasized, the phrase "may or may not" is used to provide emphasis.

3.84 **memory management control operation**: Seven operations that control *reference picture marking*.

3.85 **motion vector**: A two-dimensional vector used for *inter prediction* that provides an offset from the coordinates in the *decoded picture* to the coordinates in a *reference picture*.

3.86 **must**: A term used in expressing an observation about a requirement or an implication of a requirement that is specified elsewhere in this Recommendation | International Standard. This term is used exclusively in an *informative* context.

3.87 **NAL unit**: A syntax structure containing an indication of the type of data to follow and *bytes* containing that data in the form of an *RBSP* interspersed as necessary with *emulation prevention bytes*.

3.88 **NAL unit stream**: A sequence of *NAL units*.

3.89 **non-paired field**: A collective term for a *non-paired reference field* or a *non-paired non-reference field*.

3.90 **non-paired non-reference field:** A decoded *non-reference field* that is not part of a *complementary non-reference field pair.*

3.91 **non-paired reference field**: A decoded *reference field* that is not part of a *complementary reference field pair*.

3.92 **non-reference field**: A *field* coded with nal_ref_idc equal to 0.

3.93 **non-reference frame**: A *frame* coded with nal_ref_idc equal to 0.

3.94 **non-reference picture**: A *picture* coded with nal_ref_idc equal to 0. A *non-reference picture* is not used for *inter prediction* of any other *pictures*.

3.95 **note**: A term used to prefix *informative* remarks. This term is used exclusively in an *informative* context.

3.96 **opposite parity**: The *opposite parity* of *top* is *bottom*, and vice versa.

3.97 **output order**: The order in which the *decoded pictures* are output from the *decoded picture buffer*.

3.98 **P slice**: A *slice* that may be decoded using *intra prediction* from decoded samples within the same *slice* or *inter prediction* from previously-decoded *reference pictures*, using at most one *motion vector* and *reference index* to *predict* the sample values of each *block*.

3.99 **parameter**: A *syntax element* of a *sequence parameter set* or a *picture parameter set*. Parameter is also used as part of the defined term *quantisation parameter*.

3.100 **parity**: The parity of a *field* can be *top* or *bottom*.

3.101 **partitioning**: The division of a set into subsets such that each element of the set is in exactly one of the subsets.

3.102 **picture**: A collective term for a *field* or a *frame*.

3.103 **picture parameter set**: A *syntax structure* containing *syntax elements* that apply to zero or more entire *coded pictures* as determined by the pic_parameter_set_id *syntax element* found in each *slice header*.

3.104 **picture order count**: A variable having a value that is non-decreasing with increasing *picture* position in output order relative to the previous *IDR picture* in *decoding order* or relative to the previous *picture* containing the *memory management control operation* that marks all *reference pictures* as "unused for reference".

3.105 **prediction**: An embodiment of the *prediction process*.

3.106 **prediction process**: The use of a *predictor* to provide an estimate of the sample value or data element currently being decoded.

3.107 **predictive slice**: See *P slice*.

3.108 **predictor**: A combination of specified values or previously decoded sample values or data elements used in the *decoding process* of subsequent sample values or data elements.

3.109 **primary coded picture**: The coded representation of a *picture* to be used by the *decoding process* for a bitstream conforming to this Recommendation | International Standard. The primary coded picture contains all *macroblocks* of the *picture*. The only *pictures* that have a normative effect on the *decoding process* are primary coded pictures. See also *redundant coded picture*.

3.110 **profile**: A specified subset of the syntax of this Recommendation | International Standard.

3.111 **quantisation parameter**: A variable used by the *decoding process* for *scaling* of *transform coefficient levels*.

3.112 **random access**: The act of starting the decoding process for a *bitstream* at a point other than the beginning of the stream.

3.113 **raster scan**: A mapping of a rectangular two-dimensional pattern to a one-dimensional pattern such that the first entries in the one-dimensional pattern are from the first top row of the two-dimensional pattern scanned from left to right, followed similarly by the second, third, etc. rows of the pattern (going down) each scanned from left to right.

3.114 **raw byte sequence payload (RBSP):** A syntax structure containing an integer number of *bytes* that is encapsulated in a *NAL unit*. An RBSP is either empty or has the form of a *string of data bits* containing *syntax elements* followed by an *RBSP stop bit* and followed by zero or more subsequent bits equal to 0.

3.115 **raw byte sequence payload (RBSP) stop bit:** A bit equal to 1 present within a *raw byte sequence payload (RBSP)* after a *string of data bits*. The location of the end of the *string of data bits* within an *RBSP* can be identified by searching from the end of the *RBSP* for the *RBSP stop bit*, which is the last non-zero bit in the *RBSP*.

3.116 **recovery point**: A point in the *bitstream* at which the recovery of an exact or an approximate representation of the *decoded pictures* represented by the *bitstream* is achieved after a *random access* or *broken link*.

3.117 **redundant coded picture**: A coded representation of a *picture* or a part of a *picture*. The content of a redundant coded picture shall not be used by the *decoding process* for a *bitstream* conforming to this Recommendation | International Standard. A *redundant coded picture* is not required to contain all *macroblocks* in the *primary coded picture*. Redundant coded pictures have no normative effect on the *decoding process*. See also *primary coded picture*.

3.118 **reference field**: A *reference field* may be used for *inter prediction* when *P*, *SP*, and *B slices* of a *coded field* or *field macroblocks* of a *coded frame* are decoded. See also *reference picture*.

3.119 **reference frame**: A *reference frame* may be used for *inter prediction* when *P*, *SP*, and *B slices* of a *coded frame* are decoded. See also *reference picture*.

3.120 **reference index**: An index into a *reference picture list*.

3.121 **reference picture**: A *picture* with nal_ref_idc not equal to 0. A *reference picture* contains samples that may be used for *inter prediction* in the *decoding process* of subsequent *pictures* in *decoding order*.

3.122 **reference picture list**: A list of *reference pictures* that is used for *inter prediction* of a *P*, *B*, or *SP slice*. For the *decoding process* of a *P* or *SP slice*, there is one reference picture list. For the *decoding process* of a *B slice*, there are two reference picture lists.

3.123 **reference picture list 0**: A *reference picture list* used for *inter prediction* of a *P*, *B*, or *SP slice*. All *inter prediction* used for *P* and *SP slices* uses reference picture list 0. Reference picture list 0 is one of two *reference picture lists* used for *inter prediction* for a *B slice*, with the other being *reference picture list 1*.

3.124 **reference picture list 1**: A *reference picture list* used for *inter prediction* of a *B slice*. Reference picture list 1 is one of two lists of *reference picture lists* used for *inter prediction* for a *B slice*, with the other being *reference picture list 0*.

3.125 **reference picture marking**: Specifies, in the bitstream, how the *decoded pictures* are marked for *inter prediction*.

3.126 **reserved**: The term reserved, when used in the clauses specifying some values of a particular *syntax element*, are for future use by ITU-T | ISO/IEC. These values shall not be used in *bitstreams* conforming to this Recommendation | International Standard, but may be used in future extensions of this Recommendation | International Standard by ITU-T | ISO/IEC.

3.127 **residual**: The decoded difference between a *prediction* of a sample or data element and its decoded value.

3.128 **run**: A number of consecutive data elements represented in the decoding process. In one context, the number of zero-valued *transform coefficient levels* preceding a non-zero *transform coefficient level* in the list of *transform coefficient levels* generated by a *zig-zag scan* or a *field scan*. In other contexts, run refers to a number of *macroblocks*.

3.129 **sample aspect ratio**: Specifies, for assisting the display process, which is not specified in this Recommendation | International Standard, the ratio between the intended horizontal distance between the columns and the intended vertical distance between the rows of the *luma* sample array in a *frame*. Sample aspect ratio is expressed as *h*:*v*, where *h* is horizontal width and *v* is vertical height (in arbitrary units of spatial distance).

3.130 **scaling**: The process of multiplying *transform coefficient levels* by a factor, resulting in *transform coefficients*.

3.131 **sequence parameter set**: A *syntax structure* containing *syntax elements* that apply to zero or more entire *coded video sequences* as determined by the content of a seq_parameter_set_id *syntax element* found in the *picture parameter set* referred to by the pic_parameter_set_id *syntax element* found in each *slice header*.

3.132 **shall**: A term used to express mandatory requirements for conformance to this Recommendation | International Standard. When used to express a mandatory constraint on the values of *syntax elements* or on the results obtained by operation of the specified *decoding process*, it is the responsibility of the *encoder* to ensure that the constraint is fulfilled. When used in reference to operations performed by the *decoding process*, any *decoding process* that produces identical results to the *decoding process* described herein conforms to the *decoding process* requirements of this Recommendation | International Standard.

3.133 **should**: A term used to refer to behaviour of an implementation that is encouraged to be followed under anticipated ordinary circumstances, but is not a mandatory requirement for conformance to this Recommendation | International Standard.

3.134 **SI slice**: A *slice* that is coded using *prediction* only from decoded samples within the same *slice* and using quantisation of the *prediction* samples. An SI slice can be coded such that its decoded samples can be constructed identically to an *SP slice*.

3.135 **skipped macroblock**: A *macroblock* for which no data is coded other than an indication that the *macroblock* is to be decoded as "skipped". This indication may be common to several *macroblocks.*

3.136 **slice**: An integer number of *macroblocks* or *macroblock pairs* ordered consecutively in the *raster scan* within a particular *slice group.* For the *primary coded picture,* the division of each *slice group* into slices is a *partitioning*. Although a slice contains *macroblocks* or *macroblock pairs* that are consecutive in the *raster scan* within a *slice group,* these *macroblocks* or *macroblock pairs* are not necessarily consecutive in the *raster scan* within the *picture.* The addresses of the *macroblocks* are derived from the address of the first *macroblock* in a slice (as represented in the *slice header*) and the *macroblock to slice group map.*

3.137 **slice data partitioning**: A method of *partitioning* selected *syntax elements* into *syntax structures* based on a *category* associated with each *syntax element*.

3.138 **slice group**: A subset of the *macroblocks* or *macroblock pairs* of a *picture*. The division of the *picture* into slice groups is a *partitioning* of the *picture.* The partitioning is specified by the *macroblock to slice group map*.

3.139 **slice group map units**: The units of the *map unit to slice group map*.

3.140 **slice header**: A part of a coded *slice* containing the data elements pertaining to the first or all *macroblocks* represented in the *slice*.

3.141 **source**: Term used to describe the video material or some of its attributes before encoding.

3.142 **SP slice**: A *slice* that is coded using *inter prediction* from previously-decoded *reference pictures*, using at most one *motion vector* and *reference index* to *predict* the sample values of each *block.* An SP slice can be coded such that its decoded samples can be constructed identically to another SP slice or an *SI slice*.

3.143 **start code prefix**: A unique sequence of three *bytes* equal to 0x000001 embedded in the *byte stream* as a prefix to each *NAL unit.* The location of a start code prefix can be used by a *decoder* to identify the beginning of a new *NAL unit* and the end of a previous *NAL unit*. Emulation of start code prefixes is prevented within *NAL units* by the inclusion of *emulation prevention bytes.*

3.144 **string of data bits (SODB)**: A sequence of some number of bits representing *syntax elements* present within a *raw byte sequence payload* prior to the *raw byte sequence payload stop bit.* Within an SODB, the left-most bit is considered to be the first and most significant bit, and the right-most bit is considered to be the last and least significant bit.

3.145 **sub-macroblock**: One quarter of the samples of a *macroblock*, i.e., an 8x8 *luma block* and two corresponding *chroma blocks* of which one corner is located at a corner of the *macroblock.*

3.146 **sub-macroblock partition**: A *block* of *luma* samples and two corresponding *blocks* of *chroma* samples resulting from a *partitioning* of a *sub-macroblock* for *inter prediction*.

3.147 **switching I slice**: See *SI slice*.

3.148 **switching P slice**: See *SP slice*.

3.149 **syntax element**: An element of data represented in the *bitstream.*

3.150 **syntax structure**: Zero or more *syntax elements* present together in the *bitstream* in a specified order.

3.151 **top field**: One of two *fields* that comprise a *frame*. Each row of a *top field* is spatially located immediately above the corresponding row of the *bottom field.*

3.152 **top macroblock (of a macroblock pair)**: The *macroblock* within a *macroblock pair* that contains the samples in the top row of samples for the *macroblock pair.* For a *field macroblock pair*, the top macroblock represents the samples from the region of the *top field* of the *frame* that lie within the spatial region of the *macroblock pair.* For a *frame macroblock pair,* the top macroblock represents the samples of the *frame* that lie within the top half of the spatial region of the *macroblock pair.*

3.153 **transform coefficient**: A scalar quantity, considered to be in a frequency domain, that is associated with a particular one-dimensional or two-dimensional *frequency index* in an *inverse transform* part of the *decoding process*.

3.154 **transform coefficient level**: An integer quantity representing the value associated with a particular two-dimensional frequency index in the *decoding process* prior to *scaling* for computation of a *transform coefficient* value.

3.155 **universal unique identifier (UUID)**: An identifier that is unique with respect to the space of all universal unique identifiers.

3.156 **unspecified:** The term unspecified, when used in the clauses specifying some values of a particular *syntax element*, indicates that the values have no specified meaning in this Recommendation | International Standard and will not have a specified meaning in the future as an integral part of this Recommendation | International Standard.

3.157 **variable length coding (VLC)**: A reversible procedure for entropy coding that assigns shorter bit strings to *symbols* expected to be more frequent and longer bit strings to *symbols* expected to be less frequent.

3.158 **zig-zag scan**: A specific sequential ordering of *transform coefficient levels* from (approximately) the lowest spatial frequency to the highest. Zig-zag scan is used for *transform coefficient levels* in *frame macroblocks.*

4 Abbreviations

For the purposes of this Recommendation | International Standard, the following abbreviations apply.

CABAC Context-based Adaptive Binary Arithmetic Coding

CAVLC Context-based Adaptive Variable Length Coding

CBR Constant Bit Rate

CPB Coded Picture Buffer

DPB Decoded Picture Buffer

DUT Decoder under test

FIFO First-In, First-Out

HRD Hypothetical Reference Decoder

HSS Hypothetical Stream Scheduler

IDR Instantaneous Decoding Refresh

LSB Least Significant Bit

MB Macroblock

MBAFF Macroblock-Adaptive Frame-Field Coding

MSB Most Significant Bit

NAL Network Abstraction Layer

RBSP Raw Byte Sequence Payload

SEI Supplemental Enhancement Information

SODB String Of Data Bits

UUID Universal Unique Identifier

VBR Variable Bit Rate

VCL Video Coding Layer

VLC Variable Length Coding

VUI Video Usability Information

5 Conventions

NOTE – The mathematical operators used in this Specification are similar to those used in the C programming language. However, integer division and arithmetic shift operations are specifically defined. Numbering and counting conventions generally begin from 0.

5.1 Arithmetic operators

The following arithmetic operators are defined as follows.

+	Addition
–	Subtraction (as a two-argument operator) or negation (as a unary prefix operator)
*	Multiplication
x^y	Exponentiation. Specifies x to the power of y. In other contexts, such notation is used for superscripting not intended for interpretation as exponentiation.
/	Integer division with truncation of the result toward zero. For example, 7/4 and –7/–4 are truncated to 1 and –7/4 and 7/–4 are truncated to –1.
÷	Used to denote division in mathematical equations where no truncation or rounding is intended.
$\frac{x}{y}$	Used to denote division in mathematical equations where no truncation or rounding is intended.
$\sum_{i=x}^{y} f(i)$	The summation of f(i) with i taking all integer values from x up to and including y.
x % y	Modulus. Remainder of x divided by y, defined only for integers x and y with x >= 0 and y > 0.

When order of precedence is not indicated explicitly by use of parenthesis, the following rules apply:

– multiplication and division operations are considered to take place before addition and subtraction;

– multiplication and division operations in sequence are evaluated sequentially from left to right;

– addition and subtraction operations in sequence are evaluated sequentially from left to right.

5.2 Logical operators

The following logical operators are defined as follows:

x && y	Boolean logical "and" of x and y
x || y	Boolean logical "or" of x and y
!	Boolean logical "not"
x ? y : z	If x is TRUE or not equal to 0, evaluates to the value of y; otherwise, evaluates to the value of z

5.3 Relational operators

The following relational operators are defined as follows:

>	Greater than
>=	Greater than or equal to
<	Less than
<=	Less than or equal to
= =	Equal to
!=	Not equal to

When a relational operator is applied to a syntax element or variable that has been assigned the value "na" (not applicable), the value "na" is treated as a distinct value for the syntax element or variable. The value "na" is considered not to be equal to any other value.

5.4 Bit-wise operators

The following bit-wise operators are defined as follows:

&	Bit-wise "and". When operating on integer arguments, operates on a two's complement representation of the integer value. When operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0.

| Bit-wise "or". When operating on integer arguments, operates on a two's complement representation of the integer value. When operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0.

x >> y Arithmetic right shift of a two's complement integer representation of x by y binary digits. This function is defined only for positive integer values of y. Bits shifted into the MSBs as a result of the right shift have a value equal to the MSB of x prior to the shift operation.

x << y Arithmetic left shift of a two's complement integer representation of x by y binary digits. This function is defined only for positive integer values of y. Bits shifted into the LSBs as a result of the left shift have a value equal to 0.

5.5 Assignment operators

The following arithmetic operators are defined as follows:

= Assignment operator.

++ Increment, i.e., x++ is equivalent to $x = x + 1$; when used in an array index, evaluates to the value of the variable prior to the increment operation.

–– Decrement, i.e., x–– is equivalent to $x = x - 1$; when used in an array index, evaluates to the value of the variable prior to the decrement operation.

+= Increment by amount specified, i.e., x += 3 is equivalent to x = x + 3, and x += (-3) is equivalent to x = x + (-3).

–= Decrement by amount specified, i.e., x –= 3 is equivalent to x = x – 3, and x –= (-3) is equivalent to x = x – (-3).

5.6 Range notation

The following notation is used to specify a range of values

x = y .. z x takes on integer values starting from y to z inclusive, with x, y, and z being integer numbers.

5.7 Mathematical functions

The following mathematical functions are defined as follows:

$$\text{Abs}(x) = \begin{cases} x & ; \quad x >= 0 \\ -x & ; \quad x < 0 \end{cases} \tag{5-1}$$

Ceil(x) the smallest integer greater than or equal to x. (5-2)

$$\text{Clip1}_Y(x) = \text{Clip3}(0, (1 << \text{BitDepth}_Y) - 1, x) \tag{5-3}$$

$$\text{Clip1}_C(x) = \text{Clip3}(0, (1 << \text{BitDepth}_C) - 1, x) \tag{5-4}$$

$$\text{Clip3}(x, y, z) = \begin{cases} x & ; \quad z < x \\ y & ; \quad z > y \\ z & ; \quad \text{otherwise} \end{cases} \tag{5-5}$$

Floor(x) the greatest integer less than or equal to x. (5-6)

$$\text{InverseRasterScan}(a, b, c, d, e) = \begin{cases} (a \% (d / b)) * b; & e == 0 \\ (a / (d / b)) * c; & e == 1 \end{cases} \tag{5-7}$$

Log2(x) returns the base-2 logarithm of x. (5-8)

Log10(x) returns the base-10 logarithm of x. (5-9)

$$\text{Median}(x, y, z) = x + y + z - \text{Min}(x, \text{Min}(y, z)) - \text{Max}(x, \text{Max}(y, z)) \quad (5\text{-}10)$$

$$\text{Min}(x, y) = \begin{cases} x & ; \quad x <= y \\ y & ; \quad x > y \end{cases} \quad (5\text{-}11)$$

$$\text{Max}(x, y) = \begin{cases} x & ; \quad x >= y \\ y & ; \quad x < y \end{cases} \quad (5\text{-}12)$$

$$\text{Round}(x) = \text{Sign}(x) * \text{Floor}(\text{Abs}(x) + 0.5) \quad (5\text{-}13)$$

$$\text{Sign}(x) = \begin{cases} 1 & ; \quad x >= 0 \\ -1 & ; \quad x < 0 \end{cases} \quad (5\text{-}14)$$

$$\text{Sqrt}(x) = \sqrt{x} \quad (5\text{-}15)$$

5.8 Variables, syntax elements, and tables

Syntax elements in the bitstream are represented in **bold** type. Each syntax element is described by its name (all lower case letters with underscore characters), its one or two syntax categories, and one or two descriptors for its method of coded representation. The decoding process behaves according to the value of the syntax element and to the values of previously decoded syntax elements. When a value of a syntax element is used in the syntax tables or the text, it appears in regular (i.e., not bold) type.

In some cases the syntax tables may use the values of other variables derived from syntax elements values. Such variables appear in the syntax tables, or text, named by a mixture of lower case and upper case letter and without any underscore characters. Variables starting with an upper case letter are derived for the decoding of the current syntax structure and all depending syntax structures. Variables starting with an upper case letter may be used in the decoding process for later syntax structures mentioning the originating syntax structure of the variable. Variables starting with a lower case letter are only used within the subclause in which they are derived.

In some cases, "mnemonic" names for syntax element values or variable values are used interchangeably with their numerical values. Sometimes "mnemonic" names are used without any associated numerical values. The association of values and names is specified in the text. The names are constructed from one or more groups of letters separated by an underscore character. Each group starts with an upper case letter and may contain more upper case letters.

NOTE – The syntax is described in a manner that closely follows the C-language syntactic constructs.

Functions are described by their names, which are constructed as syntax element names, with left and right round parentheses including zero or more variable names (for definition) or values (for usage), separated by commas (if more than one variable).

A one-dimensional array is referred to as a list. A two-dimensional array is referred to as a matrix. Arrays can either be syntax elements or variables. Subscripts or square parentheses are used for the indexing of arrays. In reference to a visual depiction of a matrix, the first subscript is used as a row (vertical) index and the second subscript is used as a column (horizontal) index. The indexing order is reversed when using square parentheses rather than subscripts for indexing. Thus, an element of a matrix s at horizontal position x and vertical position y may be denoted either as s[x, y] or as s_{yx}.

Binary notation is indicated by enclosing the string of bit values by single quote marks. For example, '01000001' represents an eight-bit string having only its second and its last bits equal to 1.

Hexadecimal notation, indicated by prefixing the hexadecimal number by "0x", may be used instead of binary notation when the number of bits is an integer multiple of 4. For example, 0x41 represents an eight-bit string having only its second and its last bits equal to 1.

Numerical values not enclosed in single quotes and not prefixed by "0x" are decimal values.

A value equal to 0 represents a FALSE condition in a test statement. The value TRUE is represented by any other value different than zero.

5.9 Text description of logical operations

In the text, a statement of logical operations as would be described in pseudo-code as

```
if( condition 0 )
  statement 0
else if ( condition 1 )
  statement 1
…
else /* informative remark on remaining condition */
  statement n
```

may be described in the following manner:

... as follows / ... the following applies.

- If condition 0, statement 0
- Otherwise, if condition 1, statement 1
- …
- Otherwise (informative remark on remaining condition), statement n

Each "If...Otherwise, if...Otherwise, ..." statement in the text is introduced with "... as follows" or "... the following applies" immediately followed by "If ... ". The last condition of the "If...Otherwise, if...Otherwise, ..." is always an "Otherwise, ...". Interleaved "If...Otherwise, if...Otherwise, ..." statements can be identified by matching "... as follows" or "... the following applies" with the ending "Otherwise, ...".

In the text, a statement of logical operations as would be described in pseudo-code as

```
if( condition 0a  &&  condition 0b )
  statement 0
else if ( condition 1a  ||  condition 1b )
  statement 1
…
else
  statement n
```

may be described in the following manner:

... as follows / ... the following applies.

- If all of the following conditions are true, statement 0
  - condition 0a
  - condition 0b
- Otherwise, if any of the following conditions are true, statement 1
  - condition 1a
  - condition 1b
- …
- Otherwise, statement n

In the text, a statement of logical operations as would be described in pseudo-code as

```
if( condition 0 )
  statement 0
if ( condition 1 )
  statement 1
```

may be described in the following manner:

When condition 0, statement 0

When condition 1, statement 1

5.10 Processes

Processes are used to describe the decoding of syntax elements. A process has a separate specification and invoking. All syntax elements and upper case variables that pertain to the current syntax structure and depending syntax structures are available in the process specification and invoking. A process specification may also have a lower case variable explicitly specified as the input. Each process specification has explicitly specified an output. The output is a variable that can either be an upper case variable or a lower case variable.

The assignment of variables is specified as follows.

- If invoking a process, variables are explicitly assigned to lower case input or output variables of the process specification in case these do not have the same name.
- Otherwise (when the variables at the invoking and specification have the same name), assignment is implied.

In the specification of a process, a specific macroblock may be referred to by the variable name having a value equal to the address of the specific macroblock.

6 Source, coded, decoded and output data formats, scanning processes, and neighbouring relationships

6.1 Bitstream formats

This subclause specifies the relationship between the NAL unit stream and byte stream, either of which are referred to as the bitstream.

The bitstream can be in one of two formats: the NAL unit stream format or the byte stream format. The NAL unit stream format is conceptually the more "basic" type. It consists of a sequence of syntax structures called NAL units. This sequence is ordered in decoding order. There are constraints imposed on the decoding order (and contents) of the NAL units in the NAL unit stream.

The byte stream format can be constructed from the NAL unit stream format by ordering the NAL units in decoding order and prefixing each NAL unit with a start code prefix and zero or more zero-valued bytes to form a stream of bytes. The NAL unit stream format can be extracted from the byte stream format by searching for the location of the unique start code prefix pattern within this stream of bytes. Methods of framing the NAL units in a manner other than use of the byte stream format are outside the scope of this Recommendation | International Standard. The byte stream format is specified in Annex B.

6.2 Source, decoded, and output picture formats

This subclause specifies the relationship between source and decoded frames and fields that is given via the bitstream.

The video source that is represented by the bitstream is a sequence of either or both frames or fields (called collectively pictures) in decoding order.

The source and decoded pictures (frames or fields) are each comprised of one or more sample arrays:

- Luma (Y) only (monochrome), with or without an auxiliary array.
- Luma and two Chroma (YCbCr or YCgCo), with or without an auxiliary array.
- Green, Blue and Red (GBR, also known as RGB), with or without an auxiliary array.

– Arrays representing other unspecified monochrome or tri-stimulus colour samplings (for example, YZX, also known as XYZ), with or without an auxiliary array.

For convenience of notation and terminology in this specification, the variables and terms associated with these arrays are referred to as luma (or L or Y) and chroma, where the two chroma arrays are referred to as Cb and Cr; regardless of the actual colour representation method in use. The actual colour representation method in use can be indicated in syntax that is specified in Annex E. The (monochrome) auxiliary arrays, which may or may not be present as auxiliary pictures in a coded video sequence, are optional for decoding and can be used for such purposes as alpha blending.

The variables SubWidthC, and SubHeightC are specified in Table 6-1, depending on the chroma format sampling structure, which is specified through chroma_format_idc. An entry marked as "-" in Table 6-1 denotes an undefined value for SubWidthC or SubHeightC. Other values of chroma_format_idc, SubWidthC, and SubHeightC may be specified in the future by ITU-T | ISO/IEC.

Table 6-1 – SubWidthC, and SubHeightC values derived from chroma_format_idc

chroma_format_idc	Chroma Format	SubWidthC	SubHeightC
0	monochrome	–	–
1	4:2:0	2	2
2	4:2:2	2	1
3	4:4:4	1	1

In monochrome sampling there is only one sample array, which is nominally considered the luma array.

In 4:2:0 sampling, each of the two chroma arrays has half the height and half the width of the luma array.

In 4:2:2 sampling, each of the two chroma arrays has the same height and half the width of the luma array.

In 4:4:4 sampling, each of the two chroma arrays has the same height and width as the luma array.

The width and height of the luma sample arrays are each an integer multiple of 16. In bitstreams using 4:2:0 chroma sampling, the width and height of chroma sample arrays are each an integer multiple of 8. In bitstreams using 4:2:2 sampling, the width of the chroma sample arrays is an integer multiple of 8 and the height is an integer multiple of 16. The height of a luma array that is coded as two separate fields or in macroblock-adaptive frame-field coding (see below) is an integer multiple of 32. In bitstreams using 4:2:0 chroma sampling, the height of each chroma array that is coded as two separate fields or in macroblock-adaptive frame-field coding (see below) is an integer multiple of 16. The width or height of pictures output from the decoding process need not be an integer multiple of 16 and can be specified using a cropping rectangle.

The syntax for the luma and (when present) chroma arrays are ordered such when data for all three colour components is present, the data for the luma array is first, followed by any data for the Cb array, followed by any data for the Cr array, unless otherwise specified.

The width of fields coded referring to a specific sequence parameter set is the same as that of frames coded referring to the same sequence parameter set (see below). The height of fields coded referring to a specific sequence parameter set is half that of frames coded referring to the same sequence parameter set (see below).

The number of bits necessary for the representation of each of the samples in the luma and chroma arrays in a video sequence is in the range of 8 to 12, and the number of bits used in the luma array may differ from the number of bits used in the chroma arrays.

When the value of chroma_format_idc is equal to 1, the nominal vertical and horizontal relative locations of luma and chroma samples in frames are shown in Figure 6-1. Alternative chroma sample relative locations may be indicated in video usability information (see Annex E).

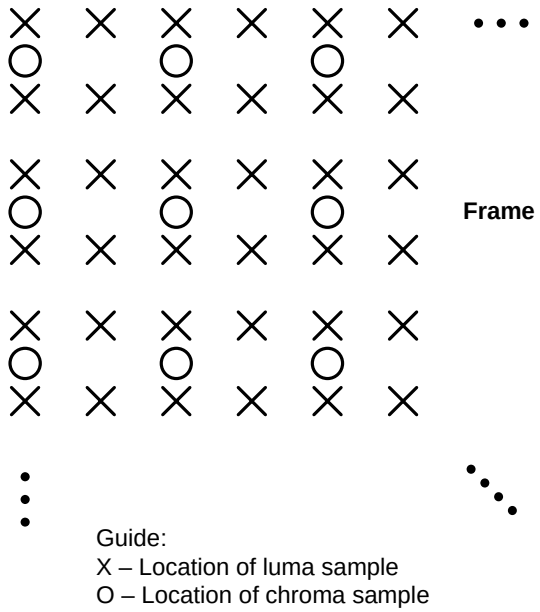


Figure 6-1 – Nominal vertical and horizontal locations of 4:2:0 luma and chroma samples in a frame

A frame consists of two fields as described below. A coded picture may represent a coded frame or an individual coded field. A coded video sequence conforming to this Recommendation | International Standard may contain arbitrary combinations of coded frames and coded fields. The decoding process is also specified in a manner that allows smaller regions of a coded frame to be coded either as a frame or field region, by use of macroblock-adaptive frame-field coding.

Source and decoded fields are one of two types: top field or bottom field. When two fields are output at the same time, or are combined to be used as a reference frame (see below), the two fields (which shall be of opposite parity) are interleaved. The first (i.e., top), third, fifth, etc. rows of a decoded frame are the top field rows. The second, fourth, sixth, etc. rows of a decoded frame are the bottom field rows. A top field consists of only the top field rows of a decoded frame. When the top field or bottom field of a decoded frame is used as a reference field (see below) only the even rows (for a top field) or the odd rows (for a bottom field) of the decoded frame are used.

When the value of chroma_format_idc is equal to 1, the nominal vertical and horizontal relative locations of luma and chroma samples in top and bottom fields are shown in Figure 6-2. The nominal vertical sampling relative locations of the chroma samples in a top field are specified as shifted up by one-quarter luma sample height relative to the field-sampling grid. The vertical sampling locations of the chroma samples in a bottom field are specified as shifted down by one-quarter luma sample height relative to the field-sampling grid. Alternative chroma sample relative locations may be indicated in the video usability information (see Annex E).

NOTE – The shifting of the chroma samples is in order for these samples to align vertically to the usual location relative to the full-frame sampling grid as shown in Figure 6-1.

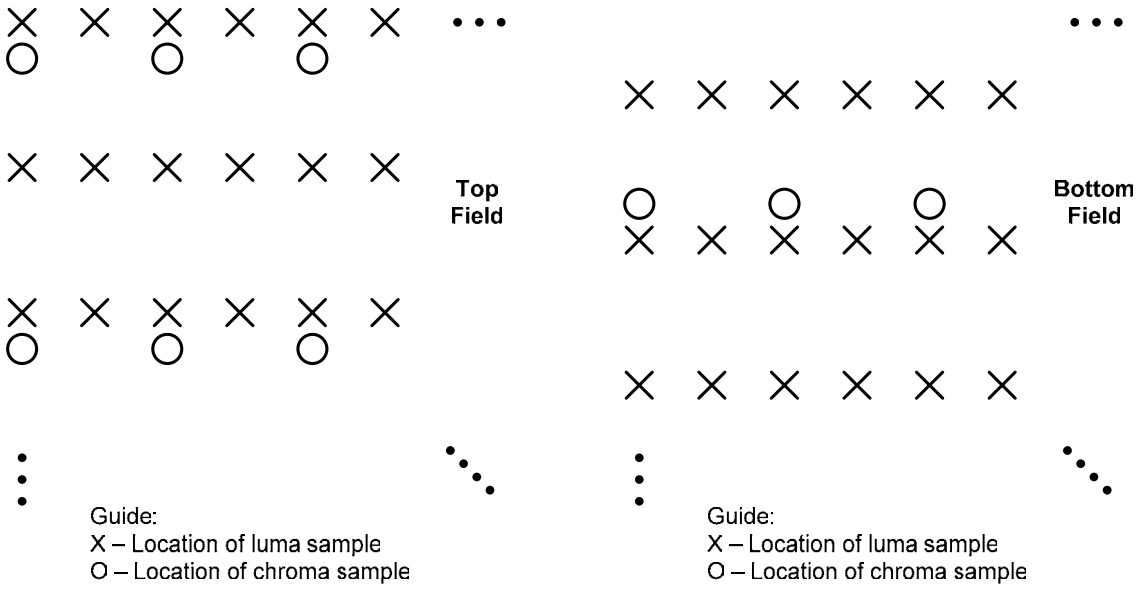


Figure 6-2 – Nominal vertical and horizontal sampling locations of 4:2:0 samples in top and bottom fields

When the value of chroma_format_idc is equal to 2, the chroma samples are co-sited with the corresponding luma samples and the nominal locations in a frame and in fields are as shown in Figure 6-3 – Nominal vertical and horizontal locations of 4:2:2 luma and chroma samples in a frameandFigure 6-4, respectively.

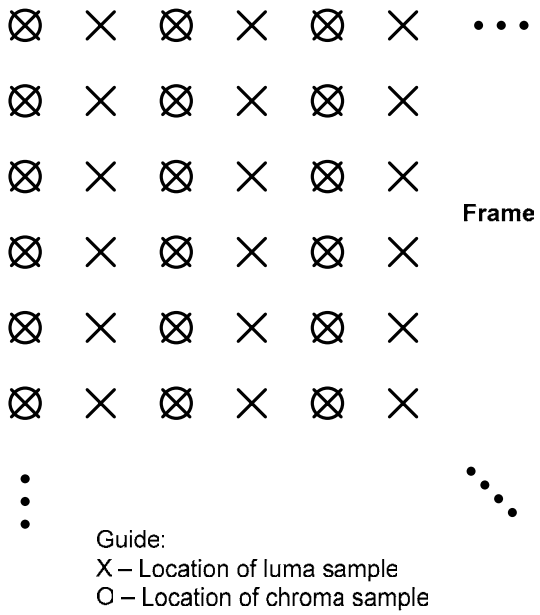


Figure 6-3 – Nominal vertical and horizontal locations of 4:2:2 luma and chroma samples in a frame

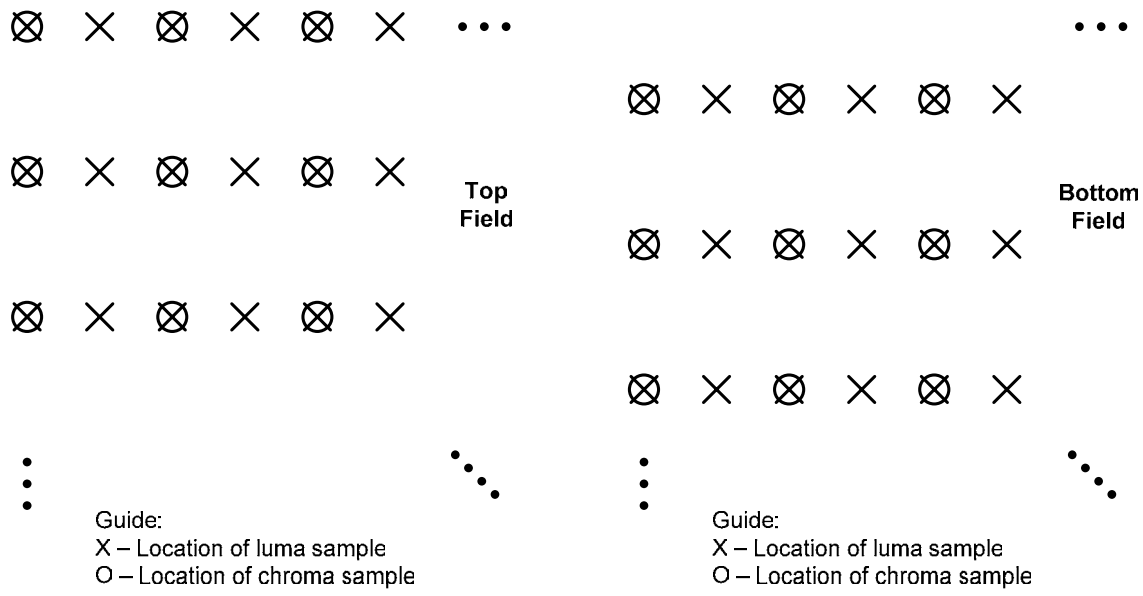


Figure 6-4 – Nominal vertical and horizontal sampling locations of 4:2:2 samples top and bottom fields

When the value of chroma_format_idc is equal to 3, all array samples are co-sited for all cases of frames and fields and the nominal locations in a frame and in fields are as shown in Figures 6-5 and 6-6, respectively.

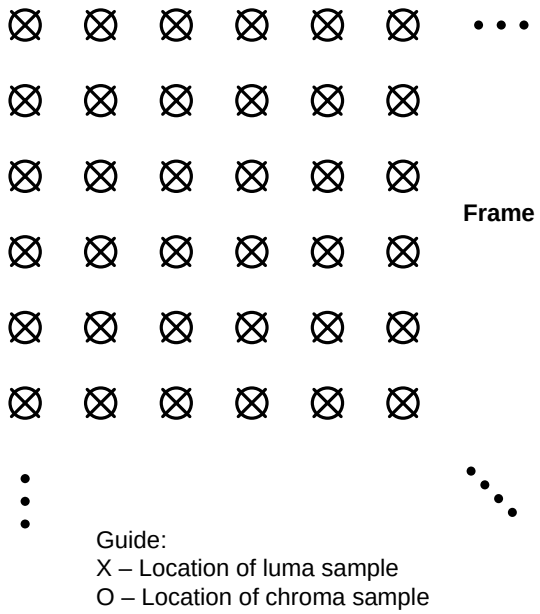


Figure 6-5 – Nominal vertical and horizontal locations of 4:4:4 luma and chroma samples in a frame

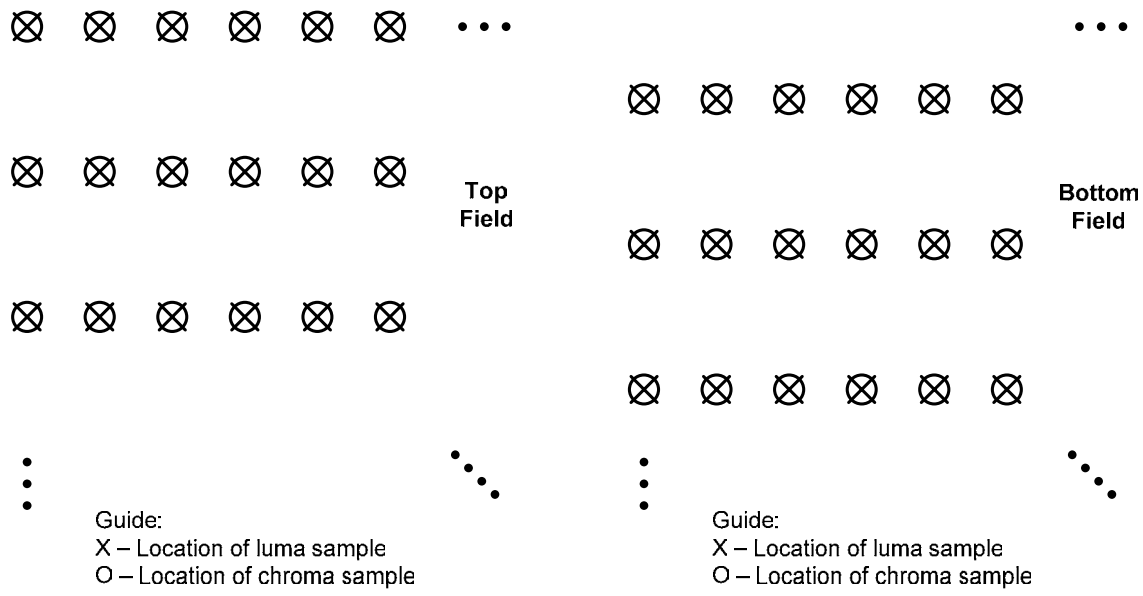


Figure 6-6 – Nominal vertical and horizontal sampling locations of 4:4:4 samples top and bottom fields

The samples are processed in units of macroblocks. The luma array for each macroblock is 16 samples in both width and height. The variables MbWidthC and MbHeightC, which specify the width and height, respectively, of the chroma arrays for each macroblock, are derived as follows.

– If chroma_format_idc is equal to 0 (monochrome), MbWidthC and MbHeightC are both equal to 0 (as no chroma arrays are specified for monochrome video).

– Otherwise, MbWidthC and MbHeightC are derived as

$$MbWidthC = 16 / SubWidthC \quad (6\text{-}1)$$
$$MbHeightC = 16 / SubHeightC \quad (6\text{-}2)$$

6.3 Spatial subdivision of pictures and slices

This subclause specifies how a picture is partitioned into slices and macroblocks. Pictures are divided into slices. A slice is a sequence of macroblocks, or, when macroblock-adaptive frame/field decoding is in use, a sequence of macroblock pairs.

Each macroblock is comprised of one 16x16 luma array and, when the video format is not monochrome, two corresponding chroma sample arrays. When macroblock-adaptive frame/field decoding is not in use, each macroblock represents a spatial rectangular region of the picture. For example, a picture may be divided into two slices as shown in Figure 6-7.

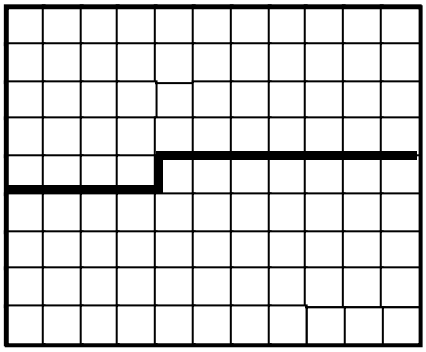


Figure 6-7 – A picture with 11 by 9 macroblocks that is partitioned into two slices

When macroblock-adaptive frame/field decoding is in use, the picture is partitioned into slices containing an integer number of macroblock pairs as shown in Figure 6-8. Each macroblock pair consists of two macroblocks.

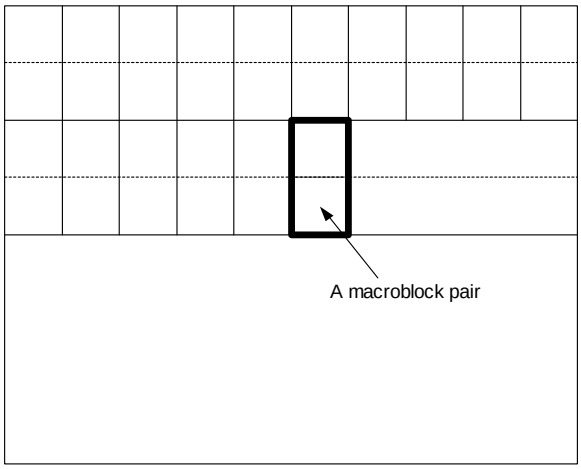


Figure 6-8 – Partitioning of the decoded frame into macroblock pairs

6.4 Inverse scanning processes and derivation processes for neighbours

This subclause specifies inverse scanning processes; i.e., the mapping of indices to locations, and derivation processes for neighbours.

6.4.1 Inverse macroblock scanning process

Input to this process is a macroblock address mbAddr.

Output of this process is the location (x, y) of the upper-left luma sample for the macroblock with address mbAddr relative to the upper-left sample of the picture.

The inverse macroblock scanning process is specified as follows.

– If MbaffFrameFlag is equal to 0,

$$x = InverseRasterScan(mbAddr, 16, 16, PicWidthInSamples_L, 0) \quad (6\text{-}3)$$

$$y = InverseRasterScan(mbAddr, 16, 16, PicWidthInSamples_L, 1) \quad (6\text{-}4)$$

– Otherwise (MbaffFrameFlag is equal to 1), the following applies.

$$xO = InverseRasterScan(mbAddr / 2, 16, 32, PicWidthInSamples_L, 0) \quad (6\text{-}5)$$

$$yO = InverseRasterScan(mbAddr / 2, 16, 32, PicWidthInSamples_L, 1) \quad (6\text{-}6)$$

Depending on the current macroblock the following applies.

– If the current macroblock is a frame macroblock

$$x = xO \quad (6\text{-}7)$$

$$y = yO + (mbAddr \% 2) * 16 \quad (6\text{-}8)$$

– Otherwise (the current macroblock is a field macroblock),

$$x = xO \quad (6\text{-}9)$$

$$y = yO + (mbAddr \% 2) \quad (6\text{-}10)$$

6.4.2 Inverse macroblock partition and sub-macroblock partition scanning process

Macroblocks or sub-macroblocks may be partitioned, and the partitions are scanned for inter prediction as shown in Figure 6-9. The outer rectangles refer to the samples in a macroblock or sub-macroblock, respectively. The rectangles refer to the partitions. The number in each rectangle specifies the index of the inverse macroblock partition scan or inverse sub-macroblock partition scan.

The functions MbPartWidth( ), MbPartHeight( ), SubMbPartWidth( ), and SubMbPartHeight( ) describing the width and height of macroblock partitions and sub-macroblock partitions are specified in Tables 7-13, 7-14, 7-17, and 7-18. MbPartWidth( ) and MbPartHeight( ) are set to appropriate values for each macroblock, depending on the macroblock type. SubMbPartWidth( ) and SubMbPartHeight( ) are set to appropriate values for each sub-macroblock of a macroblock with mb_type equal to P_8x8, P_8x8ref0, or B_8x8, depending on the sub-macroblock type.

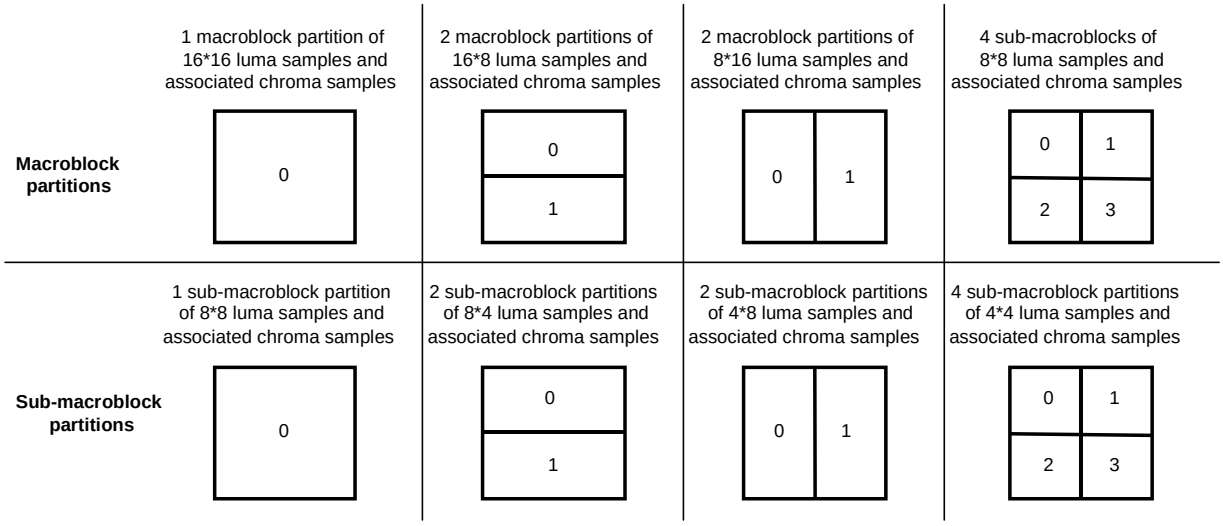


Figure 6-9 – Macroblock partitions, sub-macroblock partitions, macroblock partition scans, and sub-macroblock partition scans

6.4.2.1 Inverse macroblock partition scanning process

Input to this process is the index of a macroblock partition mbPartIdx.

Output of this process is the location (x, y) of the upper-left luma sample for the macroblock partition mbPartIdx relative to the upper-left sample of the macroblock.

The inverse macroblock partition scanning process is specified by

$$x = \text{InverseRasterScan}(\text{mbPartIdx}, \text{MbPartWidth}(\text{mb\_type}), \text{MbPartHeight}(\text{mb\_type}), 16, 0) \quad (6\text{-}11)$$

$$y = \text{InverseRasterScan}(\text{mbPartIdx}, \text{MbPartWidth}(\text{mb\_type}), \text{MbPartHeight}(\text{mb\_type}), 16, 1) \quad (6\text{-}12)$$

6.4.2.2 Inverse sub-macroblock partition scanning process

Inputs to this process are the index of a macroblock partition mbPartIdx and the index of a sub-macroblock partition subMbPartIdx.

Output of this process is the location (x, y) of the upper-left luma sample for the sub-macroblock partition subMbPartIdx relative to the upper-left sample of the sub-macroblock.

The inverse sub-macroblock partition scanning process is specified as follows.

– If mb_type is equal to P_8x8, P_8x8ref0, or B_8x8,

$$x = \text{InverseRasterScan}(\text{subMbPartIdx}, \text{SubMbPartWidth}(\text{sub\_mb\_type}[\text{mbPartIdx}]), \text{SubMbPartHeight}(\text{sub\_mb\_type}[\text{mbPartIdx}]), 8, 0) \quad (6\text{-}13)$$

$$y = \text{InverseRasterScan}(\text{subMbPartIdx}, \text{SubMbPartWidth}(\text{sub\_mb\_type}[\text{mbPartIdx}]), \text{SubMbPartHeight}(\text{sub\_mb\_type}[\text{mbPartIdx}]), 8, 1) \quad (6\text{-}14)$$

– Otherwise,

$$x = \text{InverseRasterScan}(\text{subMbPartIdx}, 4, 4, 8, 0) \quad (6\text{-}15)$$

$$y = \text{InverseRasterScan}(\text{subMbPartIdx}, 4, 4, 8, 1) \quad (6\text{-}16)$$

6.4.3 Inverse 4x4 luma block scanning process

Input to this process is the index of a 4x4 luma block luma4x4BlkIdx.

Output of this process is the location (x, y) of the upper-left luma sample for the 4x4 luma block with index luma4x4BlkIdx relative to the upper-left luma sample of the macroblock.

Figure 6-10 shows the scan for the 4x4 luma blocks.

0	1	4	5
2	3	6	7
8	9	12	13
10	11	14	15

Figure 6-10 – Scan for 4x4 luma blocks

The inverse 4x4 luma block scanning process is specified by

x = InverseRasterScan(luma4x4BlkIdx / 4, 8, 8, 16, 0) + InverseRasterScan(luma4x4BlkIdx % 4, 4, 4, 8, 0) (6-17)

y = InverseRasterScan(luma4x4BlkIdx / 4, 8, 8, 16, 1) + InverseRasterScan(luma4x4BlkIdx % 4, 4, 4, 8, 1) (6-18)

6.4.4 Inverse 8x8 luma block scanning process

Input to this process is the index of an 8x8 luma block luma8x8BlkIdx.

Output of this process is the location (x, y) of the upper-left luma sample for the 8x8 luma block with index luma8x8BlkIdx relative to the upper-left luma sample of the macroblock.

Figure 6-11 shows the scan for the 8x8 luma blocks.

0	1
2	3

Figure 6-11 – Scan for 8x8 luma blocks

The inverse 8x8 luma block scanning process is specified by

x = InverseRasterScan(luma8x8BlkIdx, 8, 8, 16, 0) (6-19)

y = InverseRasterScan(luma8x8BlkIdx, 8, 8, 16, 1) (6-20)

6.4.5 Derivation process of the availability for macroblock addresses

Input to this process is a macroblock address mbAddr.

Output of this process is the availability of the macroblock mbAddr.

NOTE – The meaning of availability is determined when this process is invoked.

The macroblock is marked as available, unless one of the following conditions is true in which case the macroblock is marked as not available:

– mbAddr < 0

– mbAddr > CurrMbAddr

– the macroblock with address mbAddr belongs to a different slice than the macroblock with address CurrMbAddr

6.4.6 Derivation process for neighbouring macroblock addresses and their availability

This process can only be invoked when MbaffFrameFlag is equal to 0.

The outputs of this process are

– mbAddrA: the address and availability status of the macroblock to the left of the current macroblock.

– mbAddrB: the address and availability status of the macroblock above the current macroblock.

– mbAddrC: the address and availability status of the macroblock above-right of the current macroblock.

– mbAddrD: the address and availability status of the macroblock above-left of the current macroblock.

Figure 6-12 shows the relative spatial locations of the macroblocks with mbAddrA, mbAddrB, mbAddrC, and mbAddrD relative to the current macroblock with CurrMbAddr.

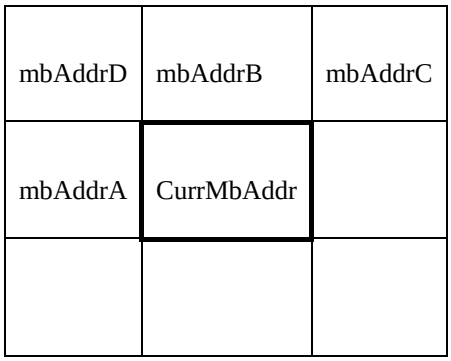


Figure 6-12 – Neighbouring macroblocks for a given macroblock

Input to the process in subclause 6.4.5 is mbAddrA = CurrMbAddr – 1 and the output is whether the macroblock mbAddrA is available. In addition, mbAddrA is marked as not available when CurrMbAddr % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.5 is mbAddrB = CurrMbAddr – PicWidthInMbs and the output is whether the macroblock mbAddrB is available.

Input to the process in subclause 6.4.5 is mbAddrC = CurrMbAddr – PicWidthInMbs + 1 and the output is whether the macroblock mbAddrC is available. In addition, mbAddrC is marked as not available when (CurrMbAddr + 1) % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.5 is mbAddrD = CurrMbAddr – PicWidthInMbs - 1 and the output is whether the macroblock mbAddrD is available. In addition, mbAddrD is marked as not available when CurrMbAddr % PicWidthInMbs is equal to 0.

6.4.7 Derivation process for neighbouring macroblock addresses and their availability in MBAFF frames

This process can only be invoked when MbaffFrameFlag is equal to 1.

The outputs of this process are

– mbAddrA: the address and availability status of the top macroblock of the macroblock pair to the left of the current macroblock pair.

– mbAddrB: the address and availability status of the top macroblock of the macroblock pair above the current macroblock pair.

– mbAddrC: the address and availability status of the top macroblock of the macroblock pair above-right of the current macroblock pair.

– mbAddrD: the address and availability status of the top macroblock of the macroblock pair above-left of the current macroblock pair.

Figure 6-13 shows the relative spatial locations of the macroblocks with mbAddrA, mbAddrB, mbAddrC, and mbAddrD relative to the current macroblock with CurrMbAddr.

mbAddrA, mbAddrB, mbAddrC, and mbAddrD have identical values regardless whether the current macroblock is the top or the bottom macroblock of a macroblock pair.

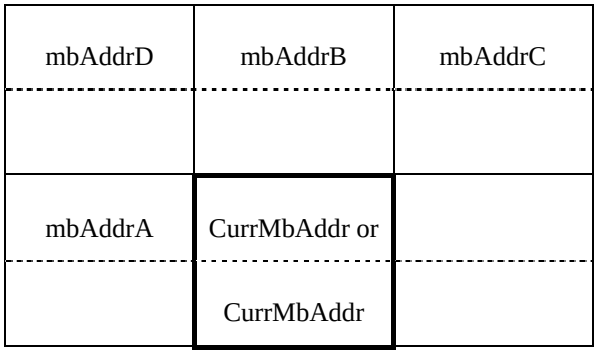


Figure 6-13 – Neighbouring macroblocks for a given macroblock in MBAFF frames

Input to the process in subclause 6.4.5 is mbAddrA =2 * (CurrMbAddr / 2 – 1) and the output is whether the macroblock mbAddrA is available. In addition, mbAddrA is marked as not available when (CurrMbAddr / 2) % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.5 is mbAddrB =2 * (CurrMbAddr / 2 – PicWidthInMbs) and the output is whether the macroblock mbAddrB is available.

Input to the process in subclause 6.4.5 is mbAddrC = 2 * (CurrMbAddr / 2 – PicWidthInMbs + 1) and the output is whether the macroblock mbAddrC is available. In addition, mbAddrC is marked as not available when (CurrMbAddr / 2 + 1) % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.5 is mbAddrD = 2 * (CurrMbAddr / 2 – PicWidthInMbs - 1) and the output is whether the macroblock mbAddrD is available. In addition, mbAddrD is marked as not available when (CurrMbAddr / 2) % PicWidthInMbs is equal to 0.

6.4.8 Derivation processes for neighbouring macroblocks, blocks, and partitions

Subclause 6.4.8.1 specifies the derivation process for neighbouring macroblocks.

Subclause 6.4.8.2 specifies the derivation process for neighbouring 8x8 luma blocks.

Subclause 6.4.8.3 specifies the derivation process for neighbouring 4x4 luma blocks.

Subclause 6.4.8.4 specifies the derivation process for neighbouring 4x4 chroma blocks.

Subclause 6.4.8.5 specifies the derivation process for neighbouring partitions.

Table 6-2 specifies the values for the difference of luma location (xD, yD) for the input and the replacement for N in mbAddrN, mbPartIdxN, subMbPartIdxN, luma8x8BlkIdxN, luma4x4BlkIdxN, and chroma4x4BlkIdxN for the output. These input and output assignments are used in subclauses 6.4.8.1 to 6.4.8.5. The variable predPartWidth is specified when Table 6-2 is referred to.

Table 6-2 – Specification of input and output assignments for subclauses 6.4.8.1 to 6.4.8.5

N	xD	yD
A	-1	0
B	0	-1
C	predPartWidth	-1
D	-1	-1

Figure 6-14 illustrates the relative location of the neighbouring macroblocks, blocks, or partitions A, B, C, and D to the current macroblock, partition, or block, when the current macroblock, partition, or block is in frame coding mode.

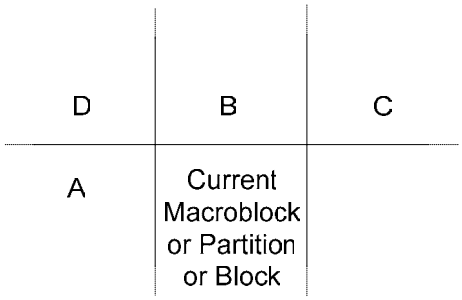


Figure 6-14 – Determination of the neighbouring macroblock, blocks, and partitions (informative)

6.4.8.1 Derivation process for neighbouring macroblocks

Outputs of this process are

– mbAddrA: the address of the macroblock to the left of the current macroblock and its availability status and

– mbAddrB: the address of the macroblock above the current macroblock and its availability status.

mbAddrN (with N being A or B) is derived as follows.

– The difference of luma location (xD, yD) is set according to Table 6-2.

– The derivation process for neighbouring locations as specified in subclause 6.4.9 is invoked for luma locations with (xN, yN) equal to (xD, yD), and the output is assigned to mbAddrN.

6.4.8.2 Derivation process for neighbouring 8x8 luma block

Input to this process is an 8x8 luma block index luma8x8BlkIdx.

The luma8x8BlkIdx specifies the 8x8 luma blocks of a macroblock in a raster scan.

Outputs of this process are

– mbAddrA: either equal to CurrMbAddr or the address of the macroblock to the left of the current macroblock and its availability status,

– luma8x8BlkIdxA: the index of the 8x8 luma block to the left of the 8x8 block with index luma8x8BlkIdx and its availability status,

– mbAddrB: either equal to CurrMbAddr or the address of the macroblock above the current macroblock and its availability status,

– luma8x8BlkIdxB: the index of the 8x8 luma block above the 8x8 block with index luma8x8BlkIdx and its availability status.

mbAddrN and luma8x8BlkIdxN (with N being A or B) are derived as follows.

– The difference of luma location (xD, yD) is set according to Table 6-2.

– The luma location (xN, yN) is specified by

$$xN = (luma8x8BlkIdx \% 2) * 8 + xD \quad (6\text{-}21)$$

$$yN = (luma8x8BlkIdx / 2) * 8 + yD \quad (6\text{-}22)$$

– The derivation process for neighbouring locations as specified in subclause 6.4.9 is invoked for luma locations with (xN, yN) as the input and the output is assigned to mbAddrN and (xW, yW).

– The variable luma8x8BlkIdxN is derived as follows.

  – If mbAddrN is not available, luma8x8BlkIdxN is marked as not available.

  – Otherwise (mbAddrN is available), the 8x8 luma block in the macroblock mbAddrN covering the luma location (xW, yW) is assigned to luma8x8BlkIdxN.

6.4.8.3 Derivation process for neighbouring 4x4 luma blocks

Input to this process is a 4x4 luma block index luma4x4BlkIdx.

Outputs of this process are

– mbAddrA: either equal to CurrMbAddr or the address of the macroblock to the left of the current macroblock and its availability status,

– luma4x4BlkIdxA: the index of the 4x4 luma block to the left of the 4x4 block with index luma4x4BlkIdx and its availability status,

– mbAddrB: either equal to CurrMbAddr or the address of the macroblock above the current macroblock and its availability status,

– luma4x4BlkIdxB: the index of the 4x4 luma block above the 4x4 block with index luma4x4BlkIdx and its availability status.

mbAddrN and luma4x4BlkIdxN (with N being A or B) are derived as follows.

– The difference of luma location (xD, yD) is set according to Table 6-2.

– The inverse 4x4 luma block scanning process as specified in subclause 6.4.3 is invoked with luma4x4BlkIdx as the input and (x, y) as the output.

– The luma location (xN, yN) is specified by

$$xN = x + xD \quad (6\text{-}23)$$

$$yN = y + yD \quad (6\text{-}24)$$

– The derivation process for neighbouring locations as specified in subclause 6.4.9 is invoked for luma locations with (xN, yN) as the input and the output is assigned to mbAddrN and (xW, yW).

– The variable luma4x4BlkIdxN is derived as follows.

  – If mbAddrN is not available, luma4x4BlkIdxN is marked as not available.

  – Otherwise (mbAddrN is available), the 4x4 luma block in the macroblock mbAddrN covering the luma location (xW, yW) is assigned to luma4x4BlkIdxN.

6.4.8.4 Derivation process for neighbouring 4x4 chroma blocks

Input to this process is a 4x4 chroma block index chroma4x4BlkIdx.

Outputs of this process are

– mbAddrA (either equal to CurrMbAddr or the address of the macroblock to the left of the current macroblock) and its availability status,

– chroma4x4BlkIdxA (the index of the 4x4 chroma block to the left of the 4x4 chroma block with index chroma4x4BlkIdx) and its availability status,

– mbAddrB (either equal to CurrMbAddr or the address of the macroblock above the current macroblock) and its availability status,

– chroma4x4BlkIdxB (the index of the 4x4 chroma block above the 4x4 chroma block with index chroma4x4BlkIdx) and its availability status.

mbAddrN and chroma4x4BlkIdxN (with N being A or B) are derived as follows.

– The difference of chroma location (xD, yD) is set according to Table 6-2.

– Depending on chroma_format_idc, the position (x, y) of the upper-left sample of the 4x4 chroma block with index chroma4x4BlkIdx is derived as follows

  – If chroma_format_idc is equal to 1 or 2, the following applies

$$x = \text{InverseRasterScan}(\text{chroma4x4BlkIdx}, 4, 4, 8, 0) \quad (6\text{-}25)$$

$$y = \text{InverseRasterScan}(\text{chroma4x4BlkIdx}, 4, 4, 8, 1) \quad (6\text{-}26)$$

  – Otherwise (chroma_format_idc is equal to 3), the following applies

$$x = \text{InverseRasterScan}(\text{chroma4x4BlkIdx} / 4, 8, 8, 16, 0) + \text{InverseRasterScan}(\text{chroma4x4BlkIdx} \% 4, 4, 4, 8, 0) \quad (6\text{-}27)$$

$$y = \text{InverseRasterScan}(\text{chroma4x4BlkIdx} / 4, 8, 8, 16, 1) + \text{InverseRasterScan}(\text{chroma4x4BlkIdx} \% 4, 4, 4, 8, 1) \quad (6\text{-}28)$$

– The chroma location (xN, yN) is specified by

$$xN = x + xD \quad (6\text{-}29)$$

$$yN = y + yD \quad (6\text{-}30)$$

– The derivation process for neighbouring locations as specified in subclause 6.4.9 is invoked for chroma locations with (xN, yN) as the input and the output is assigned to mbAddrN and (xW, yW).

– The variable chroma4x4BlkIdxN is derived as follows.

  – If mbAddrN is not available, chroma4x4BlkIdxN is marked as not available.

  – Otherwise (mbAddrN is available), the 4x4 chroma block in the macroblock mbAddrN covering the chroma location (xW, yW) is assigned to chroma4x4BlkIdxN.

6.4.8.5 Derivation process for neighbouring partitions

Inputs to this process are

– a macroblock partition index mbPartIdx

– a current sub-macroblock type currSubMbType

– a sub-macroblock partition index subMbPartIdx

Outputs of this process are

– mbAddrA\mbPartIdxA\subMbPartIdxA: specifying the macroblock or sub-macroblock partition to the left of the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status,

– mbAddrB\mbPartIdxB\subMbPartIdxB: specifying the macroblock or sub-macroblock partition above the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status,

– mbAddrC\mbPartIdxC\subMbPartIdxC: specifying the macroblock or sub-macroblock partition to the right-above of the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status,

– mbAddrD\mbPartIdxD\subMbPartIdxD: specifying the macroblock or sub-macroblock partition to the left-above of the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status.

mbAddrN, mbPartIdxN, and subMbPartIdx (with N being A, B, C, or D) are derived as follows.

– The inverse macroblock partition scanning process as described in subclause 6.4.2.1 is invoked with mbPartIdx as the input and (x, y) as the output.

– The location of the upper-left luma sample inside a macroblock partition (xS, yS) is derived as follows.

  — If mb_type is equal to P_8x8, P_8x8ref0 or B_8x8, the inverse sub-macroblock partition scanning process as described in subclause 6.4.2.2 is invoked with subMbPartIdx as the input and (xS, yS) as the output.

  — Otherwise, (xS, yS) are set to (0, 0).

– The variable predPartWidth in Table 6-2 is specified as follows.

  – If mb_type is equal to P_Skip, B_Skip, or B_Direct_16x16, predPartWidth = 16.

  – Otherwise, if mb_type is equal to B_8x8, the following applies.

    – If currSubMbType is equal to B_Direct_8x8, predPartWidth = 16.

      NOTE 1 – When currSubMbType is equal to B_Direct_8x8 and direct_spatial_mv_pred_flag is equal to 1, the predicted motion vector is the predicted motion vector for the complete macroblock.

    – Otherwise, predPartWidth = SubMbPartWidth(sub_mb_type[mbPartIdx]).

  – Otherwise, if mb_type is equal to P_8x8 or P_8x8ref0, predPartWidth = SubMbPartWidth(sub_mb_type[mbPartIdx]).

  – Otherwise, predPartWidth = MbPartWidth(mb_type).

– The difference of luma location (xD, yD) is set according to Table 6-2.

– The neighbouring luma location (xN, yN) is specified by

$$xN = x + xS + xD \tag{6-31}$$

$$yN = y + yS + yD \tag{6-32}$$

– The derivation process for neighbouring locations as specified in subclause 6.4.9 is invoked for luma locations with (xN, yN) as the input and the output is assigned to mbAddrN and (xW, yW).

– Depending on mbAddrN, the following applies.

  – If mbAddrN is not available, the macroblock or sub-macroblock partition – mbAddrN\mbPartIdxN\subMbPartIdxN is marked as not available.

  – Otherwise (mbAddrN is available), the following applies.

    – The macroblock partition in the macroblock mbAddrN covering the luma location (xW, yW) is assigned to mbPartIdxN and the sub-macroblock partition inside the macroblock partition mbPartIdxN covering the sample (xW, yW) in the macroblock mbAddrN is assigned to subMbPartIdxN.

    – When the partition given by mbPartIdxN and subMbPartIdxN is not yet decoded, the macroblock partition mbPartIdxN and the sub-macroblock partition subMbPartIdxN are marked as not available.

    NOTE 2 – The latter condition is, for example, the case when mbPartIdx = 2, subMbPartIdx = 3, xD = 4, yD = -1, i.e., when neighbour C of the last 4x4 luma block of the third sub-macroblock is requested.

6.4.9 Derivation process for neighbouring locations

Input to this process is a luma or chroma location (xN, yN) expressed relative to the upper left corner of the current macroblock.

Outputs of this process are

– mbAddrN: either equal to CurrMbAddr or to the address of neighbouring macroblock that contains (xN, yN) and its availability status,

– (xW, yW): the location (xN, yN) expressed relative to the upper-left corner of the macroblock mbAddrN (rather than relative to the upper-left corner of the current macroblock).

Let maxW and maxH be variables specifying maximum values of the location components xN, xW, and yN, yW, respectively. maxW and maxH are derived as follows.

– If this process is invoked for neighbouring luma locations,

$$maxW = maxH = 16 \tag{6-33}$$

– Otherwise (this process is invoked for neighbouring chroma locations),

$$maxW = MbWidthC \tag{6-34}$$

$$maxH = MbHeightC \tag{6-35}$$

Depending on the variable MbaffFrameFlag, the neighbouring locations are derived as follows.

– If MbaffFrameFlag is equal to 0, the specification for neighbouring locations in fields and non-MBAFF frames as described in subclause 6.4.9.1 is applied.

– Otherwise (MbaffFrameFlag is equal to 1), the specification for neighbouring locations in MBAFF frames as described in subclause 6.4.9.2 is applied.

6.4.9.1 Specification for neighbouring locations in fields and non-MBAFF frames

The specifications in this subclause are applied when MbaffFrameFlag is equal to 0.

The derivation process for neighbouring macroblock addresses and their availability in subclause 6.4.6 is invoked with mbAddrA, mbAddrB, mbAddrC, and mbAddrD as well as their availability status as the output.

Table 6-3 specifies mbAddrN depending on (xN, yN).

Table 6-3 – Specification of mbAddrN

xN	**yN**	**mbAddrN**
< 0	< 0	mbAddrD
< 0	0 .. maxH - 1	mbAddrA
0 .. maxW - 1	< 0	mbAddrB
0 .. maxW - 1	0 .. maxH - 1	CurrMbAddr
> maxW - 1	< 0	mbAddrC
> maxW - 1	0 .. maxH - 1	not available
	> maxH - 1	not available

The neighbouring location (xW, yW) relative to the upper-left corner of the macroblock mbAddrN is derived as

$$xW = (xN + maxW) \% maxW \tag{6-36}$$

$$yW = (yN + maxH) \% maxH \tag{6-37}$$

6.4.9.2 Specification for neighbouring locations in MBAFF frames

The specifications in this subclause are applied when MbaffFrameFlag is equal to 1.

The derivation process for neighbouring macroblock addresses and their availability in subclause 6.4.7 is invoked with mbAddrA, mbAddrB, mbAddrC, and mbAddrD as well as their availability status as the output.

Table 6-4 specifies the macroblock addresses mbAddrN and yM in two ordered steps:

1. Specification of a macroblock address mbAddrX depending on (xN, yN) and the following variables:
   - The variable currMbFrameFlag is derived as follows.
     - If the macroblock with address CurrMbAddr is a frame macroblock, currMbFrameFlag is set equal to 1,
     - Otherwise (the macroblock with address CurrMbAddr is a field macroblock), currMbFrameFlag is set equal to 0.
   - The variable mbIsTopMbFlag is derived as follows.
     - If the macroblock with address CurrMbAddr is a top macroblock (CurrMbAddr % 2 is equal to 0), mbIsTopMbFlag is set equal to 1;
     - Otherwise (the macroblock with address CurrMbAddr is a bottom macroblock, CurrMbAddr % 2 is equal to 1), mbIsTopMbFlag is set equal to 0.
2. Depending on the availability of mbAddrX, the following applies.
   - If mbAddrX is not available, mbAddrN is marked as not available.
   - Otherwise (mbAddrX is available), mbAddrN is marked as available and Table 6-4 specifies mbAddrN and yM depending on (xN, yN), currMbFrameFlag, mbIsTopMbFlag, and the variable mbAddrXFrameFlag, which is derived as follows.
     - If the macroblock mbAddrX is a frame macroblock, mbAddrXFrameFlag is set equal to 1,
     - Otherwise (the macroblock mbAddrX is a field macroblock), mbAddrXFrameFlag is set equal to 0.

Unspecified values (na) of the above flags in Table 6-4 indicate that the value of the corresponding flag is not relevant for the current table rows.

Table 6-4 – Specification of mbAddrN and yM

xN	yN	currMbFrameFlag	mbIsTopMbFlag	mbAddrX	mbAddrXFrameFlag	additional condition	mbAddrN	yM
< 0	< 0	1	1	mbAddrD			mbAddrD + 1	yN
			0	mbAddrA	1		mbAddrA	yN
					0		mbAddrA + 1	(yN + maxH) >> 1
		0	1	mbAddrD	1		mbAddrD + 1	2*yN
					0		mbAddrD	yN
			0	mbAddrD			mbAddrD + 1	yN
< 0	0 .. maxH - 1	1	1	mbAddrA	1		mbAddrA	yN
					0	yN % 2 = = 0	mbAddrA	yN >> 1
						yN % 2 != 0	mbAddrA + 1	yN >> 1
			0	mbAddrA	1		mbAddrA + 1	yN
					0	yN % 2 = = 0	mbAddrA	(yN + maxH) >> 1
						yN % 2 != 0	mbAddrA + 1	(yN + maxH) >> 1
		0	1	mbAddrA	1	yN < (maxH / 2)	mbAddrA	yN <<1
						yN >= (maxH / 2)	mbAddrA + 1	(yN <<1) - maxH
					0		mbAddrA	yN
			0	mbAddrA	1	yN < (maxH / 2)	mbAddrA	(yN <<1) + 1
						yN >= (maxH / 2)	mbAddrA + 1	(yN <<1) + 1 – maxH
					0		mbAddrA + 1	yN
0 .. maxW – 1	< 0	1	1	mbAddrB			mbAddrB + 1	yN
			0	CurrMbAddr			CurrMbAddr - 1	yN
		0	1	mbAddrB	1		mbAddrB + 1	2 * yN
					0		mbAddrB	yN
			0	mbAddrB			mbAddrB + 1	yN
0 .. maxW – 1	0 .. maxH - 1			CurrMbAddr			CurrMbAddr	yN
> maxW – 1	<0	1	1	mbAddrC			mbAddrC + 1	yN
			0	not available			not available	na
		0	1	mbAddrC	1		mbAddrC + 1	2 * yN
					0		mbAddrC	yN
			0	mbAddrC			mbAddrC + 1	yN
> maxW – 1	0 .. maxH - 1			not available			not available	na
	> maxH - 1			not available			not available	na

The neighbouring luma location (xW, yW) relative to the upper-left corner of the macroblock mbAddrN is derived as

$$xW = (xN + maxW) \% maxW \quad (6\text{-}38)$$

$$yW = (yM + maxH) \% maxH \quad (6\text{-}39)$$

7 Syntax and semantics

7.1 Method of specifying syntax in tabular form

The syntax tables specify a superset of the syntax of all allowed bitstreams. Additional constraints on the syntax may be specified, either directly or indirectly, in other clauses.

NOTE – An actual decoder should implement means for identifying entry points into the bitstream and means to identify and handle non-conforming bitstreams. The methods for identifying and handling errors and other such situations are not specified here.

The following table lists examples of pseudo code used to describe the syntax. When **syntax_element** appears, it specifies that a syntax element is parsed from the bitstream and the bitstream pointer is advanced to the next position beyond the syntax element in the bitstream parsing process.

	C	Descriptor
/* A statement can be a syntax element with an associated syntax category and descriptor or can be an expression used to specify conditions for the existence, type, and quantity of syntax elements, as in the following two examples */		
syntax_element	3	ue(v)
conditioning statement		
/* A group of statements enclosed in curly brackets is a compound statement and is treated functionally as a single statement. */		
{		
statement		
statement		
…		
}		
/* A "while" structure specifies a test of whether a condition is true, and if true, specifies evaluation of a statement (or compound statement) repeatedly until the condition is no longer true */		
while(condition)		
statement		
/* A "do … while" structure specifies evaluation of a statement once, followed by a test of whether a condition is true, and if true, specifies repeated evaluation of the statement until the condition is no longer true */		
do		
statement		
while(condition)		
/* An "if … else" structure specifies a test of whether a condition is true, and if the condition is true, specifies evaluation of a primary statement, otherwise, specifies evaluation of an alternative statement. The "else" part of the structure and the associated alternative statement is omitted if no alternative statement evaluation is needed */		
if(condition)		
primary statement		
else		
alternative statement		
/* A "for" structure specifies evaluation of an initial statement, followed by a test of a condition, and if the condition is true, specifies repeated evaluation of a primary statement followed by a subsequent statement until the condition is no longer true. */		
for(initial statement; condition; subsequent statement)		
primary statement		

7.2 Specification of syntax functions, categories, and descriptors

The functions presented here are used in the syntactical description. These functions assume the existence of a bitstream pointer with an indication of the position of the next bit to be read by the decoding process from the bitstream.

byte_aligned( ) is specified as follows.

- If the current position in the bitstream is on a byte boundary, i.e., the next bit in the bitstream is the first bit in a byte, the return value of byte_aligned( ) is equal to TRUE.
- Otherwise, the return value of byte_aligned( ) is equal to FALSE.

more_data_in_byte_stream( ), which is used only in the byte stream NAL unit syntax structure specified in Annex B, is specified as follows.

- If more data follow in the byte stream, the return value of more_data_in_byte_stream( ) is equal to TRUE.
- Otherwise, the return value of more_data_in_byte_stream( ) is equal to FALSE.

more_rbsp_data( ) is specified as follows.

- If there is more data in an RBSP before rbsp_trailing_bits( ), the return value of more_rbsp_data( ) is equal to TRUE.
- Otherwise, the return value of more_rbsp_data( ) is equal to FALSE.

  The method for enabling determination of whether there is more data in the RBSP is specified by the application (or in Annex B for applications that use the byte stream format).

more_rbsp_trailing_data( ) is specified as follows.

- If there is more data in an RBSP, the return value of more_rbsp_trailing_data( ) is equal to TRUE.
- Otherwise, the return value of more_rbsp_trailing_data( ) is equal to FALSE.

next_bits(n) provides the next bits in the bitstream for comparison purposes, without advancing the bitstream pointer. Provides a look at the next n bits in the bitstream with n being its argument. When used within the byte stream as specified in Annex B, next_bits(n) returns a value of 0 if fewer than n bits remain within the byte stream.

read_bits(n) reads the next n bits from the bitstream and advances the bitstream pointer by n bit positions. When n is equal to 0, read_bits(n) is specified to return a value equal to 0 and to not advance the bitstream pointer.

Categories (labelled in the table as **C**) specify the partitioning of slice data into at most three slice data partitions. Slice data partition A contains all syntax elements of category 2. Slice data partition B contains all syntax elements of category 3. Slice data partition C contains all syntax elements of category 4. The meaning of other category values is not specified. For some syntax elements, two category values, separated by a vertical bar, are used. In these cases, the category value to be applied is further specified in the text. For syntax structures used within other syntax structures, the categories of all syntax elements found within the included syntax structure are listed, separated by a vertical bar. A syntax element or syntax structure with category marked as "All" is present within all syntax structures that include that syntax element or syntax structure. For syntax structures used within other syntax structures, a numeric category value provided in a syntax table at the location of the inclusion of a syntax structure containing a syntax element with category marked as "All" is considered to apply to the syntax elements with category "All".

The following descriptors specify the parsing process of each syntax element. For some syntax elements, two descriptors, separated by a vertical bar, are used. In these cases, the left descriptors apply when entropy_coding_mode_flag is equal to 0 and the right descriptor applies when entropy_coding_mode_flag is equal to 1.

- ae(v): context-adaptive arithmetic entropy-coded syntax element. The parsing process for this descriptor is specified in subclause 9.3.
- b(8): byte having any pattern of bit string (8 bits). The parsing process for this descriptor is specified by the return value of the function read_bits(8).
- ce(v): context-adaptive variable-length entropy-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.2.
- f(n): fixed-pattern bit string using n bits written (from left to right) with the left bit first. The parsing process for this descriptor is specified by the return value of the function read_bits(n).
- i(n): signed integer using n bits. When n is "v" in the syntax table, the number of bits varies in a manner dependent on the value of other syntax elements. The parsing process for this descriptor is specified by the

return value of the function read_bits(n) interpreted as a two's complement integer representation with most significant bit written first.

– me(v): mapped Exp-Golomb-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.1.

– se(v): signed integer Exp-Golomb-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.1.

– te(v): truncated Exp-Golomb-coded syntax element with left bit first. The parsing process for this descriptor is specified in subclause 9.1.

– u(n): unsigned integer using n bits. When n is "v" in the syntax table, the number of bits varies in a manner dependent on the value of other syntax elements. The parsing process for this descriptor is specified by the return value of the function read_bits(n) interpreted as a binary representation of an unsigned integer with most significant bit written first.

– ue(v): unsigned integer Exp-Golomb-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.1.

7.3 Syntax in tabular form

7.3.1 NAL unit syntax

nal_unit(NumBytesInNALunit) {	C	Descriptor
forbidden_zero_bit	All	f(1)
nal_ref_idc	All	u(2)
nal_unit_type	All	u(5)
NumBytesInRBSP = 0		
for(i = 1; i < NumBytesInNALunit; i++) {		
if(i + 2 < NumBytesInNALunit && next_bits(24) = = 0x000003) {		
rbsp_byte[NumBytesInRBSP++ **]**	All	b(8)
rbsp_byte[NumBytesInRBSP++ **]**	All	b(8)
i += 2		
emulation_prevention_three_byte /* equal to 0x03 */	All	f(8)
} else		
rbsp_byte[NumBytesInRBSP++ **]**	All	b(8)
}		
}		

7.3.2 Raw byte sequence payloads and RBSP trailing bits syntax

7.3.2.1 Sequence parameter set RBSP syntax

seq_parameter_set_rbsp( ) {	C	Descriptor
profile_idc	0	u(8)
constraint_set0_flag	0	u(1)
constraint_set1_flag	0	u(1)
constraint_set2_flag	0	u(1)
constraint_set3_flag	0	u(1)
reserved_zero_4bits /* equal to 0 */	0	u(4)
level_idc	0	u(8)
seq_parameter_set_id	0	ue(v)
if(profile_idc = = 100 || profile_idc = = 110 || profile_idc = = 122 || profile_idc = = 144) {		
chroma_format_idc	0	ue(v)
if(chroma_format_idc = = 3)		
residual_colour_transform_flag	0	u(1)
bit_depth_luma_minus8	0	ue(v)
bit_depth_chroma_minus8	0	ue(v)
qpprime_y_zero_transform_bypass_flag	0	u(1)
seq_scaling_matrix_present_flag	0	u(1)
if(seq_scaling_matrix_present_flag)		
for(i = 0; i < 8; i++) {		
seq_scaling_list_present_flag[i **]**	0	u(1)
if(seq_scaling_list_present_flag[i])		
if(i < 6)		
scaling_list(ScalingList4x4[i], 16, UseDefaultScalingMatrix4x4Flag[i])	0	
else		
scaling_list(ScalingList8x8[i – 6], 64, UseDefaultScalingMatrix8x8Flag[i – 6])	0	
}		
}		
log2_max_frame_num_minus4	0	ue(v)
pic_order_cnt_type	0	ue(v)
if(pic_order_cnt_type = = 0)		
log2_max_pic_order_cnt_lsb_minus4	0	ue(v)
else if(pic_order_cnt_type = = 1) {		
delta_pic_order_always_zero_flag	0	u(1)
offset_for_non_ref_pic	0	se(v)
offset_for_top_to_bottom_field	0	se(v)
num_ref_frames_in_pic_order_cnt_cycle	0	ue(v)
for(i = 0; i < num_ref_frames_in_pic_order_cnt_cycle; i++)		
offset_for_ref_frame[i **]**	0	se(v)
}		
num_ref_frames	0	ue(v)
gaps_in_frame_num_value_allowed_flag	0	u(1)
pic_width_in_mbs_minus1	0	ue(v)
pic_height_in_map_units_minus1	0	ue(v)

frame_mbs_only_flag	0	u(1)
if(!frame_mbs_only_flag)		
mb_adaptive_frame_field_flag	0	u(1)
direct_8x8_inference_flag	0	u(1)
frame_cropping_flag	0	u(1)
if(frame_cropping_flag) {		
frame_crop_left_offset	0	ue(v)
frame_crop_right_offset	0	ue(v)
frame_crop_top_offset	0	ue(v)
frame_crop_bottom_offset	0	ue(v)
}		
vui_parameters_present_flag	0	u(1)
if(vui_parameters_present_flag)		
vui_parameters( )	0	
rbsp_trailing_bits( )	0	
}		

7.3.2.1.1 Scaling list syntax

scaling_list(scalingList, sizeOfScalingList, useDefaultScalingMatrixFlag) {	**C**	**Descriptor**
lastScale = 8		
nextScale = 8		
for(j = 0; j < sizeOfScalingList; j++) {		
if(nextScale != 0) {		
delta_scale	0 | 1	se(v)
nextScale = (lastScale + delta_scale + 256) % 256		
useDefaultScalingMatrixFlag = (j == 0 && nextScale == 0)		
}		
scalingList[j] = (nextScale == 0) ? lastScale : nextScale		
lastScale = scalingList[j]		
}		
}		

7.3.2.1.2 Sequence parameter set extension RBSP syntax

seq_parameter_set_extension_rbsp( ) {	**C**	**Descriptor**
seq_parameter_set_id	10	ue(v)
aux_format_idc	10	ue(v)
if(aux_format_idc != 0) {		
bit_depth_aux_minus8	10	ue(v)
alpha_incr_flag	10	u(1)
alpha_opaque_value	10	u(v)
alpha_transparent_value	10	u(v)
}		
additional_extension_flag	10	u(1)
rbsp_trailing_bits()	10	
}		

7.3.2.2 Picture parameter set RBSP syntax

pic_parameter_set_rbsp( ) {	C	Descriptor
pic_parameter_set_id	1	ue(v)
seq_parameter_set_id	1	ue(v)
entropy_coding_mode_flag	1	u(1)
pic_order_present_flag	1	u(1)
num_slice_groups_minus1	1	ue(v)
if(num_slice_groups_minus1 > 0) {		
slice_group_map_type	1	ue(v)
if(slice_group_map_type = = 0)		
for(iGroup = 0; iGroup <= num_slice_groups_minus1; iGroup++)		
run_length_minus1[iGroup **]**	1	ue(v)
else if(slice_group_map_type = = 2)		
for(iGroup = 0; iGroup < num_slice_groups_minus1; iGroup++) {		
top_left[iGroup **]**	1	ue(v)
bottom_right[iGroup **]**	1	ue(v)
}		
else if(slice_group_map_type = = 3 || slice_group_map_type = = 4 || slice_group_map_type = = 5) {		
slice_group_change_direction_flag	1	u(1)
slice_group_change_rate_minus1	1	ue(v)
} else if(slice_group_map_type = = 6) {		
pic_size_in_map_units_minus1	1	ue(v)
for(i = 0; i <= pic_size_in_map_units_minus1; i++)		
slice_group_id[i **]**	1	u(v)
}		
}		
num_ref_idx_l0_active_minus1	1	ue(v)
num_ref_idx_l1_active_minus1	1	ue(v)
weighted_pred_flag	1	u(1)
weighted_bipred_idc	1	u(2)
pic_init_qp_minus26 /* relative to 26 */	1	se(v)
pic_init_qs_minus26 /* relative to 26 */	1	se(v)
chroma_qp_index_offset	1	se(v)
deblocking_filter_control_present_flag	1	u(1)
constrained_intra_pred_flag	1	u(1)
redundant_pic_cnt_present_flag	1	u(1)
if(more_rbsp_data( )) {		
transform_8x8_mode_flag	1	u(1)
pic_scaling_matrix_present_flag	1	u(1)
if(pic_scaling_matrix_present_flag)		
for(i = 0; i < 6 + 2* transform_8x8_mode_flag; i++) {		
pic_scaling_list_present_flag[i **]**	1	u(1)
if(pic_scaling_list_present_flag[i])		
if(i < 6)		

scaling_list(ScalingList4x4[i], 16, UseDefaultScalingMatrix4x4Flag[i])	1	
else		
scaling_list(ScalingList8x8[i – 6], 64, UseDefaultScalingMatrix8x8Flag[i – 6])	1	
}		
second_chroma_qp_index_offset	1	se(v)
}		
rbsp_trailing_bits( )	1	
}		

7.3.2.3 Supplemental enhancement information RBSP syntax

sei_rbsp( ) {	C	Descriptor
do		
sei_message( )	5	
while(more_rbsp_data( ))		
rbsp_trailing_bits( )	5	
}		

7.3.2.3.1 Supplemental enhancement information message syntax

sei_message( ) {	C	Descriptor
payloadType = 0		
while(next_bits(8) = = 0xFF) {		
ff_byte /* equal to 0xFF */	5	f(8)
payloadType += 255		
}		
last_payload_type_byte	5	u(8)
payloadType += last_payload_type_byte		
payloadSize = 0		
while(next_bits(8) = = 0xFF) {		
ff_byte /* equal to 0xFF */	5	f(8)
payloadSize += 255		
}		
last_payload_size_byte	5	u(8)
payloadSize += last_payload_size_byte		
sei_payload(payloadType, payloadSize)	5	
}		

7.3.2.4 Access unit delimiter RBSP syntax

access_unit_delimiter_rbsp( ) {	C	Descriptor
primary_pic_type	6	u(3)
rbsp_trailing_bits( )	6	
}		

7.3.2.5 End of sequence RBSP syntax

end_of_seq_rbsp( ) {	C	Descriptor
}		

7.3.2.6 End of stream RBSP syntax

end_of_stream_rbsp( ) {	C	Descriptor
}		

7.3.2.7 Filler data RBSP syntax

filler_data_rbsp( ) {	C	Descriptor
while(next_bits(8) = = 0xFF)		
ff_byte /* equal to 0xFF */	9	f(8)
rbsp_trailing_bits( )	9	
}		

7.3.2.8 Slice layer without partitioning RBSP syntax

slice_layer_without_partitioning_rbsp( ) {	C	Descriptor
slice_header( )	2	
slice_data( ) /* all categories of slice_data( ) syntax */	2 | 3 | 4	
rbsp_slice_trailing_bits( )	2	
}		

7.3.2.9 Slice data partition RBSP syntax

7.3.2.9.1 Slice data partition A RBSP syntax

slice_data_partition_a_layer_rbsp( ) {	C	Descriptor
slice_header( )	2	
slice_id	All	ue(v)
slice_data( ) /* only category 2 parts of slice_data( ) syntax */	2	
rbsp_slice_trailing_bits( )	2	
}		

7.3.2.9.2 Slice data partition B RBSP syntax

slice_data_partition_b_layer_rbsp( ) {	C	Descriptor
slice_id	All	ue(v)
if(redundant_pic_cnt_present_flag)		
redundant_pic_cnt	All	ue(v)
slice_data( ) /* only category 3 parts of slice_data( ) syntax */	3	
rbsp_slice_trailing_bits( )	3	
}		

7.3.2.9.3 Slice data partition C RBSP syntax

slice_data_partition_c_layer_rbsp( ) {	C	Descriptor
slice_id	All	ue(v)
if(redundant_pic_cnt_present_flag)		
redundant_pic_cnt	All	ue(v)
slice_data( ) /* only category 4 parts of slice_data( ) syntax */	4	
rbsp_slice_trailing_bits( )	4	
}		

7.3.2.10 RBSP slice trailing bits syntax

rbsp_slice_trailing_bits( ) {	C	Descriptor
rbsp_trailing_bits( )	All	
if(entropy_coding_mode_flag)		
while(more_rbsp_trailing_data( ))		
cabac_zero_word /* equal to 0x0000 */	All	f(16)
}		

7.3.2.11 RBSP trailing bits syntax

rbsp_trailing_bits( ) {	C	Descriptor
rbsp_stop_one_bit /* equal to 1 */	All	f(1)
while(!byte_aligned( ))		
rbsp_alignment_zero_bit /* equal to 0 */	All	f(1)
}		

7.3.3 Slice header syntax

slice_header( ) {	C	Descriptor
first_mb_in_slice	2	ue(v)
slice_type	2	ue(v)
pic_parameter_set_id	2	ue(v)
frame_num	2	u(v)
if(!frame_mbs_only_flag) {		
field_pic_flag	2	u(1)
if(field_pic_flag)		
bottom_field_flag	2	u(1)
}		
if(nal_unit_type = = 5)		
idr_pic_id	2	ue(v)
if(pic_order_cnt_type = = 0) {		
pic_order_cnt_lsb	2	u(v)
if(pic_order_present_flag && !field_pic_flag)		
delta_pic_order_cnt_bottom	2	se(v)
}		
if(pic_order_cnt_type = = 1 && !delta_pic_order_always_zero_flag) {		
delta_pic_order_cnt[0 **]**	2	se(v)
if(pic_order_present_flag && !field_pic_flag)		
delta_pic_order_cnt[1 **]**	2	se(v)
}		
if(redundant_pic_cnt_present_flag)		
redundant_pic_cnt	2	ue(v)
if(slice_type = = B)		
direct_spatial_mv_pred_flag	2	u(1)
if(slice_type = = P | | slice_type = = SP | | slice_type = = B) {		
num_ref_idx_active_override_flag	2	u(1)
if(num_ref_idx_active_override_flag) {		
num_ref_idx_l0_active_minus1	2	ue(v)
if(slice_type = = B)		
num_ref_idx_l1_active_minus1	2	ue(v)
}		
}		
ref_pic_list_reordering( )	2	
if((weighted_pred_flag && (slice_type = = P || slice_type = = SP)) || (weighted_bipred_idc = = 1 && slice_type = = B))		
pred_weight_table( )	2	
if(nal_ref_idc != 0)		
dec_ref_pic_marking( )	2	
if(entropy_coding_mode_flag && slice_type != I && slice_type != SI)		
cabac_init_idc	2	ue(v)
slice_qp_delta	2	se(v)
if(slice_type = = SP || slice_type = = SI) {		
if(slice_type = = SP)		
sp_for_switch_flag	2	u(1)

slice_qs_delta	2	se(v)
}		
if(deblocking_filter_control_present_flag) {		
disable_deblocking_filter_idc	2	ue(v)
if(disable_deblocking_filter_idc != 1) {		
slice_alpha_c0_offset_div2	2	se(v)
slice_beta_offset_div2	2	se(v)
}		
}		
if(num_slice_groups_minus1 > 0 && slice_group_map_type >= 3 && slice_group_map_type <= 5)		
slice_group_change_cycle	2	u(v)
}		

7.3.3.1 Reference picture list reordering syntax

ref_pic_list_reordering( ) {	**C**	**Descriptor**
if(slice_type != I && slice_type != SI) {		
ref_pic_list_reordering_flag_l0	2	u(1)
if(ref_pic_list_reordering_flag_l0)		
do {		
reordering_of_pic_nums_idc	2	ue(v)
if(reordering_of_pic_nums_idc = = 0 || reordering_of_pic_nums_idc = = 1)		
abs_diff_pic_num_minus1	2	ue(v)
else if(reordering_of_pic_nums_idc = = 2)		
long_term_pic_num	2	ue(v)
} while(reordering_of_pic_nums_idc != 3)		
}		
if(slice_type = = B) {		
ref_pic_list_reordering_flag_l1	2	u(1)
if(ref_pic_list_reordering_flag_l1)		
do {		
reordering_of_pic_nums_idc	2	ue(v)
if(reordering_of_pic_nums_idc = = 0 || reordering_of_pic_nums_idc = = 1)		
abs_diff_pic_num_minus1	2	ue(v)
else if(reordering_of_pic_nums_idc = = 2)		
long_term_pic_num	2	ue(v)
} while(reordering_of_pic_nums_idc != 3)		
}		
}		

7.3.3.2 Prediction weight table syntax

pred_weight_table( ) {	C	Descriptor
luma_log2_weight_denom	2	ue(v)
if(chroma_format_idc != 0)		
chroma_log2_weight_denom	2	ue(v)
for(i = 0; i <= num_ref_idx_l0_active_minus1; i++) {		
luma_weight_l0_flag	2	u(1)
if(luma_weight_l0_flag) {		
luma_weight_l0[i **]**	2	se(v)
luma_offset_l0[i **]**	2	se(v)
}		
if (chroma_format_idc != 0) {		
chroma_weight_l0_flag	2	u(1)
if(chroma_weight_l0_flag)		
for(j =0; j < 2; j++) {		
chroma_weight_l0[i **][** j **]**	2	se(v)
chroma_offset_l0[i **][** j **]**	2	se(v)
}		
}		
}		
if(slice_type = = B)		
for(i = 0; i <= num_ref_idx_l1_active_minus1; i++) {		
luma_weight_l1_flag	2	u(1)
if(luma_weight_l1_flag) {		
luma_weight_l1[i **]**	2	se(v)
luma_offset_l1[i **]**	2	se(v)
}		
if(chroma_format_idc != 0) {		
chroma_weight_l1_flag	2	u(1)
if(chroma_weight_l1_flag)		
for(j = 0; j < 2; j++) {		
chroma_weight_l1[i **][** j **]**	2	se(v)
chroma_offset_l1[i **][** j **]**	2	se(v)
}		
}		
}		
}		

7.3.3.3 Decoded reference picture marking syntax

dec_ref_pic_marking( ) {	C	Descriptor
if(nal_unit_type = = 5) {		
no_output_of_prior_pics_flag	2 | 5	u(1)
long_term_reference_flag	2 | 5	u(1)
} else {		
adaptive_ref_pic_marking_mode_flag	2 | 5	u(1)
if(adaptive_ref_pic_marking_mode_flag)		
do {		
memory_management_control_operation	2 | 5	ue(v)
if(memory_management_control_operation = = 1 || memory_management_control_operation = = 3)		
difference_of_pic_nums_minus1	2 | 5	ue(v)
if(memory_management_control_operation = = 2)		
long_term_pic_num	2 | 5	ue(v)
if(memory_management_control_operation = = 3 || memory_management_control_operation = = 6)		
long_term_frame_idx	2 | 5	ue(v)
if(memory_management_control_operation = = 4)		
max_long_term_frame_idx_plus1	2 | 5	ue(v)
} while(memory_management_control_operation != 0)		
}		
}		

7.3.4 Slice data syntax

slice_data( ) {	C	Descriptor
if(entropy_coding_mode_flag)		
while(!byte_aligned( ))		
cabac_alignment_one_bit	2	f(1)
CurrMbAddr = first_mb_in_slice * (1 + MbaffFrameFlag)		
moreDataFlag = 1		
prevMbSkipped = 0		
do {		
if(slice_type != I && slice_type != SI)		
if(!entropy_coding_mode_flag) {		
mb_skip_run	2	ue(v)
prevMbSkipped = (mb_skip_run > 0)		
for(i=0; i<mb_skip_run; i++)		
CurrMbAddr = NextMbAddress(CurrMbAddr)		
moreDataFlag = more_rbsp_data( )		
} else {		
mb_skip_flag	2	ae(v)
moreDataFlag = !mb_skip_flag		
}		
if(moreDataFlag) {		
if(MbaffFrameFlag && (CurrMbAddr % 2 = = 0 || (CurrMbAddr % 2 = = 1 && prevMbSkipped)))		
mb_field_decoding_flag	2	u(1) | ae(v)
macroblock_layer( )	2 | 3 | 4	
}		
if(!entropy_coding_mode_flag)		
moreDataFlag = more_rbsp_data( )		
else {		
if(slice_type != I && slice_type != SI)		
prevMbSkipped = mb_skip_flag		
if(MbaffFrameFlag && CurrMbAddr % 2 = = 0)		
moreDataFlag = 1		
else {		
end_of_slice_flag	2	ae(v)
moreDataFlag = !end_of_slice_flag		
}		
}		
CurrMbAddr = NextMbAddress(CurrMbAddr)		
} while(moreDataFlag)		
}		

7.3.5 Macroblock layer syntax

macroblock_layer( ) {	C	Descriptor
mb_type	2	ue(v) | ae(v)
if(mb_type = = I_PCM) {		
while(!byte_aligned( ))		
pcm_alignment_zero_bit	2	f(1)
for(i = 0; i < 256; i++)		
pcm_sample_luma[i **]**	2	u(v)
for(i = 0; i < 2 * MbWidthC * MbHeightC; i++)		
pcm_sample_chroma[i **]**	2	u(v)
} else {		
noSubMbPartSizeLessThan8x8Flag = 1		
if(mb_type != I_NxN && MbPartPredMode(mb_type, 0) != Intra_16x16 && NumMbPart(mb_type) = = 4) {		
sub_mb_pred(mb_type)	2	
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if(sub_mb_type[mbPartIdx] != B_Direct_8x8) {		
if(NumSubMbPart(sub_mb_type[mbPartIdx]) > 1)		
noSubMbPartSizeLessThan8x8Flag = 0		
} else if(!direct_8x8_inference_flag)		
noSubMbPartSizeLessThan8x8Flag = 0		
} else {		
if(transform_8x8_mode_flag && mb_type = = I_NxN)		
transform_size_8x8_flag	2	u(1) | ae(v)
mb_pred(mb_type)	2	
}		
if(MbPartPredMode(mb_type, 0) != Intra_16x16) {		
coded_block_pattern	2	me(v) | ae(v)
if(CodedBlockPatternLuma > 0 && transform_8x8_mode_flag && mb_type != I_NxN && noSubMbPartSizeLessThan8x8Flag && (mb_type != B_Direct_16x16 || direct_8x8_inference_flag))		
transform_size_8x8_flag	2	u(1) | ae(v)
}		
if(CodedBlockPatternLuma > 0 || CodedBlockPatternChroma > 0 || MbPartPredMode(mb_type, 0) = = Intra_16x16) {		
mb_qp_delta	2	se(v) | ae(v)
residual( )	3 | 4	
}		
}		
}		

7.3.5.1 Macroblock prediction syntax

mb_pred(mb_type) {	C	Descriptor
if(MbPartPredMode(mb_type, 0) = = Intra_4x4 || MbPartPredMode(mb_type, 0) = = Intra_8x8 || MbPartPredMode(mb_type, 0) = = Intra_16x16) {		
if(MbPartPredMode(mb_type, 0) = = Intra_4x4)		
for(luma4x4BlkIdx=0; luma4x4BlkIdx<16; luma4x4BlkIdx++) {		
prev_intra4x4_pred_mode_flag[luma4x4BlkIdx **]**	2	u(1) | ae(v)
if(!prev_intra4x4_pred_mode_flag**[** luma4x4BlkIdx **]**)		
rem_intra4x4_pred_mode[luma4x4BlkIdx **]**	2	u(3) | ae(v)
}		
if(MbPartPredMode(mb_type, 0) = = Intra_8x8)		
for(luma8x8BlkIdx=0; luma8x8BlkIdx<4; luma8x8BlkIdx++) {		
prev_intra8x8_pred_mode_flag[luma8x8BlkIdx **]**	2	u(1) | ae(v)
if(!prev_intra8x8_pred_mode_flag[luma8x8BlkIdx])		
rem_intra8x8_pred_mode[luma8x8BlkIdx **]**	2	u(3) | ae(v)
}		
if(chroma_format_idc != 0)		
intra_chroma_pred_mode	2	ue(v) | ae(v)
} else if(MbPartPredMode(mb_type, 0) != Direct) {		
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if((num_ref_idx_l0_active_minus1 > 0 || mb_field_decoding_flag) && MbPartPredMode(mb_type, mbPartIdx) != Pred_L1)		
ref_idx_l0[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if((num_ref_idx_l1_active_minus1 > 0 || mb_field_decoding_flag) && MbPartPredMode(mb_type, mbPartIdx) != Pred_L0)		
ref_idx_l1[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if(MbPartPredMode (mb_type, mbPartIdx) != Pred_L1)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l0[mbPartIdx **][** 0 **][** compIdx **]**	2	se(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < NumMbPart(mb_type); mbPartIdx++)		
if(MbPartPredMode(mb_type, mbPartIdx) != Pred_L0)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l1[mbPartIdx **][** 0 **][** compIdx **]**	2	se(v) | ae(v)
}		
}		

7.3.5.2 Sub-macroblock prediction syntax

sub_mb_pred(mb_type) {	C	Descriptor
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
sub_mb_type[mbPartIdx **]**	2	ue(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if((num_ref_idx_l0_active_minus1 > 0 || mb_field_decoding_flag) && mb_type != P_8x8ref0 && sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L1)		
ref_idx_l0[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if((num_ref_idx_l1_active_minus1 > 0 || mb_field_decoding_flag) && sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L0)		
ref_idx_l1[mbPartIdx **]**	2	te(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if(sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L1)		
for(subMbPartIdx = 0; subMbPartIdx < NumSubMbPart(sub_mb_type[mbPartIdx]); subMbPartIdx++)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l0[mbPartIdx **][** subMbPartIdx **][** compIdx **]**	2	se(v) | ae(v)
for(mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++)		
if(sub_mb_type[mbPartIdx] != B_Direct_8x8 && SubMbPredMode(sub_mb_type[mbPartIdx]) != Pred_L0)		
for(subMbPartIdx = 0; subMbPartIdx < NumSubMbPart(sub_mb_type[mbPartIdx]); subMbPartIdx++)		
for(compIdx = 0; compIdx < 2; compIdx++)		
mvd_l1[mbPartIdx **][** subMbPartIdx **][** compIdx **]**	2	se(v) | ae(v)
}		

7.3.5.3 Residual data syntax

residual( ) {	C	Descriptor
if(!entropy_coding_mode_flag)		
residual_block = residual_block_cavlc		
else		
residual_block = residual_block_cabac		
if(MbPartPredMode(mb_type, 0) = = Intra_16x16)		
residual_block(Intra16x16DCLevel, 16)	3	
for(i8x8 = 0; i8x8 < 4; i8x8++) /* each luma 8x8 block */		
if(!transform_size_8x8_flag || !entropy_coding_mode_flag)		
for(i4x4 = 0; i4x4 < 4; i4x4++) { /* each 4x4 sub-block of block */		
if(CodedBlockPatternLuma & (1 << i8x8))		
if(MbPartPredMode(mb_type, 0) = = Intra_16x16)		
residual_block(Intra16x16ACLevel[i8x8 * 4 + i4x4], 15)	3	
else		
residual_block(LumaLevel[i8x8 * 4 + i4x4], 16)	3 | 4	
else if(MbPartPredMode(mb_type, 0) = = Intra_16x16)		
for(i = 0; i < 15; i++)		
Intra16x16ACLevel[i8x8 * 4 + i4x4][i] = 0		
else		
for(i = 0; i < 16; i++)		
LumaLevel[i8x8 * 4 + i4x4][i] = 0		
if(!entropy_coding_mode_flag && transform_size_8x8_flag)		
for(i = 0; i < 16; i++)		
LumaLevel8x8[i8x8][4 * i + i4x4] = LumaLevel[i8x8 * 4 + i4x4][i]		
}		
else if(CodedBlockPatternLuma & (1 << i8x8))		
residual_block(LumaLevel8x8[i8x8], 64)	3 | 4	
else		
for(i = 0; i < 64; i++)		
LumaLevel8x8[i8x8][i] = 0		
if(chroma_format_idc != 0) {		
NumC8x8 = 4 / (SubWidthC * SubHeightC)		
for(iCbCr = 0; iCbCr < 2; iCbCr++)		
if(CodedBlockPatternChroma & 3) /* chroma DC residual present */		
residual_block(ChromaDCLevel[iCbCr], 4 * NumC8x8)	3 | 4	
else		
for(i = 0; i < 4 * NumC8x8; i++)		
ChromaDCLevel[iCbCr][i] = 0		
for(iCbCr = 0; iCbCr < 2; iCbCr++)		
for(i8x8 = 0; i8x8 < NumC8x8; i8x8++)		
for(i4x4 = 0; i4x4 < 4; i4x4++)		
if(CodedBlockPatternChroma & 2) /* chroma AC residual present */		
residual_block(ChromaACLevel[iCbCr][i8x8*4+i4x4], 15)	3 | 4	
else		
for(i = 0; i < 15; i++)		
ChromaACLevel[iCbCr][i8x8*4+i4x4][i] = 0		
}		

7.3.5.3.1 Residual block CAVLC syntax

residual_block_cavlc(coeffLevel, maxNumCoeff) {	C	Descriptor
for(i = 0; i < maxNumCoeff; i++)		
coeffLevel[i] = 0		
coeff_token	3 | 4	ce(v)
if(TotalCoeff(coeff_token) > 0) {		
if(TotalCoeff(coeff_token) > 10 && TrailingOnes(coeff_token) < 3)		
suffixLength = 1		
else		
suffixLength = 0		
for(i = 0; i < TotalCoeff(coeff_token); i++)		
if(i < TrailingOnes(coeff_token)) {		
trailing_ones_sign_flag	3 | 4	u(1)
level[i] = 1 – 2 * trailing_ones_sign_flag		
} else {		
level_prefix	3 | 4	ce(v)
levelCode = (Min(15, level_prefix) << suffixLength)		
if(suffixLength > 0 || level_prefix >= 14) {		
level_suffix	3 | 4	u(v)
levelCode += level_suffix		
}		
if(level_prefix >= 15 && suffixLength == 0)		
levelCode += 15		
if(level_prefix >= 16)		
levelCode += (1 << (level_prefix – 3)) – 4096		
if(i == TrailingOnes(coeff_token) && TrailingOnes(coeff_token) < 3)		
levelCode += 2		
if(levelCode % 2 == 0)		
level[i] = (levelCode + 2) >> 1		
else		
level[i] = (–levelCode – 1) >> 1		
if(suffixLength == 0)		
suffixLength = 1		
if(Abs(level[i]) > (3 << (suffixLength – 1)) && suffixLength < 6)		
suffixLength++		
}		
if(TotalCoeff(coeff_token) < maxNumCoeff) {		
total_zeros	3 | 4	ce(v)
zerosLeft = total_zeros		
} else		
zerosLeft = 0		
for(i = 0; i < TotalCoeff(coeff_token) – 1; i++) {		
if(zerosLeft > 0) {		
run_before	3 | 4	ce(v)
run[i] = run_before		
} else		
run[i] = 0		

zerosLeft = zerosLeft – run[i]		
}		
run[TotalCoeff(coeff_token) – 1] = zerosLeft		
coeffNum = -1		
for(i = TotalCoeff(coeff_token) – 1; i >= 0; i--) {		
coeffNum += run[i] + 1		
coeffLevel[coeffNum] = level[i]		
}		
}		
}		

7.3.5.3.2 Residual block CABAC syntax

residual_block_cabac(coeffLevel, maxNumCoeff) {	C	Descriptor
if(maxNumCoeff = = 64)		
coded_block_flag = 1		
else		
coded_block_flag	3 | 4	ae(v)
if(coded_block_flag) {		
numCoeff = maxNumCoeff		
i = 0		
do {		
significant_coeff_flag[i **]**	3 | 4	ae(v)
if(significant_coeff_flag[i]) {		
last_significant_coeff_flag[i **]**	3 | 4	ae(v)
if(last_significant_coeff_flag[i]) {		
numCoeff = i + 1		
for(j = numCoeff; j < maxNumCoeff; j++)		
coeffLevel[j] = 0		
}		
}		
i++		
} while(i < numCoeff - 1)		
coeff_abs_level_minus1[numCoeff - 1 **]**	3 | 4	ae(v)
coeff_sign_flag[numCoeff - 1 **]**	3 | 4	ae(v)
coeffLevel[numCoeff - 1] = (coeff_abs_level_minus1[numCoeff – 1] + 1) * (1 – 2 * coeff_sign_flag[numCoeff – 1])		
for(i = numCoeff - 2; i >= 0; i--)		
if(significant_coeff_flag[i]) {		
coeff_abs_level_minus1[i **]**	3 | 4	ae(v)
coeff_sign_flag[i **]**	3 | 4	ae(v)
coeffLevel[i] = (coeff_abs_level_minus1[i] + 1) * (1 – 2 * coeff_sign_flag[i])		
} else		
coeffLevel[i] = 0		
} else		
for(i = 0; i < maxNumCoeff; i++)		
coeffLevel[i] = 0		
}		

7.4 Semantics

Semantics associated with the syntax structures and with the syntax elements within these structures are specified in this subclause. When the semantics of a syntax element are specified using a table or a set of tables, any values that are not specified in the table(s) shall not be present in the bitstream unless otherwise specified in this Recommendation | International Standard.

7.4.1 NAL unit semantics

NOTE 1 – The VCL is specified to efficiently represent the content of the video data. The NAL is specified to format that data and provide header information in a manner appropriate for conveyance on a variety of communication channels or storage media. All data are contained in NAL units, each of which contains an integer number of bytes. A NAL unit specifies a generic format for use in both packet-oriented and bitstream systems. The format of NAL units for both packet-oriented transport and byte stream is identical except that each NAL unit can be preceded by a start code prefix and extra padding bytes in the byte stream format.

NumBytesInNALunit specifies the size of the NAL unit in bytes. This value is required for decoding of the NAL unit. Some form of demarcation of NAL unit boundaries is necessary to enable inference of NumBytesInNALunit. One such demarcation method is specified in Annex B for the byte stream format. Other methods of demarcation may be specified outside of this Recommendation | International Standard.

forbidden_zero_bit shall be equal to 0.

nal_ref_idc not equal to 0 specifies that the content of the NAL unit contains a sequence parameter set or a picture parameter set or a slice of a reference picture or a slice data partition of a reference picture.

nal_ref_idc equal to 0 for a NAL unit containing a slice or slice data partition indicates that the slice or slice data partition is part of a non-reference picture.

nal_ref_idc shall not be equal to 0 for sequence parameter set or sequence parameter set extension or picture parameter set NAL units. When nal_ref_idc is equal to 0 for one slice or slice data partition NAL unit of a particular picture, it shall be equal to 0 for all slice and slice data partition NAL units of the picture.

nal_ref_idc shall not be equal to 0 for IDR NAL units, i.e., NAL units with nal_unit_type equal to 5.

nal_ref_idc shall be equal to 0 for all NAL units having nal_unit_type equal to 6, 9, 10, 11, or 12.

nal_unit_type specifies the type of RBSP data structure contained in the NAL unit as specified in Table 7-1. VCL NAL units are specified as those NAL units having nal_unit_type equal to 1 to 5, inclusive. All remaining NAL units are called non-VCL NAL units.

The column marked "C" in Table 7-1 lists the categories of the syntax elements that may be present in the NAL unit. In addition, syntax elements with syntax category "All" may be present, as determined by the syntax and semantics of the RBSP data structure. The presence or absence of any syntax elements of a particular listed category is determined from the syntax and semantics of the associated RBSP data structure. nal_unit_type shall not be equal to 3 or 4 unless at least one syntax element is present in the RBSP data structure having a syntax element category value equal to the value of nal_unit_type and not categorized as "All".

Table 7-1 – NAL unit type codes

nal_unit_type	Content of NAL unit and RBSP syntax structure	C
0	Unspecified	
1	Coded slice of a non-IDR picture slice_layer_without_partitioning_rbsp( )	2, 3, 4
2	Coded slice data partition A slice_data_partition_a_layer_rbsp( )	2
3	Coded slice data partition B slice_data_partition_b_layer_rbsp( )	3
4	Coded slice data partition C slice_data_partition_c_layer_rbsp( )	4
5	Coded slice of an IDR picture slice_layer_without_partitioning_rbsp( )	2, 3
6	Supplemental enhancement information (SEI) sei_rbsp( )	5
7	Sequence parameter set seq_parameter_set_rbsp( )	0
8	Picture parameter set pic_parameter_set_rbsp( )	1
9	Access unit delimiter access_unit_delimiter_rbsp( )	6
10	End of sequence end_of_seq_rbsp( )	7
11	End of stream end_of_stream_rbsp( )	8
12	Filler data filler_data_rbsp( )	9
13	Sequence parameter set extension seq_parameter_set_extension_rbsp( )	10
14..18	Reserved	
19	Coded slice of an auxiliary coded picture without partitioning slice_layer_without_partitioning_rbsp( )	2, 3, 4
20..23	Reserved	
24..31	Unspecified	

NAL units having nal_unit_type equal to 13 and 19 may be discarded by decoders without affecting the decoding process for NAL units having nal_unit_type not equal to 13 or 19 and without affecting conformance to this Recommendation | International Standard.

NAL units that use nal_unit_type equal to 0 or in the range of 24..31, inclusive, shall not affect the decoding process specified in this Recommendation | International Standard.

NOTE 2 – NAL unit types 0 and 24..31 may be used as determined by the application. No decoding process for these values of nal_unit_type is specified in this Recommendation | International Standard.

Decoders shall ignore (remove from the bitstream and discard) the contents of all NAL units that use reserved values of nal_unit_type.

NOTE 3 – This requirement allows future definition of compatible extensions to this Recommendation | International Standard.

In the text, coded slice NAL unit collectively refers to a coded slice of a non-IDR picture NAL unit or to a coded slice of an IDR picture NAL unit.

When the value of nal_unit_type is equal to 5 for a NAL unit containing a slice of a coded picture, the value of nal_unit_type shall be 5 in all other VCL NAL units of the same coded picture. Such a picture is referred to as an IDR picture.

NOTE 4 – Slice data partitioning cannot be used for IDR pictures.

rbsp_byte[i **]** is the i-th byte of an RBSP. An RBSP is specified as an ordered sequence of bytes as follows.

The RBSP contains an SODB as follows.

– If the SODB is empty (i.e., zero bits in length), the RBSP is also empty.

– Otherwise, the RBSP contains the SODB as follows.

1) The first byte of the RBSP contains the (most significant, left-most) eight bits of the SODB; the next byte of the RBSP shall contain the next eight bits of the SODB, etc., until fewer than eight bits of the SODB remain.

2) rbsp_trailing_bits( ) are present after the SODB as follows:

i) The first (most significant, left-most) bits of the final RBSP byte contains the remaining bits of the SODB, (if any)

ii) The next bit consists of a single rbsp_stop_one_bit equal to 1, and

iii) When the rbsp_stop_one_bit is not the last bit of a byte-aligned byte, one or more rbsp_alignment_zero_bit is present to result in byte alignment.

3) One or more cabac_zero_word 16-bit syntax elements equal to 0x0000 may be present in some RBSPs after the rbsp_trailing_bits( ) at the end of the RBSP.

Syntax structures having these RBSP properties are denoted in the syntax tables using an "_rbsp" suffix. These structures shall be carried within NAL units as the content of the rbsp_byte[i] data bytes. The association of the RBSP syntax structures to the NAL units shall be as specified in Table 7-1.

NOTE 5 – When the boundaries of the RBSP are known, the decoder can extract the SODB from the RBSP by concatenating the bits of the bytes of the RBSP and discarding the rbsp_stop_one_bit, which is the last (least significant, right-most) bit equal to 1, and discarding any following (less significant, farther to the right) bits that follow it, which are equal to 0. The data necessary for the decoding process is contained in the SODB part of the RBSP.

emulation_prevention_three_byte is a byte equal to 0x03. When an emulation_prevention_three_byte is present in the NAL unit, it shall be discarded by the decoding process.

The last byte of the NAL unit shall not be equal to 0x00.

Within the NAL unit, the following three-byte sequences shall not occur at any byte-aligned position:

– 0x000000

– 0x000001

– 0x000002

Within the NAL unit, any four-byte sequence that starts with 0x000003 other than the following sequences shall not occur at any byte-aligned position:

– 0x00000300

– 0x00000301

– 0x00000302

– 0x00000303

NOTE 6 – When nal_unit_type is equal to 0, particular care must be exercised in the design of encoders to avoid the presence of the above-listed three-byte and four-byte patterns at the beginning of the NAL unit syntax structure, as the syntax element emulation_prevention_three_byte cannot be the third byte of a NAL unit.

7.4.1.1 Encapsulation of an SODB within an RBSP (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

The form of encapsulation of an SODB within an RBSP and the use of the emulation_prevention_three_byte for encapsulation of an RBSP within a NAL unit is specified for the following purposes:

– to prevent the emulation of start codes within NAL units while allowing any arbitrary SODB to be represented within a NAL unit,

– to enable identification of the end of the SODB within the NAL unit by searching the RBSP for the rbsp_stop_one_bit starting at the end of the RBSP, and

– to enable a NAL unit to have a size larger than that of the SODB under some circumstances (using one or more cabac_zero_word).

The encoder can produce a NAL unit from an RBSP by the following procedure:

The RBSP data is searched for byte-aligned bits of the following binary patterns:

'00000000 00000000 000000xx' (where xx represents any 2 bit pattern: 00, 01, 10, or 11),

and a byte equal to 0x03 is inserted to replace these bit patterns with the patterns

'00000000 00000000 00000011 000000xx',

and finally, when the last byte of the RBSP data is equal to 0x00 (which can only occur when the RBSP ends in a cabac_zero_word), a final byte equal to 0x03 is appended to the end of the data.

The resulting sequence of bytes is then prefixed with the first byte of the NAL unit containing the indication of the type of RBSP data structure it contains. This results in the construction of the entire NAL unit.

This process can allow any SODB to be represented in a NAL unit while ensuring that

– no byte-aligned start code prefix is emulated within the NAL unit, and

– no sequence of 8 zero-valued bits followed by a start code prefix, regardless of byte-alignment, is emulated within the NAL unit.

7.4.1.2 Order of NAL units and association to coded pictures, access units, and video sequences

This subclause specifies constraints on the order of NAL units in the bitstream. Any order of NAL units in the bitstream obeying these constraints is referred to in the text as the decoding order of NAL units. Within a NAL unit, the syntax in subclauses 7.3, D.1, and E.1 specifies the decoding order of syntax elements. Decoders conforming to this Recommendation | International Standard shall be capable of receiving NAL units and their syntax elements in decoding order.

7.4.1.2.1 Order of sequence and picture parameter set RBSPs and their activation

NOTE 1 – The sequence and picture parameter set mechanism decouples the transmission of infrequently changing information from the transmission of coded macroblock data. Sequence and picture parameter sets may, in some applications, be conveyed "out-of-band" using a reliable transport mechanism.

A picture parameter set RBSP includes parameters that can be referred to by the coded slice NAL units or coded slice data partition A NAL units of one or more coded pictures. Each picture parameter set RBSP is initially considered not active at the start of the operation of the decoding process. At most one picture parameter set RBSP is considered active at any given moment during the operation of the decoding process, and the activation of any particular picture parameter set RBSP results in the deactivation of the previously-active picture parameter set RBSP (if any).

When a picture parameter set RBSP (with a particular value of pic_parameter_set_id) is not active and it is referred to by a coded slice NAL unit or coded slice data partition A NAL unit (using that value of pic_parameter_set_id), it is activated. This picture parameter set RBSP is called the active picture parameter set RBSP until it is deactivated by the activation of another picture parameter set RBSP. A picture parameter set RBSP, with that particular value of pic_parameter_set_id, shall be available to the decoding process prior to its activation.

Any picture parameter set NAL unit containing the value of pic_parameter_set_id for the active picture parameter set RBSP shall have the same content as that of the active picture parameter set RBSP unless it follows the last VCL NAL unit of a coded picture and precedes the first VCL NAL unit of another coded picture.

A sequence parameter set RBSP includes parameters that can be referred to by one or more picture parameter set RBSPs or one or more SEI NAL units containing a buffering period SEI message. Each sequence parameter set RBSP is initially considered not active at the start of the operation of the decoding process. At most one sequence parameter set RBSP is considered active at any given moment during the operation of the decoding process, and the activation of any particular sequence parameter set RBSP results in the deactivation of the previously-active sequence parameter set RBSP (if any).

When a sequence parameter set RBSP (with a particular value of seq_parameter_set_id) is not already active and it is referred to by activation of a picture parameter set RBSP (using that value of seq_parameter_set_id) or is referred to by an SEI NAL unit containing a buffering period SEI message (using that value of seq_parameter_set_id), it is activated. This sequence parameter set RBSP is called the active sequence parameter set RBSP until it is deactivated by the activation of another sequence parameter set RBSP. A sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation. An activated sequence parameter set RBSP shall remain active for the entire coded video sequence.

NOTE 2 – Because an IDR access unit begins a new coded video sequence and an activated sequence parameter set RBSP must remain active for the entire coded video sequence, a sequence parameter set RBSP can only be activated by a buffering period SEI message when the buffering period SEI message is part of an IDR access unit.

Any sequence parameter set NAL unit containing the value of seq_parameter_set_id for the active sequence parameter set RBSP shall have the same content as that of the active sequence parameter set RBSP unless it follows the last access unit of a coded video sequence and precedes the first VCL NAL unit and the first SEI NAL unit containing a buffering period SEI message (when present) of another coded video sequence.

NOTE 3 – If picture parameter set RBSP or sequence parameter set RBSP are conveyed within the bitstream, these constraints impose an order constraint on the NAL units that contain the picture parameter set RBSP or sequence parameter set RBSP, respectively. Otherwise (picture parameter set RBSP or sequence parameter set RBSP are conveyed by other means not specified in this Recommendation | International Standard), they must be available to the decoding process in a timely fashion such that these constraints are obeyed.

When present, a sequence parameter set extension RBSP includes parameters having a similar function to those of a sequence parameter set RBSP. For purposes of establishing constraints on the syntax elements of the sequence parameter set extension RBSP and for purposes of determining activation of a sequence parameter set extension RBSP, the sequence parameter set extension RBSP shall be considered part of the preceding sequence parameter set RBSP with the same value of seq_parameter_set_id. When a sequence parameter set RBSP is present that is not followed by a sequence parameter set extension RBSP with the same value of seq_parameter_set_id prior to the activation of the sequence parameter set RBSP, the sequence parameter set extension RBSP and its syntax elements shall be considered not present for the active sequence parameter set RBSP.

All constraints that are expressed on the relationship between the values of the syntax elements (and the values of variables derived from those syntax elements) in sequence parameter sets and picture parameter sets and other syntax elements are expressions of constraints that apply only to the active sequence parameter set and the active picture parameter set. If any sequence parameter set RBSP is present that is not activated in the bitstream, its syntax elements shall have values that would conform to the specified constraints if it were activated by reference in an otherwise-conforming bitstream. If any picture parameter set RBSP is present that is not ever activated in the bitstream, its syntax elements shall have values that would conform to the specified constraints if it were activated by reference in an otherwise-conforming bitstream.

During operation of the decoding process (see clause 8), the values of parameters of the active picture parameter set and the active sequence parameter set shall be considered in effect. For interpretation of SEI messages, the values of the parameters of the picture parameter set and sequence parameter set that are active for the operation of the decoding process for the VCL NAL units of the primary coded picture in the same access unit shall be considered in effect unless otherwise specified in the SEI message semantics.

7.4.1.2.2 Order of access units and association to coded video sequences

A bitstream conforming to this Recommendation | International Standard consists of one or more coded video sequences.

A coded video sequence consists of one or more access units. The order of NAL units and coded pictures and their association to access units is described in subclause 7.4.1.2.3.

The first access unit of each coded video sequence is an IDR access unit. All subsequent access units in the coded video sequence are non-IDR access units.

The values of picture order count for the coded pictures in consecutive access units in decoding order containing non-reference pictures shall be non-decreasing.

When present, an access unit following an access unit that contains an end of sequence NAL unit shall be an IDR access unit.

When an SEI NAL unit contains data that pertain to more than one access unit (for example, when the SEI NAL unit has a coded video sequence as its scope), it shall be contained in the first access unit to which it applies.

When an end of stream NAL unit is present in an access unit, this access unit shall be the last access unit in the bitstream and the end of stream NAL unit shall be the last NAL unit in that access unit.

7.4.1.2.3 Order of NAL units and coded pictures and association to access units

An access unit consists of one primary coded picture, zero or more corresponding redundant coded pictures, and zero or more non-VCL NAL units. The association of VCL NAL units to primary or redundant coded pictures is described in subclause 7.4.1.2.5.

The first access unit in the bitstream starts with the first NAL unit of the bitstream.

The first of any of the following NAL units after the last VCL NAL unit of a primary coded picture specifies the start of a new access unit.

– access unit delimiter NAL unit (when present)

– sequence parameter set NAL unit (when present)

– picture parameter set NAL unit (when present)

– SEI NAL unit (when present)

– NAL units with nal_unit_type in the range of 14 to 18, inclusive

– first VCL NAL unit of a primary coded picture (always present)

The constraints for the detection of the first VCL NAL unit of a primary coded picture are specified in subclause 7.4.1.2.4.

The following constraints shall be obeyed by the order of the coded pictures and non-VCL NAL units within an access unit.

– When an access unit delimiter NAL unit is present, it shall be the first NAL unit. There shall be at most one access unit delimiter NAL unit in any access unit.

– When any SEI NAL units are present, they shall precede the primary coded picture.

– When an SEI NAL unit containing a buffering period SEI message is present, the buffering period SEI message shall be the first SEI message payload of the first SEI NAL unit in the access unit

– The primary coded picture shall precede the corresponding redundant coded pictures.

– When redundant coded pictures are present, they shall be ordered in ascending order of the value of redundant_pic_cnt.

– When a sequence parameter set extension NAL unit is present, it shall be the next NAL unit after a sequence parameter set NAL unit having the same value of seq_parameter_set_id as in the sequence parameter set extension NAL unit.

– When one or more coded slice of an auxiliary coded picture without partitioning NAL units is present, they shall follow the primary coded picture and all redundant coded pictures (if any).

– When an end of sequence NAL unit is present, it shall follow the primary coded picture and all redundant coded pictures (if any) and all coded slice of an auxiliary coded picture without partitioning NAL units (if any).

– When an end of stream NAL unit is present, it shall be the last NAL unit.

– NAL units having nal_unit_type equal to 0, 12, or in the range of 20 to 31, inclusive, shall not precede the first VCL NAL unit of the primary coded picture.

NOTE 1 – Sequence parameter set NAL units or picture parameter set NAL units may be present in an access unit, but cannot follow the last VCL NAL unit of the primary coded picture within the access unit, as this condition would specify the start of a new access unit.

NOTE 2 – When a NAL unit having nal_unit_type equal to 7 or 8 is present in an access unit, it may or may not be referred to in the coded pictures of the access unit in which it is present, and may be referred to in coded pictures of subsequent access units.

The structure of access units not containing any NAL units with nal_unit_type equal to 0, 7, 8, or in the range of 12 to 18, inclusive, or in the range of 20 to 31, inclusive, is shown in Figure 7-1.

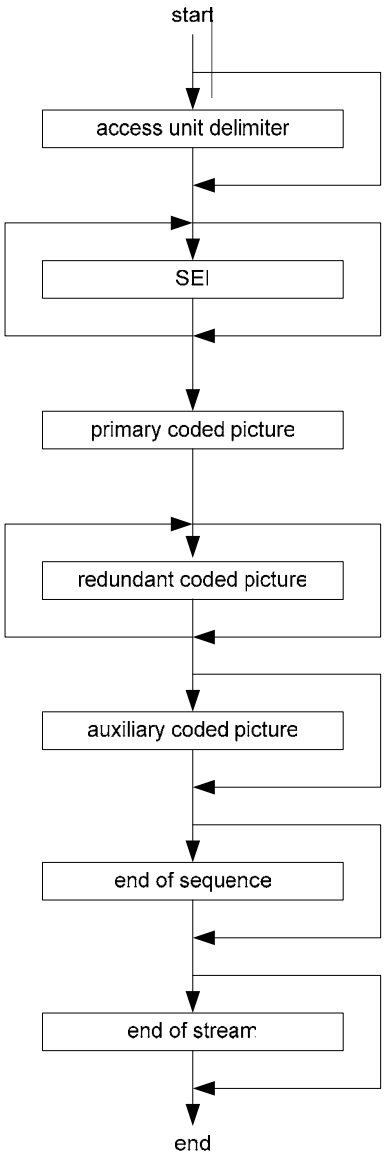


Figure 7-1 – Structure of an access unit not containing any NAL units with nal_unit_type equal to 0, 7, 8, or in the range of 12 to 18, inclusive, or in the range of 20 to 31, inclusive

7.4.1.2.4 Detection of the first VCL NAL unit of a primary coded picture

This subclause specifies constraints on VCL NAL unit syntax that are sufficient to enable the detection of the first VCL NAL unit of each primary coded picture.

Any coded slice NAL unit or coded slice data partition A NAL unit of the primary coded picture of the current access unit shall be different from any coded slice NAL unit or coded slice data partition A NAL unit of the primary coded picture of the previous access unit in one or more of the following ways.

– frame_num differs in value. The value of frame_num used to test this condition is the value of frame_num that appears in the syntax of the slice header, regardless of whether that value is inferred to have been equal to 0 for subsequent use in the decoding process due to the presence of memory_management_control_operation equal to 5.

> NOTE 1 – A consequence of the above statement is that a primary coded picture having frame_num equal to 1 cannot contain a memory_management_control_operation equal to 5 unless some other condition listed below is fulfilled for the next primary coded picture that follows after it (if any).

– pic_parameter_set_id differs in value.

– field_pic_flag differs in value.

– bottom_field_flag is present in both and differs in value.

– nal_ref_idc differs in value with one of the nal_ref_idc values being equal to 0.

– pic_order_cnt_type is equal to 0 for both and either pic_order_cnt_lsb differs in value, or delta_pic_order_cnt_bottom differs in value.

– pic_order_cnt_type is equal to 1 for both and either delta_pic_order_cnt[0] differs in value, or delta_pic_order_cnt[1] differs in value.

– nal_unit_type differs in value with one of the nal_unit_type values being equal to 5.

– nal_unit_type is equal to 5 for both and idr_pic_id differs in value.

NOTE 2 – Some of the VCL NAL units in redundant coded pictures or some non-VCL NAL units (e.g. an access unit delimiter NAL unit) may also be used for the detection of the boundary between access units, and may therefore aid in the detection of the start of a new primary coded picture.

7.4.1.2.5 Order of VCL NAL units and association to coded pictures

Each VCL NAL unit is part of a coded picture.

The order of the VCL NAL units within a coded IDR picture is constrained as follows.

– If arbitrary slice order is allowed as specified in Annex A, coded slice of an IDR picture NAL units may have any order relative to each other.

– Otherwise (arbitrary slice order is not allowed), the order of coded slice of an IDR picture NAL units shall be in the order of increasing macroblock address for the first macroblock of each coded slice of an IDR picture NAL unit.

The order of the VCL NAL units within a coded non-IDR picture is constrained as follows.

– If arbitrary slice order is allowed as specified in Annex A, coded slice of a non-IDR picture NAL units or coded slice data partition A NAL units may have any order relative to each other. A coded slice data partition A NAL unit with a particular value of slice_id shall precede any present coded slice data partition B NAL unit with the same value of slice_id. A coded slice data partition A NAL unit with a particular value of slice_id shall precede any present coded slice data partition C NAL unit with the same value of slice_id. When a coded slice data partition B NAL unit with a particular value of slice_id is present, it shall precede any present coded slice data partition C NAL unit with the same value of slice_id.

– Otherwise (arbitrary slice order is not allowed), the order of coded slice of a non-IDR picture NAL units or coded slice data partition A NAL units shall be in the order of increasing macroblock address for the first macroblock of each coded slice of a non-IDR picture NAL unit or coded slice data partition A NAL unit. A coded slice data partition A NAL unit with a particular value of slice_id shall immediately precede any present coded slice data partition B NAL unit with the same value of slice_id. A coded slice data partition A NAL unit with a particular value of slice_id shall immediately precede any present coded slice data partition C NAL unit with the same value of slice_id, when a coded slice data partition B NAL unit with the same value of slice_id is not present. When a coded slice data partition B NAL unit with a particular value of slice_id is present, it shall immediately precede any present coded slice data partition C NAL unit with the same value of slice_id.

NAL units having nal_unit_type equal to 12 may be present in the access unit but shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

NAL units having nal_unit_type equal to 0 or in the range of 24 to 31, inclusive, which are unspecified, may be present in the access unit but shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

NAL units having nal_unit_type in the range of 20 to 23, inclusive, which are reserved, shall not precede the first VCL NAL unit of the primary coded picture within the access unit (when specified in the future by ITU-T | ISO/IEC).

7.4.2 Raw byte sequence payloads and RBSP trailing bits semantics

7.4.2.1 Sequence parameter set RBSP semantics

profile_idc and **level_idc** indicate the profile and level to which the bitstream conforms, as specified in Annex A.

constraint_set0_flag equal to 1 indicates that the bitstream obeys all constraints specified in subclause A.2.1. constraint_set0_flag equal to 0 indicates that the bitstream may or may not obey all constraints specified in subclause A.2.1.

constraint_set1_flag equal to 1 indicates that the bitstream obeys all constraints specified in subclause A.2.2. constraint_set1_flag equal to 0 indicates that the bitstream may or may not obey all constraints specified in subclause A.2.2.

constraint_set2_flag equal to 1 indicates that the bitstream obeys all constraints specified in subclause A.2.3. constraint_set2_flag equal to 0 indicates that the bitstream may or may not obey all constraints specified in subclause A.2.3.

NOTE 1 – When one or more than one of constraint_set0_flag, constraint_set1_flag, or constraint_set2_flag are equal to 1, the bitstream must obey the constraints of all of the indicated subclauses of subclause A.2. When profile_idc is equal to 100, 110, 122, or 144, the values of constraint_set0_flag, constraint_set1_flag, and constraint_set2_flag must all be equal to 0.

constraint_set3_flag indicates the following.

– If profile_idc is equal to 66, 77, or 88 and level_idc is equal to 11, constraint_set3_flag equal to 1 indicates that the bitstream obeys all constraints specified in Annex A for level 1b and constraint_set3_flag equal to 0 indicates that the bitstream may or may not obey all constraints specified in Annex A for level 1b.

– Otherwise (profile_idc is equal to 100, 110, 122, or 144 or level_idc is not equal to 11), the value of 1 for constraint_set3_flag is reserved for future use by ITU-T | ISO/IEC. constraint_set3_flag shall be equal to 0 in bitstreams conforming to this Recommendation | International Standard when profile_idc is equal to 100, 110, 122, or 144 or level_idc is not equal to 11. Decoders conforming to this Recommendation | International Standard shall ignore the value of constraint_set3_flag when profile_idc is equal to 100, 110, 122, or 144 or level_idc is not equal to 11.

reserved_zero_4bits shall be equal to 0. Other values of reserved_zero_4bits may be specified in the future by ITU-T | ISO/IEC. Decoders shall ignore the value of reserved_zero_4bits.

seq_parameter_set_id identifies the sequence parameter set that is referred to by the picture parameter set. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

NOTE 2 – When feasible, encoders should use distinct values of seq_parameter_set_id when the values of other sequence parameter set syntax elements differ rather than changing the values of the syntax elements associated with a specific value of seq_parameter_set_id.

chroma_format_idc specifies the chroma sampling relative to the luma sampling as specified in subclause 6.2. The value of chroma_format_idc shall be in the range of 0 to 3, inclusive. When chroma_format_idc is not present, it shall be inferred to be equal to 1 (4:2:0 chroma format).

residual_colour_transform_flag equal to 1 specifies that the residual colour transform is applied as specified in subclause 8.5. residual_colour_transform_flag equal to 0 specifies that the residual colour transform is not applied. When residual_colour_transform_flag is not present, it shall be inferred to be equal to 0.

bit_depth_luma_minus8 specifies the bit depth of the samples of the luma array and the value of the luma quantisation parameter range offset $QpBdOffset_Y$, as specified by

$$BitDepth_Y = 8 + bit\_depth\_luma\_minus8 \quad (7\text{-}1)$$

$$QpBdOffset_Y = 6 * bit\_depth\_luma\_minus8 \quad (7\text{-}2)$$

When bit_depth_luma_minus8 is not present, it shall be inferred to be equal to 0. bit_depth_luma_minus8 shall be in the range of 0 to 4, inclusive.

bit_depth_chroma_minus8 specifies the bit depth of the samples of the chroma arrays and the value of the chroma quantisation parameter range offset $QpBdOffset_C$, as specified by

$$BitDepth_C = 8 + bit\_depth\_chroma\_minus8 \quad (7\text{-}3)$$

$$QpBdOffset_C = 6 * (bit\_depth\_chroma\_minus8 + residual\_colour\_transform\_flag) \quad (7\text{-}4)$$

When bit_depth_chroma_minus8 is not present, it shall be inferred to be equal to 0. bit_depth_chroma_minus8 shall be in the range of 0 to 4, inclusive.

The variable RawMbBits is derived as

$$RawMbBits = 256 * BitDepth_Y + 2 * MbWidthC * MbHeightC * BitDepth_C \quad (7\text{-}5)$$

qpprime_y_zero_transform_bypass_flag equal to 1 specifies that, when QP'_Y is equal to 0, a transform bypass operation for the transform coefficient decoding process and picture construction process prior to deblocking filter process as specified in subclause 8.5 shall be applied. qpprime_y_zero_transform_bypass_flag equal to 0 specifies that the transform coefficient decoding process and picture construction process prior to deblocking filter process shall not use the transform bypass operation. When qpprime_y_zero_transform_bypass_flag is not present, it shall be inferred to be equal to 0.

seq_scaling_matrix_present_flag equal to 1 specifies that the flags seq_scaling_list_present_flag[i] for i = 0..7 are present. seq_scaling_matrix_present_flag equal to 0 specifies that these flags are not present and the sequence-level scaling list specified by Flat_4x4_16 shall be inferred for i = 0..5 and the sequence-level scaling list specified by Flat_8x8_16 shall be inferred for i = 6..7. When seq_scaling_matrix_present_flag is not present, it shall be inferred to be equal to 0.

The scaling lists Flat_4x4_16 and Flat_8x8_16 are specified as follows:

Flat_4x4_16[i] = 16, with i = 0..15, (7-6)

Flat_8x8_16[i] = 16, with i = 0..63. (7-7)

seq_scaling_list_present_flag[i **]** equal to 1 specifies that the syntax structure for scaling list i is present in the sequence parameter set. seq_scaling_list_present_flag[i] equal to 0 specifies that the syntax structure for scaling list i is not present in the sequence parameter set and the scaling list fall-back rule set A specified in Table 7-2 shall be used to infer the sequence-level scaling list for index i.

Table 7-2 – Assignment of mnemonic names to scaling list indices and specification of fall-back rule

Value of scaling list index	Mnemonic name	Block size	MB prediction type	Component	Scaling list fall-back rule set A	Scaling list fall-back rule set B	Default scaling list
0	Sl_4x4_Intra_Y	4x4	Intra	Y	default scaling list	sequence-level scaling list	Default_4x4_Intra
1	Sl_4x4_Intra_Cb	4x4	Intra	Cb	scaling list for i = 0	scaling list for i = 0	Default_4x4_Intra
2	Sl_4x4_Intra_Cr	4x4	Intra	Cr	scaling list for i = 1	scaling list for i = 1	Default_4x4_Intra
3	Sl_4x4_Inter_Y	4x4	Inter	Y	default scaling list	sequence-level scaling list	Default_4x4_Inter
4	Sl_4x4_Inter_Cb	4x4	Inter	Cb	scaling list for i = 3	scaling list for i = 3	Default_4x4_Inter
5	Sl_4x4_Inter_Cr	4x4	Inter	Cr	scaling list for i = 4	scaling list for i = 4	Default_4x4_Inter
6	Sl_8x8_Intra_Y	8x8	Intra	Y	default scaling list	sequence-level scaling list	Default_8x8_Intra
7	Sl_8x8_Inter_Y	8x8	Inter	Y	default scaling list	sequence-level scaling list	Default_8x8_Inter

Table 7-3 specifies the default scaling lists Default_4x4_Intra and Default_4x4_Inter. Table 7-4 specifies the default scaling lists Default_8x8_Intra and Default_8x8_Inter.

Table 7-3 – Specification of default scaling lists Default_4x4_Intra and Default_4x4_Inter

idx	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Default_4x4_Intra[idx]	6	13	13	20	20	20	28	28	28	28	32	32	32	37	37	42
Default_4x4_Inter[idx]	10	14	14	20	20	20	24	24	24	24	27	27	27	30	30	34

Table 7-4 – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter

idx	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Default_8x8_Intra[idx]	6	10	10	13	11	13	16	16	16	16	18	18	18	18	18	23
Default_8x8_Inter[idx]	9	13	13	15	13	15	17	17	17	17	19	19	19	19	19	21

Table 7-4 (continued) – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter

idx	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Default_8x8_Intra[idx]	23	23	23	23	23	25	25	25	25	25	25	25	27	27	27	27
Default_8x8_Inter[idx]	21	21	21	21	21	22	22	22	22	22	22	22	24	24	24	24

Table 7-4 (continued) – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter

idx	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
Default_8x8_Intra[idx]	27	27	27	27	29	29	29	29	29	29	29	31	31	31	31	31
Default_8x8_Inter[idx]	24	24	24	24	25	25	25	25	25	25	25	27	27	27	27	27

Table 7-4 (concluded) – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter

idx	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
Default_8x8_Intra[idx]	31	33	33	33	33	33	36	36	36	36	38	38	38	40	40	42
Default_8x8_Inter[idx]	27	28	28	28	28	28	30	30	30	30	32	32	32	33	33	35

log2_max_frame_num_minus4 specifies the value of the variable MaxFrameNum that is used in frame_num related derivations as follows:

$$MaxFrameNum = 2^{(log2\_max\_frame\_num\_minus4 + 4)} \quad (7\text{-}8)$$

The value of log2_max_frame_num_minus4 shall be in the range of 0 to 12, inclusive.

pic_order_cnt_type specifies the method to decode picture order count (as specified in subclause 8.2.1). The value of pic_order_cnt_type shall be in the range of 0 to 2, inclusive.

pic_order_cnt_type shall not be equal to 2 in a coded video sequence that contains any of the following

- an access unit containing a non-reference frame followed immediately by an access unit containing a non-reference picture;
- two access units each containing a field with the two fields together forming a complementary non-reference field pair followed immediately by an access unit containing a non-reference picture;
- an access unit containing a non-reference field followed immediately by an access unit containing another non-reference picture that does not form a complementary non-reference field pair with the first of the two access units.

log2_max_pic_order_cnt_lsb_minus4 specifies the value of the variable MaxPicOrderCntLsb that is used in the decoding process for picture order count as specified in subclause 8.2.1 as follows:

$$MaxPicOrderCntLsb = 2^{(log2\_max\_pic\_order\_cnt\_lsb\_minus4 + 4)} \quad (7\text{-}9)$$

The value of log2_max_pic_order_cnt_lsb_minus4 shall be in the range of 0 to 12, inclusive.

delta_pic_order_always_zero_flag equal to 1 specifies that delta_pic_order_cnt[0] and delta_pic_order_cnt[1] are not present in the slice headers of the sequence and shall be inferred to be equal to 0. delta_pic_order_always_zero_flag equal to 0 specifies that delta_pic_order_cnt[0] is present in the slice headers of the sequence and delta_pic_order_cnt[1] may be present in the slice headers of the sequence.

offset_for_non_ref_pic is used to calculate the picture order count of a non-reference picture as specified in 8.2.1. The value of offset_for_non_ref_pic shall be in the range of -2^{31} to $2^{31} - 1$, inclusive.

offset_for_top_to_bottom_field is used to calculate the picture order count of a bottom field as specified in subclause 8.2.1. The value of offset_for_top_to_bottom_field shall be in the range of -2^{31} to $2^{31} - 1$, inclusive.

num_ref_frames_in_pic_order_cnt_cycle is used in the decoding process for picture order count as specified in subclause 8.2.1. The value of num_ref_frames_in_pic_order_cnt_cycle shall be in the range of 0 to 255, inclusive.

offset_for_ref_frame[i **]** is an element of a list of num_ref_frames_in_pic_order_cnt_cycle values used in the decoding process for picture order count as specified in subclause 8.2.1. The value of offset_for_ref_frame[i] shall be in the range of -2^{31} to $2^{31} - 1$, inclusive.

num_ref_frames specifies the maximum number of short-term and long-term reference frames, complementary reference field pairs, and non-paired reference fields that may be used by the decoding process for inter prediction of any picture in the sequence. num_ref_frames also determines the size of the sliding window operation as specified in subclause 8.2.5.3. The value of num_ref_frames shall be in the range of 0 to MaxDpbSize (as specified in subclause A.3.1 or A.3.2), inclusive.

gaps_in_frame_num_value_allowed_flag specifies the allowed values of frame_num as specified in subclause 7.4.3 and the decoding process in case of an inferred gap between values of frame_num as specified in subclause 8.2.5.2.

pic_width_in_mbs_minus1 plus 1 specifies the width of each decoded picture in units of macroblocks.

The variable for the picture width in units of macroblocks is derived as follows

$$PicWidthInMbs = pic\_width\_in\_mbs\_minus1 + 1 \quad (7\text{-}10)$$

The variable for picture width for the luma component is derived as follows

$$PicWidthInSamples_L = PicWidthInMbs * 16 \quad (7\text{-}11)$$

The variable for picture width for the chroma components is derived as follows

$$PicWidthInSamples_C = PicWidthInMbs * MbWidthC \quad (7\text{-}12)$$

pic_height_in_map_units_minus1 plus 1 specifies the height in slice group map units of a decoded frame or field.

The variables PicHeightInMapUnits and PicSizeInMapUnits are derived as follows

$$PicHeightInMapUnits = pic\_height\_in\_map\_units\_minus1 + 1 \quad (7\text{-}13)$$

$$PicSizeInMapUnits = PicWidthInMbs * PicHeightInMapUnits \quad (7\text{-}14)$$

frame_mbs_only_flag equal to 0 specifies that coded pictures of the coded video sequence may either be coded fields or coded frames. frame_mbs_only_flag equal to 1 specifies that every coded picture of the coded video sequence is a coded frame containing only frame macroblocks.

The allowed range of values for pic_width_in_mbs_minus1, pic_height_in_map_units_minus1, and frame_mbs_only_flag is specified by constraints in Annex A.

Depending on frame_mbs_only_flag, semantics are assigned to pic_height_in_map_units_minus1 as follows.

– If frame_mbs_only_flag is equal to 0, pic_height_in_map_units_minus1 plus 1 is the height of a field in units of macroblocks.

– Otherwise (frame_mbs_only_flag is equal to 1), pic_height_in_map_units_minus1 plus 1 is the height of a frame in units of macroblocks.

The variable FrameHeightInMbs is derived as follows

$$FrameHeightInMbs = (2 - frame\_mbs\_only\_flag) * PicHeightInMapUnits \quad (7\text{-}15)$$

mb_adaptive_frame_field_flag equal to 0 specifies no switching between frame and field macroblocks within a picture. mb_adaptive_frame_field_flag equal to 1 specifies the possible use of switching between frame and field macroblocks within frames. When mb_adaptive_frame_field_flag is not present, it shall be inferred to be equal to 0.

direct_8x8_inference_flag specifies the method used in the derivation process for luma motion vectors for B_Skip, B_Direct_16x16 and B_Direct_8x8 as specified in subclause 8.4.1.2. When frame_mbs_only_flag is equal to 0, direct_8x8_inference_flag shall be equal to 1.

frame_cropping_flag equal to 1 specifies that the frame cropping offset parameters follow next in the sequence parameter set. frame_cropping_flag equal to 0 specifies that the frame cropping offset parameters are not present.

frame_crop_left_offset, frame_crop_right_offset, frame_crop_top_offset, frame_crop_bottom_offset specify the samples of the pictures in the coded video sequence that are output from the decoding process, in terms of a rectangular region specified in frame coordinates for output.

The variables CropUnitX and CropUnitY are derived as follows:

— If chroma_format_idc is equal to 0, CropUnitX and CropUnitY are derived as

$$CropUnitX = 1 \quad (7\text{-}16)$$
$$CropUnitY = 2 - frame\_mbs\_only\_flag \quad (7\text{-}17)$$

— Otherwise (chroma_format_idc is equal to 1, 2, or 3), CropUnitX and CropUnitY are derived as

$$CropUnitX = SubWidthC \quad (7\text{-}18)$$
$$CropUnitY = SubHeightC * (2 - frame\_mbs\_only\_flag) \quad (7\text{-}19)$$

The frame cropping rectangle contains luma samples with horizontal frame coordinates from CropUnitX * frame_crop_left_offset to $PicWidthInSamples_L$ – (CropUnitX * frame_crop_right_offset + 1) and vertical frame coordinates from CropUnitY * frame_crop_top_offset to (16 * FrameHeightInMbs) – (CropUnitY * frame_crop_bottom_offset + 1), inclusive. The value of frame_crop_left_offset shall be in the range of 0 to ($PicWidthInSamples_L$ / CropUnitX) – (frame_crop_right_offset + 1), inclusive; and the value of frame_crop_top_offset shall be in the range of 0 to (16 * FrameHeightInMbs / CropUnitY) – (frame_crop_bottom_offset + 1), inclusive.

When frame_cropping_flag is equal to 0, the values of frame_crop_left_offset, frame_crop_right_offset, frame_crop_top_offset, and frame_crop_bottom_offset shall be inferred to be equal to 0.

When chroma_format_idc is not equal to 0, the corresponding specified samples of the two chroma arrays are the samples having frame coordinates (x / SubWidthC, y / SubHeightC), where (x, y) are the frame coordinates of the specified luma samples.

For decoded fields, the specified samples of the decoded field are the samples that fall within the rectangle specified in frame coordinates.

vui_parameters_present_flag equal to 1 specifies that the vui_parameters( ) syntax structure as specified in Annex E is present. vui_parameters_present_flag equal to 0 specifies that the vui_parameters( ) syntax structure as specified in Annex E is not present.

7.4.2.1.1 Scaling list semantics

delta_scale is used to derive the j-th element of the scaling list for j in the range of 0 to sizeOfScalingList - 1, inclusive. The value of delta_scale shall be in the range of -128 to +127, inclusive.

When useDefaultScalingMatrixFlag is derived to be equal to 1, the scaling list shall be inferred to be equal to the default scaling list as specified in Table 7-2.

7.4.2.1.2 Sequence parameter set extension RBSP semantics

seq_parameter_set_id identifies the sequence parameter set associated with the sequence parameter set extension. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

aux_format_idc equal to 0 indicates that there are no auxiliary coded pictures in the coded video sequence. aux_format_idc equal to 1 indicates that exactly one auxiliary coded picture is present in each access unit of the coded video sequence, and that for alpha blending purposes the decoded samples of the associated primary coded picture in each access unit should be multiplied by the interpretation sample values of the auxiliary coded picture in the access unit in the display process after output from the decoding process. aux_format_idc equal to 2 indicates that exactly one auxiliary coded picture exists in each access unit of the coded video sequence, and that for alpha blending purposes the decoded samples of the associated primary coded picture in each access unit should not be multiplied by the interpretation sample values of the auxiliary coded picture in the access unit in the display process after output from the decoding process. aux_format_idc equal to 3 indicates that exactly one auxiliary coded picture exists in each access unit of the coded video sequence, and that the usage of the auxiliary coded pictures is unspecified. The value of aux_format_idc shall be in the range of 0 to 3, inclusive. Values greater than 3 for aux_format_idc are reserved to indicate the presence of exactly one auxiliary coded picture in each access unit of the coded video sequence for purposes to be specified in the future by ITU-T | ISO/IEC. When aux_format_idc is not present, it shall be inferred to be equal to 0.

NOTE 1 – Decoders conforming to this Recommendation | International Standard are not required to decode auxiliary coded pictures.

bit_depth_aux_minus8 specifies the bit depth of the samples of the sample array of the auxiliary coded picture. bit_depth_aux_minus8 shall be in the range of 0 to 4, inclusive.

alpha_incr_flag equal to 0 indicates that the interpretation sample value for each decoded auxiliary coded picture sample value is equal to the decoded auxiliary coded picture sample value for purposes of alpha blending. alpha_incr_flag equal to 1 indicates that, for purposes of alpha blending, after decoding the auxiliary coded picture samples, any auxiliary coded picture sample value that is greater than Min(alpha_opaque_value, alpha_transparent_value) should be increased by one to obtain the interpretation sample value for the auxiliary coded picture sample, and any auxiliary coded picture sample value that is less than or equal to Min(alpha_opaque_value, alpha_transparent_value) should be used without alteration as the interpretation sample value for the decoded auxiliary coded picture sample value.

alpha_opaque_value specifies the interpretation sample value of an auxiliary coded picture sample for which the associated luma and chroma samples of the same access unit are considered opaque for purposes of alpha blending. The number of bits used for the representation of the alpha_opaque_value syntax element is bit_depth_aux_minus8 + 9 bits.

alpha_transparent_value specifies the interpretation sample value of an auxiliary coded picture sample for which the associated luma and chroma samples of the same access unit are considered transparent for purposes of alpha blending. The number of bits used for the representation of the alpha_transparent_value syntax element is bit_depth_aux_minus8 + 9 bits.

When alpha_incr_flag is equal to 1, alpha_transparent_value shall not be equal to alpha_opaque_value and Log2(Abs(alpha_opaque_value – alpha_transparent_value)) shall have an integer value. A value of alpha_transparent_value that is equal to alpha_opaque_value indicates that the auxiliary coded picture is not intended for alpha blending purposes.

NOTE 2 – For alpha blending purposes, alpha_opaque_value may be greater than alpha_transparent_value, or it may be less than alpha_transparent_value. Interpretation sample values should be clipped to the range of alpha_opaque_value to alpha_transparent_value, inclusive.

The decoding of the sequence parameter set extension and the decoding of auxiliary coded pictures is not required for conformance with this Recommendation | International Standard.

The syntax of each coded slice of an auxiliary coded picture shall obey the same constraints as a coded slice of a redundant picture, with the following differences of constraints.

– The following applies in regard to whether the primary coded picture is an IDR picture.
  – If the primary coded picture is an IDR picture, the auxiliary coded slice syntax shall correspond to that of a slice having nal_unit_type equal to 5 (a slice of an IDR picture);
  – Otherwise (the primary coded picture is not an IDR picture), the auxiliary coded slice syntax shall correspond to that of a slice having nal_unit_type equal to 1 (a slice of a non-IDR picture).
– The slices of an auxiliary coded picture (when present) shall contain all macroblocks corresponding to those of the primary coded picture.
– redundant_pic_cnt shall be equal to 0 in all auxiliary coded slices.

The (optional) decoding process for the decoding of auxiliary coded pictures is the same as if the auxiliary coded pictures were primary coded pictures in a separate coded video stream that differs from the primary coded pictures in the current coded video stream in the following ways.

– The IDR or non-IDR status of each auxiliary coded picture shall be inferred to be the same as the IDR or non-IDR status of the primary picture in the same access unit, rather than being inferred from the value of nal_ref_idc.

– The value of chroma_format_idc shall be inferred to be equal to 0 for the decoding of the auxiliary coded pictures.

– The value of bit_depth_luma_minus8 shall be inferred to be equal to bit_depth_aux_minus8 for the decoding of the auxiliary coded pictures.

NOTE 3 – Alpha blending composition is normally performed with a background picture B, a foreground picture F, and a decoded auxiliary coded picture A, all of the same size. Assume for purposes of example illustration that the chroma resolution of B and F have been upsampled to the same resolution as the luma. Denote corresponding samples of B, F and A by b, f and a, respectively. Denote luma and chroma samples by subscripts Y, Cb and Cr.

Define the variables alphaRange, alphaFwt and alphaBwt as follows:

alphaRange = Abs(alpha_opaque_value - alpha_transparent_value)

alphaFwt = Abs(a - alpha_transparent_value)

alphaBwt = Abs(a - alpha_opaque_value)

Then, in alpha blending composition, samples d of the displayed picture D may be calculated as

$d_Y = (alphaFwt*f_Y + alphaBwt*b_Y + alphaRange/2) / alphaRange$

$d_{CB} = (alphaFwt*f_{CB} + alphaBwt*b_{CB} + alphaRange/2) / alphaRange$

$d_{CR} = (alphaFwt*f_{CR} + alphaBwt*b_{CR} + alphaRange/2) / alphaRange$

The samples of pictures D, F and B could also represent red, green, and blue component values (see subclause E.2.1). Here we have assumed Y, Cb and Cr component values. Each component, e.g. Y, is assumed for purposes of example illustration above to have the same bit depth in each of the pictures D, F and B. However, different components, e.g. Y and Cb, need not have the same bit depth in this example.

When aux_format_idc is equal to 1, F would be the decoded picture obtained from the decoded luma and chroma, and A would be the decoded picture obtained from the decoded auxiliary coded picture. In this case, the indicated example alpha blending composition involves multiplying the samples of F by factors obtained from the samples of A.

A picture format that is useful for editing or direct viewing, and that is commonly used, is called pre-multiplied-black video. If the foreground picture was F, then the pre-multiplied-black video S is given by

$s_Y = (alphaFwt*f_Y) / alphaRange$

$s_{CB} = (alphaFwt*f_{CB}) / alphaRange$

$s_{CR} = (alphaFwt*f_{CR}) / alphaRange$

Pre-multiplied-black video has the characteristic that the picture S will appear correct if displayed against a black background. For a non-black background B, the composition of the displayed picture D may be calculated as

$d_Y = s_Y + (alphaBwt*b_Y + alphaRange/2) / alphaRange$

$d_{CB} = s_{CB} + (alphaBwt*b_{CB} + alphaRange/2) / alphaRange$

$d_{CR} = s_{CR} + (alphaBwt*b_{CR} + alphaRange/2) / alphaRange$

When aux_format_idc is equal to 2, S would be the decoded picture obtained from the decoded luma and chroma, and A would again be the decoded picture obtained from the decoded auxiliary coded picture. In this case, alpha blending composition does not involve multiplication of the samples of S by factors obtained from the samples of A.

additional_extension_flag equal to 0 indicates that no additional data follows within the sequence parameter set extension syntax structure prior to the RBSP trailing bits. The value of additional_extension_flag shall be equal to 0. The value of 1 for additional_extension_flag is reserved for future use by ITU-T | ISO/IEC. Decoders that conform to this Recommendation | International Standard shall ignore all data that follows the value of 1 for additional_extension_flag in a sequence parameter set extension NAL unit.

7.4.2.2 Picture parameter set RBSP semantics

pic_parameter_set_id identifies the picture parameter set that is referred to in the slice header. The value of pic_parameter_set_id shall be in the range of 0 to 255, inclusive.

seq_parameter_set_id refers to the active sequence parameter set. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

entropy_coding_mode_flag selects the entropy decoding method to be applied for the syntax elements for which two descriptors appear in the syntax tables as follows.

– If entropy_coding_mode_flag is equal to 0, the method specified by the left descriptor in the syntax table is applied (Exp-Golomb coded, see subclause 9.1 or CAVLC, see subclause 9.2).

– Otherwise (entropy_coding_mode_flag is equal to 1), the method specified by the right descriptor in the syntax table is applied (CABAC, see subclause 9.3).

pic_order_present_flag equal to 1 specifies that the picture order count related syntax elements are present in the slice headers as specified in subclause 7.3.3. pic_order_present_flag equal to 0 specifies that the picture order count related syntax elements are not present in the slice headers.

num_slice_groups_minus1 plus 1 specifies the number of slice groups for a picture. When num_slice_groups_minus1 is equal to 0, all slices of the picture belong to the same slice group. The allowed range of num_slice_groups_minus1 is specified in Annex A.

slice_group_map_type specifies how the mapping of slice group map units to slice groups is coded. The value of slice_group_map_type shall be in the range of 0 to 6, inclusive.

slice_group_map_type equal to 0 specifies interleaved slice groups.

slice_group_map_type equal to 1 specifies a dispersed slice group mapping.

slice_group_map_type equal to 2 specifies one or more "foreground" slice groups and a "leftover" slice group.

slice_group_map_type values equal to 3, 4, and 5 specify changing slice groups. When num_slice_groups_minus1 is not equal to 1, slice_group_map_type shall not be equal to 3, 4, or 5.

slice_group_map_type equal to 6 specifies an explicit assignment of a slice group to each slice group map unit.

Slice group map units are specified as follows.

– If frame_mbs_only_flag is equal to 0 and mb_adaptive_frame_field_flag is equal to 1 and the coded picture is a frame, the slice group map units are macroblock pair units.

– Otherwise, if frame_mbs_only_flag is equal to 1 or a coded picture is a field, the slice group map units are units of macroblocks.

– Otherwise (frame_mbs_only_flag is equal to 0 and mb_adaptive_frame_field_flag is equal to 0 and the coded picture is a frame), the slice group map units are units of two macroblocks that are vertically contiguous as in a frame macroblock pair of an MBAFF frame.

run_length_minus1[i **]** is used to specify the number of consecutive slice group map units to be assigned to the i-th slice group in raster scan order of slice group map units. The value of run_length_minus1[i] shall be in the range of 0 to PicSizeInMapUnits - 1, inclusive.

top_left[i **]** and **bottom_right[** i **]** specify the top-left and bottom-right corners of a rectangle, respectively. top_left[i] and bottom_right[i] are slice group map unit positions in a raster scan of the picture for the slice group map units. For each rectangle i, all of the following constraints shall be obeyed by the values of the syntax elements top_left[i] and bottom_right[i]

– top_left[i] shall be less than or equal to bottom_right[i] and bottom_right[i] shall be less than PicSizeInMapUnits.

– (top_left[i] % PicWidthInMbs) shall be less than or equal to the value of (bottom_right[i] % PicWidthInMbs).

slice_group_change_direction_flag is used with slice_group_map_type to specify the refined map type when slice_group_map_type is 3, 4, or 5.

slice_group_change_rate_minus1 is used to specify the variable SliceGroupChangeRate. SliceGroupChangeRate specifies the multiple in number of slice group map units by which the size of a slice group can change from one picture to the next. The value of slice_group_change_rate_minus1 shall be in the range of 0 to PicSizeInMapUnits – 1, inclusive. The SliceGroupChangeRate variable is specified as follows:

SliceGroupChangeRate = slice_group_change_rate_minus1 + 1 (7-20)

pic_size_in_map_units_minus1 is used to specify the number of slice group map units in the picture. pic_size_in_map_units_minus1 shall be equal to PicSizeInMapUnits - 1.

slice_group_id[i **]** identifies a slice group of the i-th slice group map unit in raster scan order. The size of the slice_group_id[i] syntax element is Ceil(Log2(num_slice_groups_minus1 + 1)) bits. The value of slice_group_id[i] shall be in the range of 0 to num_slice_groups_minus1, inclusive.

num_ref_idx_l0_active_minus1 specifies the maximum reference index for reference picture list 0 that shall be used to decode each slice of the picture in which list 0 prediction is used when num_ref_idx_active_override_flag is equal to 0 for the slice. When MbaffFrameFlag is equal to 1, num_ref_idx_l0_active_minus1 is the maximum index value for the decoding of frame macroblocks and 2 * num_ref_idx_l0_active_minus1 + 1 is the maximum index value for the decoding of field macroblocks. The value of num_ref_idx_l0_active_minus1 shall be in the range of 0 to 31, inclusive.

num_ref_idx_l1_active_minus1 has the same semantics as num_ref_idx_l0_active_minus1 with l0 and list 0 replaced by l1 and list 1, respectively.

weighted_pred_flag equal to 0 specifies that weighted prediction shall not be applied to P and SP slices. weighted_pred_flag equal to 1 specifies that weighted prediction shall be applied to P and SP slices.

weighted_bipred_idc equal to 0 specifies that the default weighted prediction shall be applied to B slices. weighted_bipred_idc equal to 1 specifies that explicit weighted prediction shall be applied to B slices. weighted_bipred_idc equal to 2 specifies that implicit weighted prediction shall be applied to B slices. The value of weighted_bipred_idc shall be in the range of 0 to 2, inclusive.

pic_init_qp_minus26 specifies the initial value minus 26 of $SliceQP_Y$ for each slice. The initial value is modified at the slice layer when a non-zero value of slice_qp_delta is decoded, and is modified further when a non-zero value of mb_qp_delta is decoded at the macroblock layer. The value of pic_init_qp_minus26 shall be in the range of $-(26 + QpBdOffset_Y)$ to +25, inclusive.

pic_init_qs_minus26 specifies the initial value minus 26 of $SliceQS_Y$ for all macroblocks in SP or SI slices. The initial value is modified at the slice layer when a non-zero value of slice_qs_delta is decoded. The value of pic_init_qs_minus26 shall be in the range of -26 to +25, inclusive.

chroma_qp_index_offset specifies the offset that shall be added to QP_Y and QS_Y for addressing the table of QP_C values for the Cb chroma component. The value of chroma_qp_index_offset shall be in the range of -12 to +12, inclusive.

deblocking_filter_control_present_flag equal to 1 specifies that a set of syntax elements controlling the characteristics of the deblocking filter is present in the slice header. deblocking_filter_control_present_flag equal to 0 specifies that the set of syntax elements controlling the characteristics of the deblocking filter is not present in the slice headers and their inferred values are in effect.

constrained_intra_pred_flag equal to 0 specifies that intra prediction allows usage of residual data and decoded samples of neighbouring macroblocks coded using Inter macroblock prediction modes for the prediction of macroblocks coded using Intra macroblock prediction modes. constrained_intra_pred_flag equal to 1 specifies constrained intra prediction, in which case prediction of macroblocks coded using Intra macroblock prediction modes only uses residual data and decoded samples from I or SI macroblock types.

redundant_pic_cnt_present_flag equal to 0 specifies that the redundant_pic_cnt syntax element is not present in slice headers, data partitions B, and data partitions C that refer (either directly or by association with a corresponding data partition A) to the picture parameter set. redundant_pic_cnt_present_flag equal to 1 specifies that the redundant_pic_cnt syntax element is present in all slice headers, data partitions B, and data partitions C that refer (either directly or by association with a corresponding data partition A) to the picture parameter set.

transform_8x8_mode_flag equal to 1 specifies that the 8x8 transform decoding process may be in use (see subclause 8.5). transform_8x8_mode_flag equal to 0 specifies that the 8x8 transform decoding process is not in use. When transform_8x8_mode_flag is not present, it shall be inferred to be 0.

pic_scaling_matrix_present_flag equal to 1 specifies that parameters are present to modify the scaling lists specified in the sequence parameter set. pic_scaling_matrix_present_flag equal to 0 specifies that the scaling lists used for the picture shall be inferred to be equal to those specified by the sequence parameter set. When pic_scaling_matrix_present_flag is not present, it shall be inferred to be equal to 0.

pic_scaling_list_present_flag[i **]** equal to 1 specifies that the scaling list syntax structure is present to specify the scaling list for index i. pic_scaling_list_present_flag[i] equal to 0 specifies that the syntax structure for scaling list i is not present in the picture parameter set and that depending on the value of seq_scaling_matrix_present_flag, the following applies.

– If seq_scaling_matrix_present_flag is equal to 0, the scaling list fall-back rule set A as specified in Table 7-2 shall be used to derive the picture-level scaling list for index i.

– Otherwise (seq_scaling_matrix_present_flag is equal to 1), the scaling list fall-back rule set B as specified in Table 7-2 shall be used to derive the picture-level scaling list for index i.

second_chroma_qp_index_offset specifies the offset that shall be added to QP_Y and QS_Y for addressing the table of QP_C values for the Cr chroma component. The value of second_chroma_qp_index_offset shall be in the range of -12 to +12, inclusive.

When second_chroma_qp_index_offset is not present, it shall be inferred to be equal to chroma_qp_index_offset.

7.4.2.3 Supplemental enhancement information RBSP semantics

Supplemental Enhancement Information (SEI) contains information that is not necessary to decode the samples of coded pictures from VCL NAL units.

7.4.2.3.1 Supplemental enhancement information message semantics

An SEI NAL unit contains one or more SEI messages. Each SEI message consists of the variables specifying the type payloadType and size payloadSize of the SEI payload. SEI payloads are specified in Annex D. The derived SEI payload size payloadSize is specified in bytes and shall be equal to the number of bytes in the SEI payload.

ff_byte is a byte equal to 0xFF identifying a need for a longer representation of the syntax structure that it is used within.

last_payload_type_byte is the last byte of the payload type of an SEI message.

last_payload_size_byte is the last byte of the size of an SEI message.

7.4.2.4 Access unit delimiter RBSP semantics

The access unit delimiter may be used to indicate the type of slices present in a primary coded picture and to simplify the detection of the boundary between access units. There is no normative decoding process associated with the access unit delimiter.

primary_pic_type indicates that the slice_type values for all slices of the primary coded picture are members of the set listed in Table 7-5 for the given value of primary_pic_type.

Table 7-5 – Meaning of primary_pic_type

primary_pic_type	slice_type values that may be present in the primary coded picture
0	I
1	I, P
2	I, P, B
3	SI
4	SI, SP
5	I, SI
6	I, SI, P, SP
7	I, SI, P, SP, B

7.4.2.5 End of sequence RBSP semantics

The end of sequence RBSP specifies that the next subsequent access unit in the bitstream in decoding order (if any) shall be an IDR access unit. The syntax content of the SODB and RBSP for the end of sequence RBSP are empty. No normative decoding process is specified for an end of sequence RBSP.

7.4.2.6 End of stream RBSP semantics

The end of stream RBSP indicates that no additional NAL units shall be present in the bitstream that are subsequent to the end of stream RBSP in decoding order. The syntax content of the SODB and RBSP for the end of stream RBSP are empty. No normative decoding process is specified for an end of stream RBSP.

7.4.2.7 Filler data RBSP semantics

The filler data RBSP contains bytes whose value shall be equal to 0xFF. No normative decoding process is specified for a filler data RBSP.

ff_byte is a byte equal to 0xFF.

7.4.2.8 Slice layer without partitioning RBSP semantics

The slice layer without partitioning RBSP consists of a slice header and slice data.

7.4.2.9 Slice data partition RBSP semantics

7.4.2.9.1 Slice data partition A RBSP semantics

When slice data partitioning is in use, the coded data for a single slice is divided into three separate partitions. Partition A contains all syntax elements of category 2.

Category 2 syntax elements include all syntax elements in the slice header and slice data syntax structures other than the syntax elements in the residual( ) syntax structure.

slice_id identifies the slice associated with the data partition. Each slice shall have a unique slice_id value within the coded picture that contains the slice. When arbitrary slice order is not allowed as specified in Annex A, the first slice of a coded picture, in decoding order, shall have slice_id equal to 0 and the value of slice_id shall be incremented by one for each subsequent slice of the coded picture in decoding order.

The range of slice_id is specified as follows.

– If MbaffFrameFlag is equal to 0, slice_id shall be in the range of 0 to PicSizeInMbs - 1, inclusive.

– Otherwise (MbaffFrameFlag is equal to 1), slice_id shall be in the range of 0 to PicSizeInMbs / 2 - 1, inclusive.

7.4.2.9.2 Slice data partition B RBSP semantics

When slice data partitioning is in use, the coded data for a single slice is divided into one to three separate partitions. Slice data partition B contains all syntax elements of category 3.

Category 3 syntax elements include all syntax elements in the residual( ) syntax structure and in syntax structures used within that syntax structure for collective macroblock types I and SI as specified in Table 7-10.

slice_id has the same semantics as specified in subclause 7.4.2.9.1.

redundant_pic_cnt shall be equal to 0 for slices and slice data partitions belonging to the primary coded picture. The redundant_pic_cnt shall be greater than 0 for coded slices and coded slice data partitions in redundant coded pictures. When redundant_pic_cnt is not present, its value shall be inferred to be equal to 0. The value of redundant_pic_cnt shall be in the range of 0 to 127, inclusive.

The presence of a slice data partition B RBSP is specified as follows.

– If the syntax elements of a slice data partition A RBSP indicate the presence of any syntax elements of category 3 in the slice data for a slice, a slice data partition B RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

– Otherwise (the syntax elements of a slice data partition A RBSP do not indicate the presence of any syntax elements of category 3 in the slice data for a slice), no slice data partition B RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

7.4.2.9.3 Slice data partition C RBSP semantics

When slice data partitioning is in use, the coded data for a single slice is divided into three separate partitions. Slice data partition C contains all syntax elements of category 4.

Category 4 syntax elements include all syntax elements in the residual( ) syntax structure and in syntax structures used within that syntax structure for collective macroblock types P and B as specified in Table 7-10.

slice_id has the same semantics as specified in subclause 7.4.2.9.1.

redundant_pic_cnt has the same semantics as specified in subclause 7.4.2.9.2.

The presence of a slice data partition C RBSP is specified as follows.

– If the syntax elements of a slice data partition A RBSP indicate the presence of any syntax elements of category 4 in the slice data for a slice, a slice data partition C RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

– Otherwise (the syntax elements of a slice data partition A RBSP do not indicate the presence of any syntax elements of category 4 in the slice data for a slice), no slice data partition C RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

7.4.2.10 RBSP slice trailing bits semantics

cabac_zero_word is a byte-aligned sequence of two bytes equal to 0x0000.

Let NumBytesInVclNALunits be the sum of the values of NumBytesInNALunit for all VCL NAL units of a coded picture.

Let BinCountsInNALunits be the number of times that the parsing process function DecodeBin( ), specified in subclause 9.3.3.2, is invoked to decode the contents of all VCL NAL units of a coded picture. When entropy_coding_mode_flag is equal to 1, BinCountsInNALunits shall not exceed (32 ÷ 3) * NumBytesInVclNALunits + (RawMbBits * PicSizeInMbs) ÷ 32.

NOTE – The constraint on the maximum number of bins resulting from decoding the contents of the slice layer NAL units can be met by inserting a number of cabac_zero_word syntax elements to increase the value of NumBytesInVclNALunits. Each cabac_zero_word is represented in a NAL unit by the three-byte sequence 0x000003 (as a result of the constraints on NAL unit contents that result in requiring inclusion of an emulation_prevention_three_byte for each cabac_zero_word).

7.4.2.11 RBSP trailing bits semantics

rbsp_stop_one_bit shall be equal to 1.

rbsp_alignment_zero_bit shall be equal to 0.

7.4.3 Slice header semantics

When present, the value of the slice header syntax elements pic_parameter_set_id, frame_num, field_pic_flag, bottom_field_flag, idr_pic_id, pic_order_cnt_lsb, delta_pic_order_cnt_bottom, delta_pic_order_cnt[0], delta_pic_order_cnt[1], sp_for_switch_flag, and slice_group_change_cycle shall be the same in all slice headers of a coded picture.

first_mb_in_slice specifies the address of the first macroblock in the slice. When arbitrary slice order is not allowed as specified in Annex A, the value of first_mb_in_slice shall not be less than the value of first_mb_in_slice for any other slice of the current picture that precedes the current slice in decoding order.

The first macroblock address of the slice is derived as follows.

– If MbaffFrameFlag is equal to 0, first_mb_in_slice is the macroblock address of the first macroblock in the slice, and first_mb_in_slice shall be in the range of 0 to PicSizeInMbs - 1, inclusive.

– Otherwise (MbaffFrameFlag is equal to 1), first_mb_in_slice * 2 is the macroblock address of the first macroblock in the slice, which is the top macroblock of the first macroblock pair in the slice, and first_mb_in_slice shall be in the range of 0 to PicSizeInMbs / 2 - 1, inclusive.

slice_type specifies the coding type of the slice according to Table 7-6.

Table 7-6 – Name association to slice_type

slice_type	Name of slice_type
0	P (P slice)
1	B (B slice)
2	I (I slice)
3	SP (SP slice)
4	SI (SI slice)
5	P (P slice)
6	B (B slice)
7	I (I slice)
8	SP (SP slice)
9	SI (SI slice)

slice_type values in the range 5..9 specify, in addition to the coding type of the current slice, that all other slices of the current coded picture shall have a value of slice_type equal to the current value of slice_type or equal to the current value of slice_type – 5.

When nal_unit_type is equal to 5 (IDR picture), slice_type shall be equal to 2, 4, 7, or 9.

When num_ref_frames is equal to 0, slice_type shall be equal to 2, 4, 7, or 9.

pic_parameter_set_id specifies the picture parameter set in use. The value of pic_parameter_set_id shall be in the range of 0 to 255, inclusive.

frame_num is used as an identifier for pictures and shall be represented by log2_max_frame_num_minus4 + 4 bits in the bitstream. frame_num is constrained as follows:

The variable PrevRefFrameNum is derived as follows.

– If the current picture is an IDR picture, PrevRefFrameNum is set equal to 0.

– Otherwise (the current picture is not an IDR picture), PrevRefFrameNum is set as follows.

  – If the decoding process for gaps in frame_num specified in subclause 8.2.5.2 was invoked by the decoding process for an access unit that contained a non-reference picture that followed the previous access unit in decoding order that contained a reference picture, PrevRefFrameNum is set equal to the value of frame_num for the last of the "non-existing" reference frames inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2.

  – Otherwise, PrevRefFrameNum is set equal to the value of frame_num for the previous access unit in decoding order that contained a reference picture.

The value of frame_num is constrained as follows.

– If the current picture is an IDR picture, frame_num shall be equal to 0.

– Otherwise (the current picture is not an IDR picture), referring to the primary coded picture in the previous access unit in decoding order that contains a reference picture as the preceding reference picture, the value of frame_num for the current picture shall not be equal to PrevRefFrameNum unless all of the following three conditions are true.

  – the current picture and the preceding reference picture belong to consecutive access units in decoding order

  – the current picture and the preceding reference picture are reference fields having opposite parity

  – one or more of the following conditions is true

    – the preceding reference picture is an IDR picture

    – the preceding reference picture includes a memory_management_control_operation syntax element equal to 5

      NOTE 1 – When the preceding reference picture includes a memory_management_control_operation syntax element equal to 5, PrevRefFrameNum is equal to 0.

    – there is a primary coded picture that precedes the preceding reference picture and the primary coded picture that precedes the preceding reference picture does not have frame_num equal to PrevRefFrameNum

    – there is a primary coded picture that precedes the preceding reference picture and the primary coded picture that precedes the preceding reference picture is not a reference picture

When the value of frame_num is not equal to PrevRefFrameNum, the following applies.

– There shall not be any previous field or frame in decoding order that is currently marked as "used for short-term reference" that has a value of frame_num equal to any value taken on by the variable UnusedShortTermFrameNum in the following:

```
UnusedShortTermFrameNum = ( PrevRefFrameNum + 1 ) % MaxFrameNum
while( UnusedShortTermFrameNum  !=  frame_num )                    (7-21)
    UnusedShortTermFrameNum = ( UnusedShortTermFrameNum + 1 ) % MaxFrameNum
```

– The value of frame_num is constrained as follows.

  – If gaps_in_frame_num_value_allowed_flag is equal to 0, the value of frame_num for the current picture shall be equal to (PrevRefFrameNum + 1) % MaxFrameNum.

  – Otherwise (gaps_in_frame_num_value_allowed_flag is equal to 1), the following applies.

    – If frame_num is greater than PrevRefFrameNum, there shall not be any non-reference pictures in the bitstream that follow the previous reference picture and precede the current picture in decoding order in which either of the following conditions is true.

      – The value of frame_num for the non-reference picture is less than PrevRefFrameNum.

      – The value of frame_num for the non-reference picture is greater than the value of frame_num for the current picture.

– Otherwise (frame_num is less than PrevRefFrameNum), there shall not be any non-reference pictures in the bitstream that follow the previous reference picture and precede the current picture in decoding order in which both of the following conditions are true.
  – The value of frame_num for the non-reference picture is less than PrevRefFrameNum.
  – The value of frame_num for the non-reference picture is greater than the value of frame_num for the current picture.

A picture including a memory_management_control_operation equal to 5 shall have frame_num constraints as described above and, after the decoding of the current picture and the processing of the memory management control operations, the picture shall be inferred to have had frame_num equal to 0 for all subsequent use in the decoding process, except as specified in subclause 7.4.1.2.4.

NOTE 2 – When the primary coded picture is not an IDR picture and does not contain memory_management_control_operation syntax element equal to 5, the value of frame_num of a corresponding redundant coded picture is the same as the value of frame_num in the primary coded picture. Alternatively, the redundant coded picture includes a memory_management_control_operation syntax element equal to 5 and the corresponding primary coded picture is an IDR picture.

field_pic_flag equal to 1 specifies that the slice is a slice of a coded field. field_pic_flag equal to 0 specifies that the slice is a slice of a coded frame. When field_pic_flag is not present it shall be inferred to be equal to 0.

The variable MbaffFrameFlag is derived as follows.

MbaffFrameFlag = (mb_adaptive_frame_field_flag && !field_pic_flag) (7-22)

The variable for the picture height in units of macroblocks is derived as follows

PicHeightInMbs = FrameHeightInMbs / (1 + field_pic_flag) (7-23)

The variable for picture height for the luma component is derived as follows

$PicHeightInSamples_L$ = PicHeightInMbs * 16 (7-24)

The variable for picture height for the chroma component is derived as follows

$PicHeightInSamples_C$ = PicHeightInMbs * MbHeightC (7-25)

The variable PicSizeInMbs for the current picture is derived according to:

PicSizeInMbs = PicWidthInMbs * PicHeightInMbs (7-26)

The variable MaxPicNum is derived as follows.

– If field_pic_flag is equal to 0, MaxPicNum is set equal to MaxFrameNum.

– Otherwise (field_pic_flag is equal to 1), MaxPicNum is set equal to 2*MaxFrameNum.

The variable CurrPicNum is derived as follows.

– If field_pic_flag is equal to 0, CurrPicNum is set equal to frame_num.

– Otherwise (field_pic_flag is equal to 1), CurrPicNum is set equal to 2 * frame_num + 1.

bottom_field_flag equal to 1 specifies that the slice is part of a coded bottom field. bottom_field_flag equal to 0 specifies that the picture is a coded top field. When this syntax element is not present for the current slice, it shall be inferred to be equal to 0.

idr_pic_id identifies an IDR picture. The values of idr_pic_id in all the slices of an IDR picture shall remain unchanged. When two consecutive access units in decoding order are both IDR access units, the value of idr_pic_id in the slices of the first such IDR access unit shall differ from the idr_pic_id in the second such IDR access unit. The value of idr_pic_id shall be in the range of 0 to 65535, inclusive.

pic_order_cnt_lsb specifies the picture order count modulo MaxPicOrderCntLsb for the top field of a coded frame or for a coded field. The size of the pic_order_cnt_lsb syntax element is log2_max_pic_order_cnt_lsb_minus4 + 4 bits. The value of the pic_order_cnt_lsb shall be in the range of 0 to MaxPicOrderCntLsb – 1, inclusive.

delta_pic_order_cnt_bottom specifies the picture order count difference between the bottom field and the top field of a coded frame as follows.

– If the current picture includes a memory_management_control_operation equal to 5, the value of delta_pic_order_cnt_bottom shall be in the range of (1 – MaxPicOrderCntLsb) to 2^{31} - 1, inclusive.

– Otherwise (the current picture does not include a memory_management_control_operation equal to 5), the value of delta_pic_order_cnt_bottom shall be in the range of -2^{31} to 2^{31} - 1, inclusive.

When this syntax element is not present in the bitstream for the current slice, it shall be inferred to be equal to 0.

delta_pic_order_cnt[0 **]** specifies the picture order count difference from the expected picture order count for the top field of a coded frame or for a coded field as specified in subclause 8.2.1. The value of delta_pic_order_cnt[0] shall be in the range of -2^{31} to 2^{31} - 1, inclusive. When this syntax element is not present in the bitstream for the current slice, it shall be inferred to be equal to 0.

delta_pic_order_cnt[1 **]** specifies the picture order count difference from the expected picture order count for the bottom field of a coded frame specified in subclause 8.2.1. The value of delta_pic_order_cnt[1] shall be in the range of -2^{31} to 2^{31} - 1, inclusive. When this syntax element is not present in the bitstream for the current slice, it shall be inferred to be equal to 0.

redundant_pic_cnt shall be equal to 0 for slices and slice data partitions belonging to the primary coded picture. The value of redundant_pic_cnt shall be greater than 0 for coded slices or coded slice data partitions of a redundant coded picture. When redundant_pic_cnt is not present in the bitstream, its value shall be inferred to be equal to 0. The value of redundant_pic_cnt shall be in the range of 0 to 127, inclusive.

NOTE 3 – Any area of the decoded primary picture and the corresponding area that would result from application of the decoding process specified in clause 8 for any redundant picture in the same access unit should be visually similar in appearance.

The value of pic_parameter_set_id in a coded slice or coded slice data partition of a redundant coded picture shall be such that the value of pic_order_present_flag in the picture parameter set in use in a redundant coded picture is equal to the value of pic_order_present_flag in the picture parameter set in use in the corresponding primary coded picture.

When present in the primary coded picture and any redundant coded picture, the following syntax elements shall have the same value: field_pic_flag, bottom_field_flag, and idr_pic_id.

When the value of nal_ref_idc in one VCL NAL unit of an access unit is equal to 0, the value of nal_ref_idc in all other VCL NAL units of the same access unit shall be equal to 0.

NOTE 4 – The above constraint also has the following implications. If the value of nal_ref_idc for the VCL NAL units of the primary coded picture is equal to 0, the value of nal_ref_idc for the VCL NAL units of any corresponding redundant coded picture are equal to 0; otherwise (the value of nal_ref_idc for the VCL NAL units of the primary coded picture is greater than 0), the value of nal_ref_idc for the VCL NAL units of any corresponding redundant coded picture are also greater than 0.

The marking status of reference pictures and the value of frame_num after the decoded reference picture marking process as specified in subclause 8.2.5 is invoked for the primary coded picture or any redundant coded picture of the same access unit shall be identical regardless whether the primary coded picture or any redundant coded picture (instead of the primary coded picture) of the access unit would be decoded.

NOTE 5 – The above constraint also has the following implications.

If a primary coded picture is not an IDR picture, the contents of the dec_ref_pic_marking( ) syntax structure must be identical in all slice headers of the primary coded picture and all redundant coded pictures corresponding to the primary coded picture.

Otherwise (a primary coded picture is an IDR picture), the following applies.

If a redundant coded picture corresponding to the primary coded picture is an IDR picture, the contents of the dec_ref_pic_marking( ) syntax structure must be identical in all slice headers of the primary coded picture and the redundant coded picture corresponding to the primary coded picture.

Otherwise (a redundant picture corresponding to the primary coded picture is not an IDR picture), all slice headers of the redundant picture must contain a dec_ref_pic_marking syntax( ) structure including a memory_management_control_operation syntax element equal to 5, and the following applies.

If the value of long_term_reference_flag in the primary coded picture is equal to 0, the dec_ref_pic_marking syntax structure of the redundant coded picture must not include a memory_management_control_operation syntax element equal to 6.

Otherwise (the value of long_term_reference_flag in the primary coded picture is equal to 1), the dec_ref_pic_marking syntax structure of the redundant coded picture must include memory_management_control_operation syntax elements equal to 5, 4, and 6 in decoding order, and the value of max_long_term_frame_idx_plus1 must be equal to 1, and the value of long_term_frame_idx must be equal to 0.

The values of TopFieldOrderCnt and BottomFieldOrderCnt (if applicable) that result after completion of the decoding process for any redundant coded picture or the primary coded picture of the same access unit shall be identical regardless whether the primary coded picture or any redundant coded picture (instead of the primary coded picture) of the access unit would be decoded.

There is no required decoding process for a coded slice or coded slice data partition of a redundant coded picture. When the redundant_pic_cnt in the slice header of a coded slice is greater than 0, the decoder may discard the coded slice. However, a coded slice or coded slice data partition of any redundant coded picture shall obey the same constraints as a coded slice or coded slice data partition of a primary picture.

NOTE 6 – When some of the samples in the decoded primary picture cannot be correctly decoded due to errors or losses in transmission of the sequence and a coded redundant slice can be correctly decoded, the decoder should replace the samples of the decoded primary picture with the corresponding samples of the decoded redundant slice. When more than one redundant slice covers the relevant region of the primary picture, the redundant slice having the lowest value of redundant_pic_cnt should be used.

Redundant slices and slice data partitions having the same value of redundant_pic_cnt belong to the same redundant picture. Decoded slices within the same redundant picture need not cover the entire picture area and shall not overlap.

direct_spatial_mv_pred_flag specifies the method used in the decoding process to derive motion vectors and reference indices for inter prediction as follows.

– If direct_spatial_mv_pred_flag is equal to 1, the derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8 in subclause 8.4.1.2 shall use spatial direct mode prediction as specified in subclause 8.4.1.2.2.

– Otherwise (direct_spatial_mv_pred_flag is equal to 0), the derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8 in subclause 8.4.1.2 shall use temporal direct mode prediction as specified in subclause 8.4.1.2.3.

num_ref_idx_active_override_flag equal to 0 specifies that the values of the syntax elements num_ref_idx_l0_active_minus1 and num_ref_idx_l1_active_minus1 specified in the referred picture parameter set are in effect. num_ref_idx_active_override_flag equal to 1 specifies that the num_ref_idx_l0_active_minus1 and num_ref_idx_l1_active_minus1 specified in the referred picture parameter set are overridden for the current slice (and only for the current slice) by the following values in the slice header.

When the current slice is a P, SP, or B slice and field_pic_flag is equal to 0 and the value of num_ref_idx_l0_active_minus1 in the picture parameter set exceeds 15, num_ref_idx_active_override_flag shall be equal to 1.

When the current slice is a B slice and field_pic_flag is equal to 0 and the value of num_ref_idx_l1_active_minus1 in the picture parameter set exceeds 15, num_ref_idx_active_override_flag shall be equal to 1.

num_ref_idx_l0_active_minus1 specifies the maximum reference index for reference picture list 0 that shall be used to decode the slice.

The range of num_ref_idx_l0_active_minus1 is specified as follows.

– If field_pic_flag is equal to 0, num_ref_idx_l0_active_minus1 shall be in the range of 0 to 15, inclusive. When MbaffFrameFlag is equal to 1, num_ref_idx_l0_active_minus1 is the maximum index value for the decoding of frame macroblocks and 2 * num_ref_idx_l0_active_minus1 + 1 is the maximum index value for the decoding of field macroblocks.

– Otherwise (field_pic_flag is equal to 1), num_ref_idx_l0_active_minus1 shall be in the range of 0 to 31, inclusive.

num_ref_idx_l1_active_minus1 has the same semantics as num_ref_idx_l0_active_minus1 with l0 and list 0 replaced by l1 and list 1, respectively.

cabac_init_idc specifies the index for determining the initialisation table used in the initialisation process for context variables. The value of cabac_init_idc shall be in the range of 0 to 2, inclusive.

slice_qp_delta specifies the initial value of QP_Y to be used for all the macroblocks in the slice until modified by the value of mb_qp_delta in the macroblock layer. The initial QP_Y quantisation parameter for the slice is computed as:

$$SliceQP_Y = 26 + pic\_init\_qp\_minus26 + slice\_qp\_delta \quad (7\text{-}27)$$

The value of slice_qp_delta shall be limited such that $SliceQP_Y$ is in the range of $-QpBdOffset_Y$ to +51, inclusive.

sp_for_switch_flag specifies the decoding process to be used to decode P macroblocks in an SP slice as follows.

– If sp_for_switch_flag is equal to 0, the P macroblocks in the SP slice shall be decoded using the SP decoding process for non-switching pictures as specified in subclause 8.6.1.

– Otherwise (sp_for_switch_flag is equal to 1), the P macroblocks in the SP slice shall be decoded using the SP and SI decoding process for switching pictures as specified in subclause 8.6.2.

slice_qs_delta specifies the value of QS_Y for all the macroblocks in SP and SI slices. The QS_Y quantisation parameter for the slice is computed as:

$$QS_Y = 26 + pic\_init\_qs\_minus26 + slice\_qs\_delta \quad (7\text{-}28)$$

The value of slice_qs_delta shall be limited such that QS_Y is in the range of 0 to 51, inclusive. This value of QS_Y is used for the decoding of all macroblocks in SI slices with mb_type equal to SI and all macroblocks in SP slices with prediction mode equal to inter.

disable_deblocking_filter_idc specifies whether the operation of the deblocking filter shall be disabled across some block edges of the slice and specifies for which edges the filtering is disabled. When disable_deblocking_filter_idc is not present in the slice header, the value of disable_deblocking_filter_idc shall be inferred to be equal to 0.

The value of disable_deblocking_filter_idc shall be in the range of 0 to 2, inclusive.

slice_alpha_c0_offset_div2 specifies the offset used in accessing the α and t_{C0} deblocking filter tables for filtering operations controlled by the macroblocks within the slice. From this value, the offset that shall be applied when addressing these tables shall be computed as:

$$FilterOffsetA = slice\_alpha\_c0\_offset\_div2 << 1 \quad (7\text{-}29)$$

The value of slice_alpha_c0_offset_div2 shall be in the range of -6 to +6, inclusive. When slice_alpha_c0_offset_div2 is not present in the slice header, the value of slice_alpha_c0_offset_div2 shall be inferred to be equal to 0.

slice_beta_offset_div2 specifies the offset used in accessing the β deblocking filter table for filtering operations controlled by the macroblocks within the slice. From this value, the offset that is applied when addressing the β table of the deblocking filter shall be computed as:

$$FilterOffsetB = slice\_beta\_offset\_div2 << 1 \quad (7\text{-}30)$$

The value of slice_beta_offset_div2 shall be in the range of -6 to +6, inclusive. When slice_beta_offset_div2 is not present in the slice header the value of slice_beta_offset_div2 shall be inferred to be equal to 0.

slice_group_change_cycle is used to derive the number of slice group map units in slice group 0 when slice_group_map_type is equal to 3, 4, or 5, as specified by

$$MapUnitsInSliceGroup0 = Min(slice\_group\_change\_cycle * SliceGroupChangeRate, PicSizeInMapUnits) \quad (7\text{-}31)$$

The value of slice_group_change_cycle is represented in the bitstream by the following number of bits

$$Ceil(Log2(PicSizeInMapUnits \div SliceGroupChangeRate + 1)) \quad (7\text{-}32)$$

The value of slice_group_change_cycle shall be in the range of 0 to Ceil(PicSizeInMapUnits÷SliceGroupChangeRate), inclusive.

7.4.3.1 Reference picture list reordering semantics

The syntax elements reordering_of_pic_nums_idc, abs_diff_pic_num_minus1, and long_term_pic_num specify the change from the initial reference picture lists to the reference picture lists to be used for decoding the slice.

ref_pic_list_reordering_flag_l0 equal to 1 specifies that the syntax element reordering_of_pic_nums_idc is present for specifying reference picture list 0. ref_pic_list_reordering_flag_l0 equal to 0 specifies that this syntax element is not present.

When ref_pic_list_reordering_flag_l0 is equal to 1, the number of times that reordering_of_pic_nums_idc is not equal to 3 following ref_pic_list_reordering_flag_l0 shall not exceed num_ref_idx_l0_active_minus1 + 1.

When RefPicList0[num_ref_idx_l0_active_minus1] in the initial reference picture list produced as specified in subclause 8.2.4.2 is equal to "no reference picture", ref_pic_list_reordering_flag_l0 shall be equal to 1 and reordering_of_pic_nums_idc shall not be equal to 3 until RefPicList0[num_ref_idx_l0_active_minus1] in the reordered list produced as specified in subclause 8.2.4.3 is not equal to "no reference picture".

ref_pic_list_reordering_flag_l1 equal to 1 specifies that the syntax element reordering_of_pic_nums_idc is present for specifying reference picture list 1. ref_pic_list_reordering_flag_l1 equal to 0 specifies that this syntax element is not present.

When ref_pic_list_reordering_flag_l1 is equal to 1, the number of times that reordering_of_pic_nums_idc is not equal to 3 following ref_pic_list_reordering_flag_l1 shall not exceed num_ref_idx_l1_active_minus1 + 1.

When decoding a B slice and RefPicList1[num_ref_idx_l1_active_minus1] in the initial reference picture list produced as specified in subclause 8.2.4.2 is equal to "no reference picture", ref_pic_list_reordering_flag_l1 shall be equal to 1 and reordering_of_pic_nums_idc shall not be equal to 3 until RefPicList1[num_ref_idx_l1_active_minus1] in the reordered list produced as specified in subclause 8.2.4.3 is not equal to "no reference picture".

reordering_of_pic_nums_idc together with abs_diff_pic_num_minus1 or long_term_pic_num specifies which of the reference pictures are re-mapped. The values of reordering_of_pic_nums_idc are specified in Table 7-7. The value of the first reordering_of_pic_nums_idc that follows immediately after ref_pic_list_reordering_flag_l0 or ref_pic_list_reordering_flag_l1 shall not be equal to 3.

Table 7-7 – reordering_of_pic_nums_idc operations for reordering of reference picture lists

reordering_of_pic_nums_idc	Reordering specified
0	abs_diff_pic_num_minus1 is present and corresponds to a difference to subtract from a picture number prediction value
1	abs_diff_pic_num_minus1 is present and corresponds to a difference to add to a picture number prediction value
2	long_term_pic_num is present and specifies the long-term picture number for a reference picture
3	End loop for reordering of the initial reference picture list

abs_diff_pic_num_minus1 plus 1 specifies the absolute difference between the picture number of the picture being moved to the current index in the list and the picture number prediction value. abs_diff_pic_num_minus1 shall be in the range of 0 to MaxPicNum – 1. The allowed values of abs_diff_pic_num_minus1 are further restricted as specified in subclause 8.2.4.3.1.

long_term_pic_num specifies the long-term picture number of the picture being moved to the current index in the list. When decoding a coded frame, long_term_pic_num shall be equal to a LongTermPicNum assigned to one of the reference frames or complementary reference field pairs marked as "used for long-term reference". When decoding a coded field, long_term_pic_num shall be equal to a LongTermPicNum assigned to one of the reference fields marked as "used for long-term reference".

7.4.3.2 Prediction weight table semantics

luma_log2_weight_denom is the base 2 logarithm of the denominator for all luma weighting factors. The value of luma_log2_weight_denom shall be in the range of 0 to 7, inclusive.

chroma_log2_weight_denom is the base 2 logarithm of the denominator for all chroma weighting factors. The value of chroma_log2_weight_denom shall be in the range of 0 to 7, inclusive.

luma_weight_l0_flag equal to 1 specifies that weighting factors for the luma component of list 0 prediction are present. luma_weight_l0_flag equal to 0 specifies that these weighting factors are not present.

luma_weight_l0[i **]** is the weighting factor applied to the luma prediction value for list 0 prediction using RefPicList0[i]. When luma_weight_l0_flag is equal to 1, the value of luma_weight_l0[i] shall be in the range of –128 to 127, inclusive. When luma_weight_l0_flag is equal to 0, luma_weight_l0[i] shall be inferred to be equal to $2^{luma\_log2\_weight\_denom}$ for RefPicList0[i].

luma_offset_l0[i **]** is the additive offset applied to the luma prediction value for list 0 prediction using RefPicList0[i]. The value of luma_offset_l0[i] shall be in the range of –128 to 127, inclusive. When luma_weight_l0_flag is equal to 0, luma_offset_l0[i] shall be inferred as equal to 0 for RefPicList0[i].

chroma_weight_l0_flag equal to 1 specifies that weighting factors for the chroma prediction values of list 0 prediction are present. chroma_weight_l0_flag equal to 0 specifies that these weighting factors are not present.

chroma_weight_l0[i **][** j **]** is the weighting factor applied to the chroma prediction values for list 0 prediction using RefPicList0[i] with j equal to 0 for Cb and j equal to 1 for Cr. When chroma_weight_l0_flag is equal to 1, the value of chroma_weight_l0[i][j] shall be in the range of –128 to 127, inclusive. When chroma_weight_l0_flag is equal to 0**,** chroma_weight_l0[i][j] shall be inferred to be equal to $2^{\text{chroma\_log2\_weight\_denom}}$ for RefPicList0[i].

chroma_offset_l0[i **][** j **]** is the additive offset applied to the chroma prediction values for list 0 prediction using RefPicList0[i] with j equal to 0 for Cb and j equal to 1 for Cr. The value of chroma_offset_l0[i][j] shall be in the range of -128 to 127, inclusive. When chroma_weight_l0_flag is equal to 0**,** chroma_offset_l0[i][j] shall be inferred to be equal to 0 for RefPicList0[i].

luma_weight_l1_flag, luma_weight_l1, **luma_offset_l1**, **chroma_weight_l1_flag**, **chroma_weight_l1**, **chroma_offset_l1** have the same semantics as luma_weight_l0_flag, luma_weight_l0, luma_offset_l0, chroma_weight_l0_flag, chroma_weight_l0, chroma_offset_l0, respectively, with l0, list 0, and List0 replaced by l1, list 1, and List1, respectively.

7.4.3.3 Decoded reference picture marking semantics

The syntax elements no_output_of_prior_pics_flag, long_term_reference_flag, adaptive_ref_pic_marking_mode_flag, memory_management_control_operation, difference_of_pic_nums_minus1, long_term_frame_idx, long_term_pic_num, and max_long_term_frame_idx_plus1 specify marking of the reference pictures.

The marking of a reference picture can be "unused for reference", "used for short-term reference", or "used for long-term reference", but only one among these three. When a reference picture is referred to as being marked as "used for reference", this collectively refers to the picture being marked as "used for short-term reference" or "used for long-term reference" (but not both). A reference picture that is marked as "used for short-term reference" is referred to as a short-term reference picture. A reference picture that is marked as "used for long-term reference" is referred to as a long-term reference picture.

The syntax element adaptive_ref_pic_marking_mode_flag and the content of the decoded reference picture marking syntax structure shall be identical for all coded slices of a coded picture.

The syntax category of the decoded reference picture marking syntax structure shall be inferred as follows.

– If the decoded reference picture marking syntax structure is in a slice header, the syntax category of the decoded reference picture marking syntax structure shall be inferred to be equal to 2.

– Otherwise (the decoded reference picture marking syntax structure is in a decoded reference picture marking repetition SEI message as specified in Annex D), the syntax category of the decoded reference picture marking syntax structure shall be inferred to be equal to 5.

no_output_of_prior_pics_flag specifies how the previously-decoded pictures in the decoded picture buffer are treated after decoding of an IDR picture. See Annex C. When the IDR picture is the first IDR picture in the bitstream, the value of no_output_of_prior_pics_flag has no effect on the decoding process. When the IDR picture is not the first IDR picture in the bitstream and the value of PicWidthInMbs, FrameHeightInMbs, or max_dec_frame_buffering derived from the active sequence parameter set is different from the value of PicWidthInMbs, FrameHeightInMbs, or max_dec_frame_buffering derived from the sequence parameter set active for the preceding sequence, no_output_of_prior_pics_flag equal to 1 may be inferred by the decoder, regardless of the actual value of no_output_of_prior_pics_flag.

long_term_reference_flag equal to 0 specifies that the MaxLongTermFrameIdx variable is set equal to “no long-term frame indices” and that the IDR picture is marked as “used for short-term reference”. long_term_reference_flag equal to 1 specifies that the MaxLongTermFrameIdx variable is set equal to 0 and that the current IDR picture is marked “used for long-term reference” and is assigned LongTermFrameIdx equal to 0. When num_ref_frames is equal to 0, long_term_reference_flag shall be equal to 0.

adaptive_ref_pic_marking_mode_flag selects the reference picture marking mode of the currently decoded picture as specified in Table 7-8. adaptive_ref_pic_marking_mode_flag shall be equal to 1 when the number of frames, complementary field pairs, and non-paired fields that are currently marked as "used for long-term reference" is equal to Max(num_ref_frames, 1).

Table 7-8 – Interpretation of adaptive_ref_pic_marking_mode_flag

adaptive_ref_pic_marking_mode_flag	Reference picture marking mode specified
0	Sliding window reference picture marking mode: A marking mode providing a first-in first-out mechanism for short-term reference pictures.
1	Adaptive reference picture marking mode: A reference picture marking mode providing syntax elements to specify marking of reference pictures as “unused for reference” and to assign long-term frame indices.

memory_management_control_operation specifies a control operation to be applied to affect the reference picture marking. The memory_management_control_operation syntax element is followed by data necessary for the operation specified by the value of memory_management_control_operation. The values and control operations associated with memory_management_control_operation are specified in Table 7-9. The memory_management_control_operation syntax elements are processed by the decoding process in the order in which they appear in the slice header, and the semantics constraints expressed for each memory_management_control_operation apply at the specific position in that order at which that individual memory_management_control_operation is processed.

For interpretation of memory_management_control_operation, the term reference picture is interpreted as follows.

– If the current picture is a frame, the term reference picture refers either to a reference frame or a complementary reference field pair.

– Otherwise (the current picture is a field), the term reference picture refers either to a reference field or a field of a reference frame.

memory_management_control_operation shall not be equal to 1 in a slice header unless the specified reference picture is marked as "used for short-term reference" when the memory_management_control_operation is processed by the decoding process.

memory_management_control_operation shall not be equal to 2 in a slice header unless the specified long-term picture number refers to a reference picture that is marked as "used for long-term reference" when the memory_management_control_operation is processed by the decoding process.

memory_management_control_operation shall not be equal to 3 in a slice header unless the specified reference picture is marked as "used for short-term reference" when the memory_management_control_operation is processed by the decoding process.

memory_management_control_operation shall not be equal to 3 or 6 if the value of the variable MaxLongTermFrameIdx is equal to "no long-term frame indices" when the memory_management_control_operation is processed by the decoding process.

Not more than one memory_management_control_operation equal to 4 shall be present in a slice header.

Not more than one memory_management_control_operation equal to 5 shall be present in a slice header.

Not more than one memory_management_control_operation equal to 6 shall be present in a slice header.

memory_management_control_operation shall not be equal to 5 in a slice header unless no memory_management_control_operation in the range of 1 to 3 is present in the same decoded reference picture marking syntax structure.

A memory_management_control_operation equal to 5 shall not follow a memory_management_control_operation equal to 6 in the same slice header.

When a memory_management_control_operation equal to 6 is present, any memory_management_control_operation equal to 2, 3, or 4 that follows the memory_management_control_operation equal to 6 within the same slice header shall not specify the current picture to be marked as "unused for reference".

NOTE 1 – These constraints prohibit any combination of multiple memory_management_control_operation syntax elements that would specify the current picture to be marked as "unused for reference". However, some other combinations of memory_management_control_operation syntax elements are permitted that may affect the marking status of other reference pictures more than once in the same slice header. In particular, it is permitted for a memory_management_control_operation equal to 3 that specifies a long-term frame index to be assigned to a particular short-term reference picture to be followed in the same slice header by a memory_management_control_operation equal to 2, 3, 4 or 6 that specifies the same reference picture to subsequently be marked as "unused for reference".

Table 7-9 – Memory management control operation (memory_management_control_operation) values

memory_management_control_operation	Memory Management Control Operation
0	End memory_management_control_operation syntax element loop
1	Mark a short-term reference picture as “unused for reference”
2	Mark a long-term reference picture as “unused for reference”
3	Mark a short-term reference picture as "used for long-term reference" and assign a long-term frame index to it
4	Specify the maximum long-term frame index and mark all long-term reference pictures having long-term frame indices greater than the maximum value as "unused for reference"
5	Mark all reference pictures as "unused for reference" and set the MaxLongTermFrameIdx variable to "no long-term frame indices"
6	Mark the current picture as "used for long-term reference" and assign a long-term frame index to it

When decoding a field and a memory_management_control_operation command equal to 3 is present that assigns a long-term frame index to a field that is part of a short-term reference frame or part of a short-term complementary reference field pair, another memory_management_control_operation command to assign the same long-term frame index to the other field of the same frame or complementary reference field pair shall be present in the same decoded reference picture marking syntax structure.

NOTE 2 – The above requirement must be fulfilled even when the field referred to by the memory_management_control_operation equal to 3 is subsequently marked as "unused for reference" (for example when a memory_management_control_operation equal to 2 is present in the same slice header that causes the field to be marked as "unused for reference").

When the first field (in decoding order) of a complementary reference field pair includes a long_term_reference_flag equal to 1 or a memory_management_control_operation command equal to 6, the decoded reference picture marking syntax structure for the other field of the complementary reference field pair shall contain a memory_management_control_operation command equal to 6 that assigns the same long-term frame index to the other field.

NOTE 3 – The above requirement must be fulfilled even when the first field of the complementary reference field pair is subsequently marked as "unused for reference" (for example, when a memory_management_control_operation equal to 2 is present in the slice header of the second field that causes the first field to be marked as "unused for reference").

difference_of_pic_nums_minus1 is used (with memory_management_control_operation equal to 3 or 1) to assign a long-term frame index to a short-term reference picture or to mark a short-term reference picture as “unused for reference”. When the associated memory_management_control_operation is processed by the decoding process, the resulting picture number derived from difference_of_pic_nums_minus1 shall be a picture number assigned to one of the reference pictures marked as "used for reference" and not previously assigned to a long-term frame index.

The resulting picture number is constrained as follows.

– If field_pic_flag is equal to 0, the resulting picture number shall be one of the set of picture numbers assigned to reference frames or complementary reference field pairs.

  NOTE 4 – When field_pic_flag is equal to 0, the resulting picture number must be a picture number assigned to a complementary reference field pair in which both fields are marked as "used for reference" or a frame in which both fields are marked as "used for reference". In particular, when field_pic_flag is equal to 0, the marking of a non-paired field or a frame in which a single field is marked as "used for reference" cannot be affected by a memory_management_control_operation equal to 1.

– Otherwise (field_pic_flag is equal to 1), the resulting picture number shall be one of the set of picture numbers assigned to reference fields.

long_term_pic_num is used (with memory_management_control_operation equal to 2) to mark a long-term reference picture as "unused for reference". When the associated memory_management_control_operation is processed by the decoding process, long_term_pic_num shall be equal to a long-term picture number assigned to one of the reference pictures that is currently marked as "used for long-term reference".

The resulting long-term picture number is constrained as follows.

– If field_pic_flag is equal to 0, the resulting long-term picture number shall be one of the set of long-term picture numbers assigned to reference frames or complementary reference field pairs.

  NOTE 5 – When field_pic_flag is equal to 0, the resulting long-term picture number must be a long-term picture number assigned to a complementary reference field pair in which both fields are marked as "used for reference" or a frame in which both fields are marked as "used for reference". In particular, when field_pic_flag is equal to 0, the marking of a non-paired field or a frame in which a single field is marked as "used for reference" cannot be affected by a memory_management_control_operation equal to 2.

– Otherwise (field_pic_flag is equal to 1), the resulting long-term picture number shall be one of the set of long-term picture numbers assigned to reference fields.

long_term_frame_idx is used (with memory_management_control_operation equal to 3 or 6) to assign a long-term frame index to a picture. When the associated memory_management_control_operation is processed by the decoding process, the value of long_term_frame_idx shall be in the range of 0 to MaxLongTermFrameIdx, inclusive.

max_long_term_frame_idx_plus1 minus 1 specifies the maximum value of long-term frame index allowed for long-term reference pictures (until receipt of another value of max_long_term_frame_idx_plus1). The value of max_long_term_frame_idx_plus1 shall be in the range of 0 to num_ref_frames, inclusive.

7.4.4 Slice data semantics

cabac_alignment_one_bit is a bit equal to 1.

mb_skip_run specifies the number of consecutive skipped macroblocks for which, when decoding a P or SP slice, mb_type shall be inferred to be P_Skip and the macroblock type is collectively referred to as a P macroblock type, or for which, when decoding a B slice, mb_type shall be inferred to be B_Skip and the macroblock type is collectively referred to as a B macroblock type. The value of mb_skip_run shall be in the range of 0 to PicSizeInMbs – CurrMbAddr, inclusive.

mb_skip_flag equal to 1 specifies that for the current macroblock, when decoding a P or SP slice, mb_type shall be inferred to be P_Skip and the macroblock type is collectively referred to as P macroblock type, or for which, when decoding a B slice, mb_type shall be inferred to be B_Skip and the macroblock type is collectively referred to as B macroblock type. mb_skip_flag equal to 0 specifies that the current macroblock is not skipped.

mb_field_decoding_flag equal to 0 specifies that the current macroblock pair is a frame macroblock pair. mb_field_decoding_flag equal to 1 specifies that the macroblock pair is a field macroblock pair. Both macroblocks of a frame macroblock pair are referred to in the text as frame macroblocks, whereas both macroblocks of a field macroblock pair are referred to in the text as field macroblocks.

When mb_field_decoding_flag is not present for either macroblock of a macroblock pair, the value of mb_field_decoding_flag is derived as follows.

– If there is a neighbouring macroblock pair immediately to the left of the current macroblock pair in the same slice, the value of mb_field_decoding_flag shall be inferred to be equal to the value of mb_field_decoding_flag for the neighbouring macroblock pair immediately to the left of the current macroblock pair,

– Otherwise, if there is no neighbouring macroblock pair immediately to the left of the current macroblock pair in the same slice and there is a neighbouring macroblock pair immediately above the current macroblock pair in the same slice, the value of mb_field_decoding_flag shall be inferred to be equal to the value of mb_field_decoding_flag for the neighbouring macroblock pair immediately above the current macroblock pair,

– Otherwise (there is no neighbouring macroblock pair either immediately to the left or immediately above the current macroblock pair in the same slice), the value of mb_field_decoding_flag shall be inferred to be equal to 0.

end_of_slice_flag equal to 0 specifies that another macroblock is following in the slice. end_of_slice_flag equal to 1 specifies the end of the slice and that no further macroblock follows.

The function NextMbAddress( ) used in the slice data syntax table is specified in subclause 8.2.2.

7.4.5 Macroblock layer semantics

mb_type specifies the macroblock type. The semantics of mb_type depend on the slice type.

Tables and semantics are specified for the various macroblock types for I, SI, P, SP, and B slices. Each table presents the value of mb_type, the name of mb_type, the number of macroblock partitions used (given by the NumMbPart(mb_type) function), the prediction mode of the macroblock (when it is not partitioned) or the first partition (given by the MbPartPredMode(mb_type, 0) function) and the prediction mode of the second partition (given by the MbPartPredMode(mb_type, 1) function). When a value is not applicable it is designated by “na”. In the text, the value of mb_type may be referred to as the macroblock type and a value X of MbPartPredMode( ) may be referred to in the text by "X macroblock (partition) prediction mode" or as “X prediction macroblocks”.

Table 7-10 shows the allowed collective macroblock types for each slice_type.

NOTE 1 – There are some macroblock types with Pred_L0 prediction mode that are classified as B macroblock types.

Table 7-10 – Allowed collective macroblock types for slice_type

slice_type	allowed collective macroblock types
I (slice)	I (see Table 7-11) (macroblock types)
P (slice)	P (see Table 7-13) and I (see Table 7-11) (macroblock types)
B (slice)	B (see Table 7-14) and I (see Table 7-11) (macroblock types)
SI (slice)	SI (see Table 7-12) and I (see Table 7-11) (macroblock types)
SP (slice)	P (see Table 7-13) and I (see Table 7-11) (macroblock types)

transform_size_8x8_flag equal to 1 specifies that for the current macroblock the transform coefficient decoding process and picture construction process prior to deblocking filter process for residual 8x8 blocks shall be invoked for luma samples. transform_size_8x8_flag equal to 0 specifies that for the current macroblock the transform coefficient decoding process and picture construction process prior to deblocking filter process for residual 4x4 blocks shall be invoked for luma samples. When transform_size_8x8_flag is not present in the bitstream, it shall be inferred to be equal to 0.

NOTE 2 – When the current macroblock prediction mode MbPartPredMode(mb_type, 0) is equal to Intra_16x16, transform_size_8x8_flag is not present in the bitstream and then inferred to be equal to 0.

When sub_mb_type[mbPartIdx] (see subclause 7.4.5.2) is present in the bitstream for all 8x8 blocks indexed by mbPartIdx = 0..3, the variable noSubMbPartSizeLessThan8x8Flag indicates whether for each of the four 8x8 blocks the corresponding SubMbPartWidth(sub_mb_type[mbPartIdx]) and SubMbPartHeight(sub_mb_type[mbPartIdx]) are both equal to 8.

NOTE 3 – When noSubMbPartSizeLessThan8x8Flag is equal to 0 and the current macroblock type is not equal to I_NxN, transform_size_8x8_flag is not present in the bitstream and then inferred to be equal to 0.

Macroblock types that may be collectively referred to as I macroblock types are specified in Table 7-11.

The macroblock types for I slices are all I macroblock types.

Table 7-11 – Macroblock types for I slices

mb_type	Name of mb_type	transform_size_8x8_flag	MbPartPredMode (mb_type, 0)	Intra16x16PredMode	CodedBlockPatternChroma	CodedBlockPatternLuma
0	I_NxN	0	Intra_4x4	na	Equation 7-33	Equation 7-33
0	I_NxN	1	Intra_8x8	na	Equation 7-33	Equation 7-33
1	I_16x16_0_0_0	na	Intra_16x16	0	0	0
2	I_16x16_1_0_0	na	Intra_16x16	1	0	0
3	I_16x16_2_0_0	na	Intra_16x16	2	0	0
4	I_16x16_3_0_0	na	Intra_16x16	3	0	0
5	I_16x16_0_1_0	na	Intra_16x16	0	1	0
6	I_16x16_1_1_0	na	Intra_16x16	1	1	0
7	I_16x16_2_1_0	na	Intra_16x16	2	1	0
8	I_16x16_3_1_0	na	Intra_16x16	3	1	0
9	I_16x16_0_2_0	na	Intra_16x16	0	2	0
10	I_16x16_1_2_0	na	Intra_16x16	1	2	0
11	I_16x16_2_2_0	na	Intra_16x16	2	2	0
12	I_16x16_3_2_0	na	Intra_16x16	3	2	0
13	I_16x16_0_0_1	na	Intra_16x16	0	0	15
14	I_16x16_1_0_1	na	Intra_16x16	1	0	15
15	I_16x16_2_0_1	na	Intra_16x16	2	0	15
16	I_16x16_3_0_1	na	Intra_16x16	3	0	15
17	I_16x16_0_1_1	na	Intra_16x16	0	1	15
18	I_16x16_1_1_1	na	Intra_16x16	1	1	15
19	I_16x16_2_1_1	na	Intra_16x16	2	1	15
20	I_16x16_3_1_1	na	Intra_16x16	3	1	15
21	I_16x16_0_2_1	na	Intra_16x16	0	2	15
22	I_16x16_1_2_1	na	Intra_16x16	1	2	15
23	I_16x16_2_2_1	na	Intra_16x16	2	2	15
24	I_16x16_3_2_1	na	Intra_16x16	3	2	15
25	I_PCM	na	na	na	na	na

The following semantics are assigned to the macroblock types in Table 7-11.

I_NxN: A mnemonic name for mb_type equal to 0 with MbPartPredMode(mb_type, 0) equal to Intra_4x4 or Intra_8x8.

I_16x16_0_0_0, I_16x16_1_0_0, I_16x16_2_0_0, I_16x16_3_0_0, I_16x16_0_1_0, I_16x16_1_1_0, I_16x16_2_1_0, I_16x16_3_1_0, I_16x16_0_2_0, I_16x16_1_2_0, I_16x16_2_2_0, I_16x16_3_2_0, I_16x16_0_0_1, I_16x16_1_0_1, I_16x16_2_0_1, I_16x16_3_0_1, I_16x16_0_1_1, I_16x16_1_1_1, I_16x16_2_1_1, I_16x16_3_1_1, I_16x16_0_2_1, I_16x16_1_2_1, I_16x16_2_2_1, I_16x16_3_2_1: the macroblock is coded as an Intra_16x16 prediction mode macroblock.

To each Intra_16x16 prediction macroblock, an Intra16x16PredMode is assigned, which specifies the Intra_16x16 prediction mode. CodedBlockPatternChroma contains the coded block pattern value for chroma as specified in Table 7-15. When chroma_format_idc is equal to 0, CodedBlockPatternChroma shall be equal to 0. CodedBlockPatternLuma specifies whether, for the luma component, non-zero AC transform coefficient levels are present. CodedBlockPatternLuma equal to 0 specifies that all AC transform coefficient levels in the luma component of the macroblock are equal to 0. CodedBlockPatternLuma equal to 15 specifies that at least one of the AC transform coefficient levels in the luma component of the macroblock is non-zero, requiring scanning of AC transform coefficient levels for all 16 of the 4x4 blocks in the 16x16 block.

Intra_4x4 specifies the macroblock prediction mode and specifies that the Intra_4x4 prediction process is invoked as specified in subclause 8.3.1. Intra_4x4 is an Intra macroblock prediction mode.

Intra_8x8 specifies the macroblock prediction mode and specifies that the Intra_8x8 prediction process is invoked as specified in subclause 8.3.2. Intra_8x8 is an Intra macroblock prediction mode.

Intra_16x16 specifies the macroblock prediction mode and specifies that the Intra_16x16 prediction process is invoked as specified in subclause 8.3.3. Intra_16x16 is an Intra macroblock prediction mode.

For a macroblock coded with mb_type equal to I_PCM, the Intra macroblock prediction mode shall be inferred.

A macroblock type that may be referred to as SI macroblock type is specified in Table 7-12.

The macroblock types for SI slices are specified in Tables 7-12 and 7-11. The mb_type value 0 is specified in Table 7-12 and the mb_type values 1 to 26 are specified in Table 7-11, indexed by subtracting 1 from the value of mb_type.

Table 7-12 – Macroblock type with value 0 for SI slices

mb_type	Name of mb_type	MbPartPredMode (mb_type, 0)	Intra16x16PredMode	CodedBlockPatternChroma	CodedBlockPatternLuma
0	SI	Intra_4x4	na	Equation 7-33	Equation 7-33

The following semantics are assigned to the macroblock type in Table 7-12. The SI macroblock is coded as Intra_4x4 prediction macroblock.

Macroblock types that may be collectively referred to as P macroblock types are specified in Table 7-13.

The macroblock types for P and SP slices are specified in Tables 7-13 and 7-11. mb_type values 0 to 4 are specified in Table 7-13 and mb_type values 5 to 30 are specified in Table 7-11, indexed by subtracting 5 from the value of mb_type.

Table 7-13 – Macroblock type values 0 to 4 for P and SP slices

mb_type	Name of mb_type	NumMbPart (mb_type)	MbPartPredMode (mb_type, 0)	MbPartPredMode (mb_type, 1)	MbPartWidth (mb_type)	MbPartHeight (mb_type)
0	P_L0_16x16	1	Pred_L0	na	16	16
1	P_L0_L0_16x8	2	Pred_L0	Pred_L0	16	8
2	P_L0_L0_8x16	2	Pred_L0	Pred_L0	8	16
3	P_8x8	4	na	na	8	8
4	P_8x8ref0	4	na	na	8	8
inferred	P_Skip	1	Pred_L0	na	16	16

The following semantics are assigned to the macroblock types in Table 7-13.

– P_L0_16x16: the samples of the macroblock are predicted with one luma macroblock partition of size 16x16 luma samples and associated chroma samples.

– P_L0_L0_MxN, with MxN being replaced by 16x8 or 8x16: the samples of the macroblock are predicted using two luma partitions of size MxN equal to 16x8, or two luma partitions of size MxN equal to 8x16, and associated chroma samples, respectively.

– P_8x8: for each sub-macroblock an additional syntax element (sub_mb_type) is present in the bitstream that specifies the type of the corresponding sub-macroblock (see subclause 7.4.5.2).

– P_8x8ref0: has the same semantics as P_8x8 but no syntax element for the reference index (ref_idx_l0) is present in the bitstream and ref_idx_l0[mbPartIdx] shall be inferred to be equal to 0 for all sub-macroblocks of the macroblock (with indices mbPartIdx equal to 0..3).

– P_Skip: no further data is present for the macroblock in the bitstream.

The following semantics are assigned to the macroblock prediction modes (MbPartPredMode( )) in Table 7-13.

– Pred_L0: specifies that the inter prediction process is invoked using list 0 prediction. Pred_L0 is an Inter macroblock prediction mode.

Macroblock types that may be collectively referred to as B macroblock types are specified in Table 7-14.

The macroblock types for B slices are specified in Tables 7-14 and 7-11. The mb_type values 0 to 22 are specified in Table 7-14 and the mb_type values 23 to 48 are specified in Table 7-11, indexed by subtracting 23 from the value of mb_type.

Table 7-14 – Macroblock type values 0 to 22 for B slices

mb_type	Name of mb_type	NumMbPart (mb_type)	MbPartPredMode (mb_type, 0)	MbPartPredMode (mb_type, 1)	MbPartWidth (mb_type)	MbPartHeight (mb_type)
0	B_Direct_16x16	na	Direct	na	8	8
1	B_L0_16x16	1	Pred_L0	na	16	16
2	B_L1_16x16	1	Pred_L1	na	16	16
3	B_Bi_16x16	1	BiPred	na	16	16
4	B_L0_L0_16x8	2	Pred_L0	Pred_L0	16	8
5	B_L0_L0_8x16	2	Pred_L0	Pred_L0	8	16
6	B_L1_L1_16x8	2	Pred_L1	Pred_L1	16	8
7	B_L1_L1_8x16	2	Pred_L1	Pred_L1	8	16
8	B_L0_L1_16x8	2	Pred_L0	Pred_L1	16	8
9	B_L0_L1_8x16	2	Pred_L0	Pred_L1	8	16
10	B_L1_L0_16x8	2	Pred_L1	Pred_L0	16	8
11	B_L1_L0_8x16	2	Pred_L1	Pred_L0	8	16
12	B_L0_Bi_16x8	2	Pred_L0	BiPred	16	8
13	B_L0_Bi_8x16	2	Pred_L0	BiPred	8	16
14	B_L1_Bi_16x8	2	Pred_L1	BiPred	16	8
15	B_L1_Bi_8x16	2	Pred_L1	BiPred	8	16
16	B_Bi_L0_16x8	2	BiPred	Pred_L0	16	8
17	B_Bi_L0_8x16	2	BiPred	Pred_L0	8	16
18	B_Bi_L1_16x8	2	BiPred	Pred_L1	16	8
19	B_Bi_L1_8x16	2	BiPred	Pred_L1	8	16
20	B_Bi_Bi_16x8	2	BiPred	BiPred	16	8
21	B_Bi_Bi_8x16	2	BiPred	BiPred	8	16
22	B_8x8	4	na	na	8	8
inferred	B_Skip	na	Direct	na	8	8

The following semantics are assigned to the macroblock types in Table 7-14:

– B_Direct_16x16: no motion vector differences or reference indices are present for the macroblock in the bitstream. The functions MbPartWidth(B_Direct_16x16), and MbPartHeight(B_Direct_16x16) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.

– B_X_16x16 with X being replaced by L0, L1, or Bi: the samples of the macroblock are predicted with one luma macroblock partition of size 16x16 luma samples and associated chroma samples. For a macroblock with type B_X_16x16 with X being replaced by either L0 or L1, one motion vector difference and one reference index is

present in the bitstream for the macroblock. For a macroblock with type B_X_16x16 with X being replaced by Bi, two motion vector differences and two reference indices are present in the bitstream for the macroblock.

– B_X0_X1_MxN, with X0, X1 referring to the first and second macroblock partition and being replaced by L0, L1, or Bi, and MxN being replaced by 16x8 or 8x16: the samples of the macroblock are predicted using two luma partitions of size MxN equal to 16x8, or two luma partitions of size MxN equal to 8x16, and associated chroma samples, respectively. For a macroblock partition X0 or X1 with X0 or X1 being replaced by either L0 or L1, one motion vector difference and one reference index is present in the bitstream. For a macroblock partition X0 or X1 with X0 or X1 being replaced by Bi, two motion vector differences and two reference indices are present in the bitstream for the macroblock partition.

– B_8x8: for each sub-macroblock an additional syntax element (sub_mb_type) is present in the bitstream that specifies the type of the corresponding sub-macroblock (see subclause 7.4.5.2).

– B_Skip: no further data is present for the macroblock in the bitstream. The functions MbPartWidth(B_Skip), and MbPartHeight(B_Skip) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.

The following semantics are assigned to the macroblock prediction modes (MbPartPredMode( )) in Table 7-14.

– Direct: no motion vector differences or reference indices are present for the macroblock (in case of B_Skip or B_Direct_16x16) in the bitstream. Direct is an Inter macroblock prediction mode.

– Pred_L0: see semantics for Table 7-13.

– Pred_L1: specifies that the Inter prediction process is invoked using list 1 prediction. Pred_L1 is an Inter macroblock prediction mode.

– BiPred: specifies that the Inter prediction process is invoked using list 0 and list 1 prediction. BiPred is an Inter macroblock prediction mode.

pcm_alignment_zero_bit is a bit equal to 0.

pcm_sample_luma[i] is a sample value. The first pcm_sample_luma[i] values represent luma sample values in the raster scan within the macroblock. The number of bits used to represent each of these samples is $BitDepth_Y$. When profile_idc is not equal to 100, 110, 122, or 144, pcm_sample_luma[i] shall not be equal to 0.

pcm_sample_chroma[i] is a sample value. The first MbWidthC * MbHeightC pcm_sample_chroma[i] values represent Cb sample values in the raster scan within the macroblock and the remaining MbWidthC * MbHeightC pcm_sample_chroma[i] values represent Cr sample values in the raster scan within the macroblock. The number of bits used to represent each of these samples is $BitDepth_C$. When profile_idc is not equal to 100, 110, 122, or 144, pcm_sample_chroma[i] shall not be equal to 0.

coded_block_pattern specifies which of the four 8x8 luma blocks and associated chroma blocks of a macroblock may contain non-zero transform coefficient levels. For macroblocks with prediction mode not equal to Intra_16x16, coded_block_pattern is present in the bitstream and the variables CodedBlockPatternLuma and CodedBlockPatternChroma are derived as follows.

```
CodedBlockPatternLuma = coded_block_pattern % 16
CodedBlockPatternChroma = coded_block_pattern / 16          (7-33)
```

When coded_block_pattern is present, CodedBlockPatternLuma specifies, for each of the four 8x8 luma blocks of the macroblock, one of the following cases.

– All transform coefficient levels of the four 4x4 luma blocks in the 8x8 luma block are equal to zero

– One or more transform coefficient levels of one or more of the 4x4 luma blocks in the 8x8 luma block shall be non-zero valued.

The meaning of CodedBlockPatternChroma is specified in Table 7-15.

Table 7-15 – Specification of CodedBlockPatternChroma values

CodedBlockPatternChroma	Description
0	All chroma transform coefficient levels are equal to 0.
1	One or more chroma DC transform coefficient levels shall be non-zero valued. All chroma AC transform coefficient levels are equal to 0.
2	Zero or more chroma DC transform coefficient levels are non-zero valued. One or more chroma AC transform coefficient levels shall be non-zero valued.

mb_qp_delta can change the value of QP_Y in the macroblock layer. The decoded value of mb_qp_delta shall be in the range of $-(26 + QpBdOffset_Y / 2)$ to $+(25 + QpBdOffset_Y / 2)$, inclusive. mb_qp_delta shall be inferred to be equal to 0 when it is not present for any macroblock (including P_Skip and B_Skip macroblock types).

The value of QP_Y is derived as

$$QP_Y = ((QP_{Y,PREV} + mb\_qp\_delta + 52 + 2 * QpBdOffset_Y) \% (52 + QpBdOffset_Y)) - QpBdOffset_Y \quad (7\text{-}34)$$

where $QP_{Y,PREV}$ is the luma quantisation parameter, QP_Y, of the previous macroblock in decoding order in the current slice. For the first macroblock in the slice $QP_{Y,PREV}$ is initially set equal to $SliceQP_Y$ derived in Equation 7-27 at the start of each slice.

The value of QP'_Y is derived as

$$QP'_Y = QP_Y + QpBdOffset_Y \quad (7\text{-}35)$$

7.4.5.1 Macroblock prediction semantics

All samples of the macroblock are predicted. The prediction modes are derived using the following syntax elements.

prev_intra4x4_pred_mode_flag[luma4x4BlkIdx **]** and **rem_intra4x4_pred_mode[** luma4x4BlkIdx **]** specify the Intra_4x4 prediction of the 4x4 luma block with index luma4x4BlkIdx = 0..15.

prev_intra8x8_pred_mode_flag[luma8x8BlkIdx] and **rem_intra8x8_pred_mode**[luma8x8BlkIdx] specify the Intra_8x8 prediction of the 8x8 luma block with index luma8x8BlkIdx = 0..3.

intra_chroma_pred_mode specifies the type of spatial prediction used for chroma in macroblocks using Intra_4x4 or Intra_16x16 prediction, as shown in Table 7-16. The value of intra_chroma_pred_mode shall be in the range of 0 to 3, inclusive.

Table 7-16 – Relationship between intra_chroma_pred_mode and spatial prediction modes

intra_chroma_pred_mode	Intra Chroma Prediction Mode
0	DC
1	Horizontal
2	Vertical
3	Plane

ref_idx_l0[mbPartIdx **]** when present, specifies the index in reference picture list 0 of the reference picture to be used for prediction.

The range of ref_idx_l0[mbPartIdx], the index in list 0 of the reference picture, and, if applicable, the parity of the field within the reference picture used for prediction are specified as follows.

– If MbaffFrameFlag is equal to 0 or mb_field_decoding_flag is equal to 0, the value of ref_idx_l0[mbPartIdx] shall be in the range of 0 to num_ref_idx_l0_active_minus1, inclusive.

– Otherwise (MbaffFrameFlag is equal to 1 and mb_field_decoding_flag is equal to 1), the value of ref_idx_l0[mbPartIdx] shall be in the range of 0 to 2 * num_ref_idx_l0_active_minus1 + 1, inclusive.

When only one reference picture is used for inter prediction, the values of ref_idx_l0[mbPartIdx] shall be inferred to be equal to 0.

ref_idx_l1[mbPartIdx **]** has the same semantics as ref_idx_l0, with l0 and list 0 replaced by l1 and list 1, respectively.

mvd_l0[mbPartIdx **][** 0 **][** compIdx **]** specifies the difference between a vector component to be used and its prediction. The index mbPartIdx specifies to which macroblock partition mvd_l0 is assigned. The partitioning of the macroblock is specified by mb_type. The horizontal motion vector component difference is decoded first in decoding order and is assigned CompIdx = 0. The vertical motion vector component is decoded second in decoding order and is assigned CompIdx = 1. The range of the components of mvd_l0[mbPartIdx][0][compIdx] is specified by constraints on the motion vector variable values derived from it as specified in Annex A.

mvd_l1[mbPartIdx **][** 0 **][** compIdx **]** has the same semantics as mvd_l0, with l0 and L0 replaced by l1 and L1, respectively.

7.4.5.2 Sub-macroblock prediction semantics

sub_mb_type[mbPartIdx **]** specifies the sub-macroblock types.

Tables and semantics are specified for the various sub-macroblock types for P, and B macroblock types. Each table presents the value of sub_mb_type, the name of sub_mb_type, the number of sub-macroblock partitions used (given by the NumSubMbPart(sub_mb_type) function), and the prediction mode of the sub-macroblock (given by the SubMbPredMode(sub_mb_type) function). In the text, the value of sub_mb_type may be referred to by "sub-macroblock type". In the text, the value of SubMbPredMode( ) may be referred to by "sub-macroblock prediction mode".

The interpretation of sub_mb_type[mbPartIdx] for P macroblock types is specified in Table 7-17, where the row for "inferred" specifies values inferred when sub_mb_type[mbPartIdx] is not present.

Table 7-17 – Sub-macroblock types in P macroblocks

sub_mb_type[mbPartIdx]	Name of sub_mb_type[mbPartIdx]	NumSubMbPart (sub_mb_type[mbPartIdx])	SubMbPredMode (sub_mb_type[mbPartIdx])	SubMbPartWidth (sub_mb_type[mbPartIdx])	SubMbPartHeight (sub_mb_type[mbPartIdx])
inferred	na	na	na	na	na
0	P_L0_8x8	1	Pred_L0	8	8
1	P_L0_8x4	2	Pred_L0	8	4
2	P_L0_4x8	2	Pred_L0	4	8
3	P_L0_4x4	4	Pred_L0	4	4

The following semantics are assigned to the sub-macroblock types in Table 7-17.

– P_L0_MxN, with MxN being replaced by 8x8, 8x4, 4x8, or 4x4: the samples of the sub-macroblock are predicted using one luma partition of size MxN equal to 8x8, two luma partitions of size MxN equal to 8x4, or two luma partitions of size MxN equal to 4x8, or four luma partitions of size MxN equal to 4x4, and associated chroma samples, respectively.

The following semantics are assigned to the sub-macroblock prediction modes (SubMbPredMode( )) in Table 7-17.

– Pred_L0: see semantics for Table 7-13.

The interpretation of sub_mb_type[mbPartIdx] for B macroblock types is specified in Table 7-18, where the row for "inferred" specifies values inferred when sub_mb_type[mbPartIdx] is not present, and the inferred value "mb_type" specifies that the name of sub_mb_type[mbPartIdx] is the same as the name of mb_type for this case.

Table 7-18 – Sub-macroblock types in B macroblocks

sub_mb_type[mbPartIdx]	Name of sub_mb_type[mbPartIdx]	NumSubMbPart (sub_mb_type[mbPartIdx])	SubMbPredMode (sub_mb_type[mbPartIdx])	SubMbPartWidth (sub_mb_type[mbPartIdx])	SubMbPartHeight (sub_mb_type[mbPartIdx])
inferred	mb_type	4	Direct	4	4
0	B_Direct_8x8	4	Direct	4	4
1	B_L0_8x8	1	Pred_L0	8	8
2	B_L1_8x8	1	Pred_L1	8	8
3	B_Bi_8x8	1	BiPred	8	8
4	B_L0_8x4	2	Pred_L0	8	4
5	B_L0_4x8	2	Pred_L0	4	8
6	B_L1_8x4	2	Pred_L1	8	4
7	B_L1_4x8	2	Pred_L1	4	8
8	B_Bi_8x4	2	BiPred	8	4
9	B_Bi_4x8	2	BiPred	4	8
10	B_L0_4x4	4	Pred_L0	4	4
11	B_L1_4x4	4	Pred_L1	4	4
12	B_Bi_4x4	4	BiPred	4	4

The following semantics are assigned to the sub-macroblock types in Table 7-18:

– B_Skip and B_Direct_16x16: no motion vector differences or reference indices are present for the sub-macroblock in the bitstream. The functions SubMbPartWidth( ) and SubMbPartHeight( ) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.

– B_Direct_8x8: no motion vector differences or reference indices are present for the sub-macroblock in the bitstream. The functions SubMbPartWidth(B_Direct_8x8) and SubMbPartHeight(B_Direct_8x8) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.

– B_X_MxN, with X being replaced by L0, L1, or Bi, and MxN being replaced by 8x8, 8x4, 4x8 or 4x4: the samples of the sub-macroblock are predicted using one luma partition of size MxN equal to 8x8, or the samples of the sub-macroblock are predicted using two luma partitions of size MxN equal to 8x4, or the samples of the sub-macroblock are predicted using two luma partitions of size MxN equal to 4x8, or the samples of the sub-macroblock are predicted using four luma partitions of size MxN equal to 4x4, and associated chroma samples, respectively. All sub-macroblock partitions share the same reference index. For an MxN sub-macroblock partition in a sub-macroblock with sub_mb_type being B_X_MxN with X being replaced by either L0 or L1, one motion vector difference is present in the bitstream. For an MxN sub-macroblock partition in a sub-macroblock with sub_mb_type being B_Bi_MxN, two motion vector difference are present in the bitstream.

The following semantics are assigned to the sub-macroblock prediction modes (SubMbPredMode( )) in Table 7-18.

– Direct: see semantics for Table 7-14.

– Pred_L0: see semantics for Table 7-13.

– Pred_L1: see semantics for Table 7-14.

– BiPred: see semantics for Table 7-14.

ref_idx_l0[mbPartIdx **]** has the same semantics as ref_idx_l0 in subclause 7.4.5.1.

ref_idx_l1[mbPartIdx **]** has the same semantics as ref_idx_l1 in subclause 7.4.5.1.

mvd_l0[mbPartIdx **][** subMbPartIdx **][** compIdx **]** has the same semantics as mvd_l0 in subclause 7.4.5.1, except that it is applied to the sub-macroblock partition index with subMbPartIdx. The indices mbPartIdx and subMbPartIdx specify to which macroblock partition and sub-macroblock partition mvd_l0 is assigned.

mvd_l1[mbPartIdx **][** subMbPartIdx **][** compIdx **]** has the same semantics as mvd_l1 in subclause 7.4.5.1.

7.4.5.3 Residual data semantics

The syntax structure residual_block( ), which is used for parsing the transform coefficient levels, is assigned as follows.

– If entropy_coding_mode_flag is equal to 0, residual_block is set equal to residual_block_cavlc, which is used for parsing the syntax elements for transform coefficient levels.

– Otherwise (entropy_coding_mode_flag is equal to 1), residual_block is set equal to residual_block_cabac, which is used for parsing the syntax elements for transform coefficient levels.

Depending on mb_type, luma or chroma, and chroma format, the syntax structure residual_block(coeffLevel, maxNumCoeff) is used with the arguments coeffLevel, which is a list containing the maxNumCoeff transform coefficient levels that are parsed in residual_block( ) and maxNumCoeff as follows.

– Depending on MbPartPredMode(mb_type, 0), the following applies.

  – If MbPartPredMode(mb_type, 0) is equal to Intra_16x16, the transform coefficient levels are parsed into the list Intra16x16DCLevel and into the 16 lists Intra16x16ACLevel[i]. Intra16x16DCLevel contains the 16 transform coefficient levels of the DC transform coefficient levels for each 4x4 luma block. For each of the 16 4x4 luma blocks indexed by i = 0..15, the 15 AC transform coefficients levels of the i-th block are parsed into the i-th list Intra16x16ACLevel[i].

  – Otherwise (MbPartPredMode(mb_type, 0) is not equal to Intra_16x16), the following applies.

    – If transform_size_8x8_flag is equal to 0, for each of the 16 4x4 luma blocks indexed by i = 0..15, the 16 transform coefficient levels of the i-th block are parsed into the i-th list LumaLevel[i].

    – Otherwise (transform_size_8x8_flag is equal to 1), for each of the 4 8x8 luma blocks indexed by i8x8 = 0..3, the following applies.

      – If entropy_coding_mode_flag is equal to 0, first for each of the 4 4x4 luma blocks indexed by i4x4 = 0..3, the 16 transform coefficient levels of the i4x4-th block are parsed into the (i8x8 * 4 + i4x4)-th list LumaLevel[i8x8 * 4 + i4x4]. Then, the 64 transform coefficient levels of the i8x8-th 8x8 luma block which are indexed by 4 * i + i4x4, where i = 0..15 and i4x4 = 0..3, are derived as LumaLevel8x8[i8x8][4 * i + i4x4] = LumaLevel[i8x8 * 4 + i4x4][i].

        NOTE – The 4x4 luma blocks with luma4x4BlkIdx = i8x8 * 4 + i4x4 containing every fourth transform coefficient level of the corresponding i8x8-th 8x8 luma block with offset i4x4 are assumed to represent spatial locations given by the inverse 4x4 luma block scanning process in subclause 6.4.3.

      – Otherwise (entropy_coding_mode_flag is equal to 1), the 64 transform coefficient levels of the i8x8-th block are parsed into the i8x8-th list LumaLevel8x8[i8x8].

– For each chroma component, indexed by iCbCr = 0..1, the DC transform coefficient levels of the 4 * NumC8x8 4x4 chroma blocks are parsed into the iCbCr-th list ChromaDCLevel[iCbCr].

– For each of the 4x4 chroma blocks, indexed by i4x4 = 0..3 and i8x8 = 0..NumC8x8 – 1, of each chroma component, indexed by iCbCr = 0..1, the 15 AC transform coefficient levels are parsed into the (i8x8*4 + i4x4)-th list of the iCbCr-th chroma component ChromaACLevel[iCbCr][i8x8*4 + i4x4].

7.4.5.3.1 Residual block CAVLC semantics

The function TotalCoeff(coeff_token) that is used in subclause 7.3.5.3.1 returns the number of non-zero transform coefficient levels derived from coeff_token.

The function TrailingOnes(coeff_token) that is used in subclause 7.3.5.3.1 returns the trailing ones derived from coeff_token.

coeff_token specifies the total number of non-zero transform coefficient levels and the number of trailing one transform coefficient levels in a transform coefficient level scan. A trailing one transform coefficient level is one of up to three consecutive non-zero transform coefficient levels having an absolute value equal to 1 at the end of a scan of non-zero transform coefficient levels. The range of coeff_token is specified in subclause 9.2.1.

trailing_ones_sign_flag specifies the sign of a trailing one transform coefficient level as follows.

– If trailing_ones_sign_flag is equal to 0, the corresponding transform coefficient level is decoded as +1.

– Otherwise (trailing_ones_sign_flag equal to 1), the corresponding transform coefficient level is decoded as -1.

level_prefix and **level_suffix** specify the value of a non-zero transform coefficient level. The range of level_prefix and level_suffix is specified in subclause 9.2.2.

total_zeros specifies the total number of zero-valued transform coefficient levels that are located before the position of the last non-zero transform coefficient level in a scan of transform coefficient levels. The range of total_zeros is specified in subclause 9.2.3.

run_before specifies the number of consecutive transform coefficient levels in the scan with zero value before a non-zero valued transform coefficient level. The range of run_before is specified in subclause 9.2.3.

coeffLevel contains maxNumCoeff transform coefficient levels for the current list of transform coefficient levels.

7.4.5.3.2 Residual block CABAC semantics

coded_block_flag specifies whether the block contains non-zero transform coefficient levels as follows.

- If coded_block_flag is equal to 0, the block contains no non-zero transform coefficient levels.

- Otherwise (coded_block_flag is equal to 1), the block contains at least one non-zero transform coefficient level.

significant_coeff_flag[i **]** specifies whether the transform coefficient level at scanning position i is non-zero as follows.

– If significant_coeff_flag[i] is equal to 0, the transform coefficient level at scanning position i is set equal to 0;

– Otherwise (significant_coeff_flag[i] is equal to 1), the transform coefficient level at scanning position i has a non-zero value.

last_significant_coeff_flag[i **]** specifies for the scanning position i whether there are non-zero transform coefficient levels for subsequent scanning positions i + 1 to maxNumCoeff – 1 as follows.

– If last_significant_coeff_flag[i] is equal to 1, all following transform coefficient levels (in scanning order) of the block have value equal to 0.

– Otherwise (last_significant_coeff_flag[i] is equal to 0), there are further non-zero transform coefficient levels along the scanning path.

coeff_abs_level_minus1[i **]** is the absolute value of a transform coefficient level minus 1. The value of coeff_abs_level_minus1 is constrained by the limits in subclause 8.5.

coeff_sign_flag[i **]** specifies the sign of a transform coefficient level as follows.

– If coeff_sign_flag is equal to 0, the corresponding transform coefficient level has a positive value.

– Otherwise (coeff_sign_flag is equal to 1), the corresponding transform coefficient level has a negative value.

coeffLevel contains maxNumCoeff transform coefficient levels for the current list of transform coefficient levels.

8 Decoding process

Outputs of this process are decoded samples of the current picture (sometimes referred to by the variable CurrPic).

This clause describes the decoding process, given syntax elements and upper-case variables from clause 7.

The decoding process is specified such that all decoders shall produce numerically identical results. Any decoding process that produces identical results to the process described here conforms to the decoding process requirements of this Recommendation | International Standard.

Each picture referred to in this clause is a primary picture. Each slice referred to in this clause is a slice of a primary picture. Each slice data partition referred to in this clause is a slice data partition of a primary picture.

An overview of the decoding process is given as follows.

– The decoding of NAL units is specified in subclause 8.1.

– The processes in subclause 8.2 specify decoding processes using syntax elements in the slice layer and above.

  – Variables and functions relating to picture order count are derived in subclause 8.2.1. (only needed to be invoked for one slice of a picture)

  – Variables and functions relating to the macroblock to slice group map are derived in subclause 8.2.2. (only needed to be invoked for one slice of a picture)

  – The method of combining the various partitions when slice data partitioning is used is described in subclause 8.2.3.

  – When the frame_num of the current picture is not equal to PrevRefFrameNum and is not equal to (PrevRefFrameNum + 1) % MaxFrameNum, the decoding process for gaps in frame_num is performed according to subclause 8.2.5.2 prior to the decoding of any slices of the current picture.

  – At the beginning of the decoding process for each P, SP, or B slice, the decoding process for reference picture lists construction specified in 8.2.4 performed for derivation of reference picture list 0 (RefPicList0), and when decoding a B slice, reference picture list 1 (RefPicList1).

  – When the current picture is a reference picture and after all slices of the current picture have been decoded, the decoded reference picture marking process in subclause 8.2.5 specifies how the current picture is used in the decoding process of inter prediction in later decoded pictures.

– The processes in subclauses 8.3, 8.4, 8.5, 8.6, and 8.7 specify decoding processes using syntax elements in the macroblock layer and above.

  – The intra prediction process for I and SI macroblocks, except for I_PCM macroblocks as specified in subclause 8.3, has intra prediction samples as its output. For I_PCM macroblocks subclause 8.3 directly specifies a picture construction process. The output are the constructed samples prior to the deblocking filter process.

  – The inter prediction process for P and B macroblocks is specified in subclause 8.4 with inter prediction samples being the output.

  – The transform coefficient decoding process and picture construction process prior to deblocking filter process are specified in subclause 8.5. That process derives samples for I and B macroblocks and for P macroblocks in P slices. The output are constructed samples prior to the deblocking filter process.

  – The decoding process for P macroblocks in SP slices or SI macroblocks is specified in subclause 8.6. That process derives samples for P macroblocks in SP slices and for SI macroblocks. The output are constructed samples prior to the deblocking filter process.

  – The constructed samples prior to the deblocking filter process that are next to the edges of blocks and macroblocks are processed by a deblocking filter as specified in subclause 8.7 with the output being the decoded samples.

8.1 NAL unit decoding process

Inputs to this process are NAL units.

Outputs of this process are the RBSP syntax structures encapsulated within the NAL units.

The decoding process for each NAL unit extracts the RBSP syntax structure from the NAL unit and then operates the decoding processes specified for the RBSP syntax structure in the NAL unit as follows.

Subclause 8.2 describes the decoding process for NAL units with nal_unit_type equal to 1 through 5.

Subclauses 8.3 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1, 2, and 5.

Subclause 8.4 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 and 2.

Subclause 8.5 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 and 3 to 5.

Subclause 8.6 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 and 3 to 5.

Subclause 8.7 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 to 5.

NAL units with nal_unit_type equal to 7 and 8 contain sequence parameter sets and picture parameter sets, respectively. Picture parameter sets are used in the decoding processes of other NAL units as determined by reference to a picture parameter set within the slice headers of each picture. Sequence parameter sets are used in the decoding processes of other NAL units as determined by reference to a sequence parameter set within the picture parameter sets of each sequence.

No normative decoding process is specified for NAL units with nal_unit_type equal to 6, 9, 10, 11, and 12.

8.2 Slice decoding process

8.2.1 Decoding process for picture order count

Outputs of this process are TopFieldOrderCnt (if applicable) and BottomFieldOrderCnt (if applicable).

Picture order counts are used to determine initial picture orderings for reference pictures in the decoding of B slices (see subclauses 8.2.4.2.3 and 8.2.4.2.4), to represent picture order differences between frames or fields for motion vector derivation in temporal direct mode (see subclause 8.4.1.2.3), for implicit mode weighted prediction in B slices (see subclause 8.4.2.3.2), and for decoder conformance checking (see subclause C.4).

Picture order count information is derived for every frame, field (whether decoded from a coded field or as a part of a decoded frame), or complementary field pair as follows:

– Each coded frame is associated with two picture order counts, called TopFieldOrderCnt and BottomFieldOrderCnt for its top field and bottom field, respectively.

– Each coded field is associated with a picture order count, called TopFieldOrderCnt for a coded top field and BottomFieldOrderCnt for a bottom field.

– Each complementary field pair is associated with two picture order counts, which are the TopFieldOrderCnt for its coded top field and the BottomFieldOrderCnt for its coded bottom field, respectively.

TopFieldOrderCnt and BottomFieldOrderCnt indicate the picture order of the corresponding top field or bottom field relative to the first output field of the previous IDR picture or the previous reference picture including a memory_management_control_operation equal to 5 in decoding order.

TopFieldOrderCnt and BottomFieldOrderCnt are derived by invoking one of the decoding processes for picture order count type 0, 1, and 2 in subclauses 8.2.1.1, 8.2.1.2, and 8.2.1.3, respectively. When the current picture includes a memory management control operation equal to 5, after the decoding of the current picture, tempPicOrderCnt is set equal to PicOrderCnt(CurrPic), TopFieldOrderCnt of the current picture (if any) is set equal to TopFieldOrderCnt - tempPicOrderCnt, and BottomFieldOrderCnt of the current picture (if any) is set equal to BottomFieldOrderCnt - tempPicOrderCnt.

The bitstream shall not contain data that results in Min(TopFieldOrderCnt, BottomFieldOrderCnt) not equal to 0 for a coded IDR frame, TopFieldOrderCnt not equal to 0 for a coded IDR top field, or BottomFieldOrderCnt not equal to 0 for a coded IDR bottom field. Thus, at least one of TopFieldOrderCnt and BottomFieldOrderCnt shall be equal to 0 for the fields of a coded IDR frame.

When the current picture is not an IDR picture, the following applies.

– Consider the list variable listD containing as elements the TopFieldOrderCnt and BottomFieldOrderCnt values associated with the list of pictures including all of the following
  – the first picture in the list is the previous picture of any of the following types
    – an IDR picture
    – a picture containing a memory_management_control_operation equal to 5
  – the following additional pictures.

– If pic_order_cnt_type is equal to 0, all other pictures that follow in decoding order after the first picture in the list and are not "non-existing" frames inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2 and either precede the current picture in decoding order or are the current picture. When pic_order_cnt_type is equal to 0 and the current picture is not a "non-existing" frame inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2, the current picture is included in listD prior to the invoking of the decoded reference picture marking process.

  Otherwise (pic_order_cnt_type is not equal to 0), all other pictures that follow in decoding order after the first picture in the list and either precede the current picture in decoding order or are the current picture. When pic_order_cnt_type is not equal to 0, the current picture is included in listD prior to the invoking of the decoded reference picture marking process.

– Consider the list variable listO which contains the elements of listD sorted in ascending order. listO shall not contain any of the following.
  – a pair of TopFieldOrderCnt and BottomFieldOrderCnt for a frame or complementary field pair that are not at consecutive positions in listO.
  – a TopFieldOrderCnt that has a value equal to another TopFieldOrderCnt.
  – a BottomFieldOrderCnt that has a value equal to another BottomFieldOrderCnt.
  – a BottomFieldOrderCnt that has a value equal to a TopFieldOrderCnt unless the BottomFieldOrderCnt and TopFieldOrderCnt belong to the same coded frame or complementary field pair.

The bitstream shall not contain data that results in values of TopFieldOrderCnt, BottomFieldOrderCnt, PicOrderCntMsb, or FrameNumOffset used in the decoding process as specified in subclauses 8.2.1.1 to 8.2.1.3 that exceed the range of values from -2^{31} to $2^{31}-1$, inclusive.

The function PicOrderCnt(picX) is specified as follows:

```
if( picX is a frame or a complementary field pair )
   PicOrderCnt( picX ) = Min( TopFieldOrderCnt, BottomFieldOrderCnt ) of the frame or complementary field
pair picX
else if( picX is a top field )
   PicOrderCnt( picX ) = TopFieldOrderCnt of field picX                                        (8-1)
else if( picX is a bottom field )
   PicOrderCnt( picX ) = BottomFieldOrderCnt of field picX
```

Then DiffPicOrderCnt(picA, picB) is specified as follows:

```
DiffPicOrderCnt( picA, picB ) = PicOrderCnt( picA ) - PicOrderCnt( picB )                      (8-2)
```

The bitstream shall not contain data that results in values of DiffPicOrderCnt(picA, picB) used in the decoding process that exceed the range of -2^{15} to $2^{15} - 1$, inclusive.

NOTE 1 – Let X be the current picture and Y and Z be two other pictures in the same sequence, Y and Z are considered to be in the same output order direction from X when both DiffPicOrderCnt(X, Y) and DiffPicOrderCnt(X, Z) are positive or both are negative.

NOTE 2 – Many applications assign PicOrderCnt(X) proportional to the sampling time of the picture X relative to the sampling time of an IDR picture.

When the current picture includes a memory_management_control_operation equal to 5, PicOrderCnt(CurrPic) shall be greater than PicOrderCnt(any other picture in listD).

8.2.1.1 Decoding process for picture order count type 0

This process is invoked when pic_order_cnt_type is equal to 0.

Input to this process is PicOrderCntMsb of the previous reference picture in decoding order as specified in this subclause.

Outputs of this process are either or both TopFieldOrderCnt or BottomFieldOrderCnt.

The variables prevPicOrderCntMsb and prevPicOrderCntLsb are derived as follows.

– If the current picture is an IDR picture, prevPicOrderCntMsb is set equal to 0 and prevPicOrderCntLsb is set equal to 0.

– Otherwise (the current picture is not an IDR picture), the following applies.

– If the previous reference picture in decoding order included a memory_management_control_operation equal to 5, the following applies.
  – If the previous reference picture in decoding order is not a bottom field, prevPicOrderCntMsb is set equal to 0 and prevPicOrderCntLsb is set equal to the value of TopFieldOrderCnt for the previous reference picture in decoding order.
  – Otherwise (the previous reference picture in decoding order is a bottom field), prevPicOrderCntMsb is set equal to 0 and prevPicOrderCntLsb is set equal to 0.
– Otherwise (the previous reference picture in decoding order did not include a memory_management_control_operation equal to 5), prevPicOrderCntMsb is set equal to PicOrderCntMsb of the previous reference picture in decoding order and prevPicOrderCntLsb is set equal to the value of pic_order_cnt_lsb of the previous reference picture in decoding order.

PicOrderCntMsb of the current picture is derived as follows:

```
if( ( pic_order_cnt_lsb  <  prevPicOrderCntLsb )  &&
    ( ( prevPicOrderCntLsb – pic_order_cnt_lsb )  >=  ( MaxPicOrderCntLsb / 2 ) ) )
     PicOrderCntMsb = prevPicOrderCntMsb + MaxPicOrderCntLsb                    (8-3)
else if( ( pic_order_cnt_lsb  >  prevPicOrderCntLsb )  &&
         ( ( pic_order_cnt_lsb – prevPicOrderCntLsb )  >  ( MaxPicOrderCntLsb / 2 ) ) )
     PicOrderCntMsb = prevPicOrderCntMsb – MaxPicOrderCntLsb
else
     PicOrderCntMsb = prevPicOrderCntMsb
```

When the current picture is not a bottom field, TopFieldOrderCnt is derived as follows:

```
if( !field_pic_flag  ||  !bottom_field_flag )
     TopFieldOrderCnt = PicOrderCntMsb + pic_order_cnt_lsb                      (8-4)
```

When the current picture is not a top field, BottomFieldOrderCnt is derived as follows:

```
if( !field_pic_flag )
     BottomFieldOrderCnt = TopFieldOrderCnt + delta_pic_order_cnt_bottom
else if( bottom_field_flag )                                                    (8-5)
     BottomFieldOrderCnt = PicOrderCntMsb + pic_order_cnt_lsb
```

8.2.1.2 Decoding process for picture order count type 1

This process is invoked when pic_order_cnt_type is equal to 1.

Input to this process is FrameNumOffset of the previous picture in decoding order as specified in this subclause.

Outputs of this process are either or both TopFieldOrderCnt or BottomFieldOrderCnt.

The values of TopFieldOrderCnt and BottomFieldOrderCnt are derived as specified in this subclause. Let prevFrameNum be equal to the frame_num of the previous picture in decoding order.

When the current picture is not an IDR picture, the variable prevFrameNumOffset is derived as follows.

– If the previous picture in decoding order included a memory_management_control_operation equal to 5, prevFrameNumOffset is set equal to 0.

– Otherwise (the previous picture in decoding order did not include a memory_management_control_operation equal to 5), prevFrameNumOffset is set equal to the value of FrameNumOffset of the previous picture in decoding order.

NOTE – When gaps_in_frame_num_value_allowed_flag is equal to 1, the previous picture in decoding order may be a "non-existing" frame inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2.

The derivation proceeds in the following ordered steps.

1. The variable FrameNumOffset is derived as follows:

```
if( nal_unit_type  =  =  5 )
     FrameNumOffset = 0
else if( prevFrameNum > frame_num )                                             (8-6)
     FrameNumOffset = prevFrameNumOffset + MaxFrameNum
```

```
    else
        FrameNumOffset = prevFrameNumOffset
```

2. The variable absFrameNum is derived as follows:

```
if( num_ref_frames_in_pic_order_cnt_cycle  !=  0 )
    absFrameNum = FrameNumOffset + frame_num
else                                                                    (8-7)
    absFrameNum = 0
if( nal_ref_idc  = =  0  &&  absFrameNum  >  0 )
    absFrameNum = absFrameNum – 1
```

3. When absFrameNum > 0, picOrderCntCycleCnt and frameNumInPicOrderCntCycle are derived as follows:

```
if( absFrameNum  >  0 ) {
    picOrderCntCycleCnt = ( absFrameNum – 1 ) / num_ref_frames_in_pic_order_cnt_cycle
    frameNumInPicOrderCntCycle = ( absFrameNum – 1 ) % num_ref_frames_in_pic_order_cnt_cycle      (8-8)
}
```

4. The variable expectedDeltaPerPicOrderCntCycle is derived as follows:

```
expectedDeltaPerPicOrderCntCycle = 0
for( i = 0;  i < num_ref_frames_in_pic_order_cnt_cycle;  i++ )
    expectedDeltaPerPicOrderCntCycle += offset_for_ref_frame[ i ]       (8-9)
```

5. The variable expectedPicOrderCnt is derived as follows:

```
if( absFrameNum > 0 ){
    expectedPicOrderCnt = picOrderCntCycleCnt * expectedDeltaPerPicOrderCntCycle
    for( i = 0; i <= frameNumInPicOrderCntCycle; i++ )
        expectedPicOrderCnt = expectedPicOrderCnt + offset_for_ref_frame[ i ]
} else
    expectedPicOrderCnt = 0
if( nal_ref_idc  = =  0 )                                               (8-10)
    expectedPicOrderCnt = expectedPicOrderCnt + offset_for_non_ref_pic
```

6. The variables TopFieldOrderCnt or BottomFieldOrderCnt are derived as follows:

```
if( !field_pic_flag ) {
    TopFieldOrderCnt = expectedPicOrderCnt + delta_pic_order_cnt[ 0 ]
    BottomFieldOrderCnt = TopFieldOrderCnt +
            offset_for_top_to_bottom_field + delta_pic_order_cnt[ 1 ]   (8-11)
} else if( !bottom_field_flag )
    TopFieldOrderCnt = expectedPicOrderCnt + delta_pic_order_cnt[ 0 ]
else
    BottomFieldOrderCnt = expectedPicOrderCnt + offset_for_top_to_bottom_field + delta_pic_order_cnt[ 0 ]
```

8.2.1.3 Decoding process for picture order count type 2

This process is invoked when pic_order_cnt_type is equal to 2.

Outputs of this process are either or both TopFieldOrderCnt or BottomFieldOrderCnt.

Let prevFrameNum be equal to the frame_num of the previous picture in decoding order.

When the current picture is not an IDR picture, the variable prevFrameNumOffset is derived as follows.

– If the previous picture in decoding order included a memory_management_control_operation equal to 5, prevFrameNumOffset is set equal to 0.

– Otherwise (the previous picture in decoding order did not include a memory_management_control_operation equal to 5), prevFrameNumOffset is set equal to the value of FrameNumOffset of the previous picture in decoding order.

NOTE 1 – When gaps_in_frame_num_value_allowed_flag is equal to 1, the previous picture in decoding order may be a "non-existing" frame inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2.

The variable FrameNumOffset is derived as follows.

```
if( nal_unit_type  = =  5 )
    FrameNumOffset = 0
else if( prevFrameNum  >  frame_num )                                    (8-12)
    FrameNumOffset = prevFrameNumOffset + MaxFrameNum
else
    FrameNumOffset = prevFrameNumOffset
```

The variable tempPicOrderCnt is derived as follows:

```
if( nal_unit_type  = =  5 )
    tempPicOrderCnt = 0
else if( nal_ref_idc  = =  0 )                                           (8-13)
    tempPicOrderCnt = 2 * ( FrameNumOffset + frame_num ) – 1
else
    tempPicOrderCnt = 2 * ( FrameNumOffset + frame_num )
```

The variables TopFieldOrderCnt or BottomFieldOrderCnt are derived as follows:

```
if( !field_pic_flag ) {
    TopFieldOrderCnt = tempPicOrderCnt
    BottomFieldOrderCnt = tempPicOrderCnt                                (8-14)
} else if( bottom_field_flag )
    BottomFieldOrderCnt = tempPicOrderCnt
else
    TopFieldOrderCnt = tempPicOrderCnt
```

NOTE 2 – Picture order count type 2 cannot be used in a coded video sequence that contains consecutive non-reference pictures that would result in more than one of these pictures having the same value of TopFieldOrderCnt or more than one of these pictures having the same value of BottomFieldOrderCnt.

NOTE 3 – Picture order count type 2 results in an output order that is the same as the decoding order.

8.2.2 Decoding process for macroblock to slice group map

Inputs to this process are the active picture parameter set and the slice header of the slice to be decoded.

Output of this process is a macroblock to slice group map MbToSliceGroupMap.

This process is invoked at the start of every slice.

NOTE – The output of this process is equal for all slices of a picture.

When num_slice_groups_minus1 is equal to 1 and slice_group_map_type is equal to 3, 4, or 5, slice groups 0 and 1 have a size and shape determined by slice_group_change_direction_flag as shown in Table 8-1 and specified in subclauses 8.2.2.4 to 8.2.2.6.

Table 8-1 – Refined slice group map type

slice_group_map_type	slice_group_change_direction_flag	refined slice group map type
3	0	Box-out clockwise
3	1	Box-out counter-clockwise
4	0	Raster scan
4	1	Reverse raster scan
5	0	Wipe right
5	1	Wipe left

In such a case, MapUnitsInSliceGroup0 slice group map units in the specified growth order are allocated for slice group 0 and the remaining PicSizeInMapUnits – MapUnitsInSliceGroup0 slice group map units of the picture are allocated for slice group 1.

When num_slice_groups_minus1 is equal to 1 and slice_group_map_type is equal to 4 or 5, the variable sizeOfUpperLeftGroup is defined as follows:

```
sizeOfUpperLeftGroup = ( slice_group_change_direction_flag ?
                         ( PicSizeInMapUnits – MapUnitsInSliceGroup0 ) : MapUnitsInSliceGroup0 )   (8-15)
```

The variable mapUnitToSliceGroupMap is derived as follows.

– If num_slice_groups_minus1 is equal to 0, the map unit to slice group map is generated for all i ranging from 0 to PicSizeInMapUnits – 1, inclusive, as specified by:

```
mapUnitToSliceGroupMap[ i ] = 0                                                    (8-16)
```

– Otherwise (num_slice_groups_minus1 is not equal to 0), mapUnitToSliceGroupMap is derived as follows.
  – If slice_group_map_type is equal to 0, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.1 applies.
  – Otherwise, if slice_group_map_type is equal to 1, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.2 applies.
  – Otherwise, if slice_group_map_type is equal to 2, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.3 applies.
  – Otherwise, if slice_group_map_type is equal to 3, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.4 applies.
  – Otherwise, if slice_group_map_type is equal to 4, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.5 applies.
  – Otherwise, if slice_group_map_type is equal to 5, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.6 applies.
  – Otherwise (slice_group_map_type is equal to 6), the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.7 applies.

After derivation of the mapUnitToSliceGroupMap, the process specified in subclause 8.2.2.8 is invoked to convert the map unit to slice group map mapUnitToSliceGroupMap to the macroblock to slice group map MbToSliceGroupMap. After derivation of the macroblock to slice group map as specified in subclause 8.2.2.8, the function NextMbAddress(n) is defined as the value of the variable nextMbAddress derived as specified by:

```
i = n + 1
while( i < PicSizeInMbs && MbToSliceGroupMap[ i ] != MbToSliceGroupMap[ n ] )
    i++;
nextMbAddress = i                                                                  (8-17)
```

8.2.2.1 Specification for interleaved slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 0.

The map unit to slice group map is generated as specified by:

```
i = 0
do
    for( iGroup = 0; iGroup <= num_slice_groups_minus1 && i < PicSizeInMapUnits;
         i += run_length_minus1[ iGroup++ ] + 1 )
        for( j = 0; j <= run_length_minus1[ iGroup ] && i + j < PicSizeInMapUnits; j++ )
            mapUnitToSliceGroupMap[ i + j ] = iGroup                               (8-18)
while( i < PicSizeInMapUnits )
```

8.2.2.2 Specification for dispersed slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 1.

The map unit to slice group map is generated as specified by:

```
for( i = 0; i < PicSizeInMapUnits; i++ )
    mapUnitToSliceGroupMap[ i ] = ( ( i % PicWidthInMbs ) +
                                    ( ( ( i / PicWidthInMbs ) * ( num_slice_groups_minus1 + 1 ) ) / 2 ) )
                                  % ( num_slice_groups_minus1 + 1 )                                    (8-19)
```

8.2.2.3 Specification for foreground with left-over slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 2.

The map unit to slice group map is generated as specified by:

```
for( i = 0; i < PicSizeInMapUnits; i++ )
    mapUnitToSliceGroupMap[ i ] = num_slice_groups_minus1
for( iGroup = num_slice_groups_minus1 – 1; iGroup >= 0; iGroup-- ) {
    yTopLeft = top_left[ iGroup ] / PicWidthInMbs
    xTopLeft = top_left[ iGroup ] % PicWidthInMbs
    yBottomRight = bottom_right[ iGroup ] / PicWidthInMbs
    xBottomRight = bottom_right[ iGroup ] % PicWidthInMbs
    for( y = yTopLeft; y <= yBottomRight; y++ )
        for( x = xTopLeft; x <= xBottomRight; x++ )
            mapUnitToSliceGroupMap[ y * PicWidthInMbs + x ] = iGroup                                   (8-20)
}
```

NOTE – The rectangles may overlap. Slice group 0 contains the macroblocks that are within the rectangle specified by top_left[0] and bottom_right[0]. A slice group having slice group ID greater than 0 and less than num_slice_groups_minus1 contains the macroblocks that are within the specified rectangle for that slice group that are not within the rectangle specified for any slice group having a smaller slice group ID. The slice group with slice group ID equal to num_slice_groups_minus1 contains the macroblocks that are not in the other slice groups.

8.2.2.4 Specification for box-out slice group map types

The specifications in this subclause apply when slice_group_map_type is equal to 3.

The map unit to slice group map is generated as specified by:

```
for( i = 0; i < PicSizeInMapUnits; i++ )
    mapUnitToSliceGroupMap[ i ] = 1
x = ( PicWidthInMbs – slice_group_change_direction_flag ) / 2
y = ( PicHeightInMapUnits – slice_group_change_direction_flag ) / 2
( leftBound, topBound ) = ( x, y )
( rightBound, bottomBound ) = ( x, y )
( xDir, yDir ) = ( slice_group_change_direction_flag – 1, slice_group_change_direction_flag )
for( k = 0; k < MapUnitsInSliceGroup0; k += mapUnitVacant ) {
    mapUnitVacant = ( mapUnitToSliceGroupMap[ y * PicWidthInMbs + x ]  = =  1 )
    if( mapUnitVacant )
        mapUnitToSliceGroupMap[ y * PicWidthInMbs + x ] = 0                                            (8-21)
    if( xDir  = =  –1  &&  x  = =  leftBound ) {
        leftBound = Max( leftBound – 1, 0 )
        x = leftBound
        ( xDir, yDir ) = ( 0, 2 * slice_group_change_direction_flag – 1 )
    } else if( xDir  = =  1  &&  x  = =  rightBound ) {
        rightBound = Min( rightBound + 1, PicWidthInMbs – 1 )
        x = rightBound
        ( xDir, yDir ) = ( 0, 1 – 2 * slice_group_change_direction_flag )
    } else if( yDir  = =  –1  &&  y  = =  topBound ) {
        topBound = Max( topBound – 1, 0 )
        y = topBound
        ( xDir, yDir ) = ( 1 – 2 * slice_group_change_direction_flag, 0 )
    } else if( yDir  = =  1  &&  y  = =  bottomBound ) {
        bottomBound  =  Min( bottomBound + 1, PicHeightInMapUnits – 1 )
        y = bottomBound
        ( xDir, yDir ) = ( 2 * slice_group_change_direction_flag – 1, 0 )
    } else
```

```
        ( x, y ) = ( x + xDir, y + yDir )
}
```

8.2.2.5 Specification for raster scan slice group map types

The specifications in this subclause apply when slice_group_map_type is equal to 4.

The map unit to slice group map is generated as specified by:

```
for( i = 0; i < PicSizeInMapUnits; i++ )
    if( i < sizeOfUpperLeftGroup )
        mapUnitToSliceGroupMap[ i ] = slice_group_change_direction_flag
    else                                                                    (8-22)
        mapUnitToSliceGroupMap[ i ] = 1 – slice_group_change_direction_flag
```

8.2.2.6 Specification for wipe slice group map types

The specifications in this subclause apply when slice_group_map_type is equal to 5.

The map unit to slice group map is generated as specified by:

```
k = 0;
for( j = 0; j < PicWidthInMbs; j++ )
    for( i = 0; i < PicHeightInMapUnits; i++ )
        if( k++ < sizeOfUpperLeftGroup )
            mapUnitToSliceGroupMap[ i * PicWidthInMbs + j ] = slice_group_change_direction_flag
        else                                                                    (8-23)
            mapUnitToSliceGroupMap[ i * PicWidthInMbs + j ] = 1 – slice_group_change_direction_flag
```

8.2.2.7 Specification for explicit slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 6.

The map unit to slice group map is generated as specified by:

```
mapUnitToSliceGroupMap[ i ] = slice_group_id[ i ]                           (8-24)
```

for all i ranging from 0 to PicSizeInMapUnits – 1, inclusive.

8.2.2.8 Specification for conversion of map unit to slice group map to macroblock to slice group map

For each value of i ranging from 0 to PicSizeInMbs – 1, inclusive, the macroblock to slice group map is specified as follows.

— If frame_mbs_only_flag is equal to 1 or field_pic_flag is equal to 1, the macroblock to slice group map is specified by:

```
MbToSliceGroupMap[ i ] = mapUnitToSliceGroupMap[ i ]                        (8-25)
```

– Otherwise, if MbaffFrameFlag is equal to 1, the macroblock to slice group map is specified by:

```
MbToSliceGroupMap[ i ] = mapUnitToSliceGroupMap[ i / 2 ]                    (8-26)
```

– Otherwise (frame_mbs_only_flag is equal to 0 and mb_adaptive_frame_field_flag is equal to 0 and field_pic_flag is equal to 0), the macroblock to slice group map is specified by:

```
MbToSliceGroupMap[ i ] = mapUnitToSliceGroupMap[ ( i / ( 2 * PicWidthInMbs ) ) * PicWidthInMbs
                                                 + ( i % PicWidthInMbs ) ]  (8-27)
```

8.2.3 Decoding process for slice data partitioning

Inputs to this process are

– a slice data partition A layer RBSP,

– when syntax elements of category 3 are present in the slice data, a slice data partition B layer RBSP having the same slice_id as in the slice data partition A layer RBSP, and

– when syntax elements of category 4 are present in the slice data, a slice data partition C layer RBSP having the same slice_id as in the slice data partition A layer RBSP.

NOTE 1 – The slice data partition B layer RBSP and slice data partition C layer RBSP need not be present.

Output of this process is a coded slice.

When slice data partitioning is not used, coded slices are represented by a slice layer without partitioning RBSP that contains a slice header followed by a slice data syntax structure that contains all the syntax elements of categories 2, 3, and 4 (see category column in subclause 7.3) of the macroblock data for the macroblocks of the slice.

When slice data partitioning is used, the macroblock data of a slice is partitioned into one to three partitions contained in separate NAL units. Partition A contains a slice data partition A header, and all syntax elements of category 2. Partition B, when present, contains a slice data partition B header and all syntax elements of category 3. Partition C, when present, contains a slice data partition C header and all syntax elements of category 4.

When slice data partitioning is used, the syntax elements of each category are parsed from a separate NAL unit, which need not be present when no symbols of the respective category exist. The decoding process shall process the slice data partitions of a coded slice in a manner equivalent to processing a corresponding slice layer without partitioning RBSP by extracting each syntax element from the slice data partition in which the syntax element appears depending on the slice data partition assignment in the syntax tables in subclause 7.3.

NOTE 2 – Syntax elements of category 3 are relevant to the decoding of residual data of I and SI macroblock types. Syntax elements of category 4 are relevant to the decoding of residual data of P and B macroblock types. Category 2 encompasses all other syntax elements related to the decoding of macroblocks, and their information is often denoted as header information. The slice data partition A header contains all the syntax elements of the slice header, and additionally a slice_id that are used to associate the slice data partitions B and C with the slice data partition A. The slice data partition B and C headers contain the slice_id syntax element that establishes their association with the slice data partition A of the slice.

8.2.4 Decoding process for reference picture lists construction

This process is invoked at the beginning of decoding of each P, SP, or B slice.

Decoded reference pictures are marked as "used for short-term reference" or "used for long-term reference" as specified by the bitstream and specified in subclause 8.2.5. Short-term reference pictures are identified by the value of frame_num. Long-term reference pictures are assigned a long-term frame index as specified by the bitstream and specified in subclause 8.2.5.

Subclause 8.2.4.1 is invoked to specify

– the assignment of variables FrameNum, FrameNumWrap, and PicNum to each of the short-term reference pictures, and

– the assignment of variable LongTermPicNum to each of the long-term reference pictures.

Reference pictures are addressed through reference indices as specified in subclause 8.4.2.1. A reference index is an index into a reference picture list. When decoding a P or SP slice, there is a single reference picture list RefPicList0. When decoding a B slice, there is a second independent reference picture list RefPicList1 in addition to RefPicList0.

At the beginning of decoding of each slice, reference picture list RefPicList0, and for B slices RefPicList1, are derived as follows.

– An initial reference picture list RefPicList0 and for B slices RefPicList1 are derived as specified in subclause 8.2.4.2.

– The initial reference picture list RefPicList0 and for B slices RefPicList1 are modified as specified in subclause 8.2.4.3.

NOTE – The reordering process for reference picture lists specified in subclause 8.2.4.3 allows the contents of RefPicList0 and for B slices RefPicList1 to be modified in a flexible fashion. In particular, it is possible for a picture that is currently marked "used for reference" to be inserted into RefPicList0 and for B slices RefPicList1 even when the picture is not in the initial reference picture list derived as specified in subclause 8.2.4.2.

The number of entries in the modified reference picture list RefPicList0 is num_ref_idx_l0_active_minus1 + 1, and for B slices the number of entries in the modified reference picture list RefPicList1 is num_ref_idx_l1_active_minus1 + 1. A reference picture may appear at more than one index in the modified reference picture lists RefPicList0 or RefPicList1.

8.2.4.1 Decoding process for picture numbers

This process is invoked when the decoding process for reference picture lists construction specified in subclause 8.2.4 or the decoded reference picture marking process specified in subclause 8.2.5 is invoked.

The variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum are used for the initialisation process for reference picture lists in subclause 8.2.4.2, the modification process for reference picture lists in subclause 8.2.4.3, and for the decoded reference picture marking process in subclause 8.2.5.

To each short-term reference picture the variables FrameNum and FrameNumWrap are assigned as follows. First, FrameNum is set equal to the syntax element frame_num that has been decoded in the slice header(s) of the corresponding short-term reference picture. Then the variable FrameNumWrap is derived as

```
if( FrameNum > frame_num )
    FrameNumWrap = FrameNum – MaxFrameNum                    (8-28)
else
    FrameNumWrap = FrameNum
```

where the value of frame_num used in Equation 8-28 is the frame_num in the slice header(s) for the current picture.

Each long-term reference picture has an associated value of LongTermFrameIdx (that was assigned to it as specified in subclause 8.2.5).

To each short-term reference picture a variable PicNum is assigned, and to each long-term reference picture a variable LongTermPicNum is assigned. The values of these variables depend on the value of field_pic_flag and bottom_field_flag for the current picture and they are set as follows.

– If field_pic_flag is equal to 0, the following applies.
  – For each short-term reference frame or complementary reference field pair:

    PicNum = FrameNumWrap (8-29)

  – For each long-term reference frame or long-term complementary reference field pair:

    LongTermPicNum = LongTermFrameIdx (8-30)

    NOTE – When decoding a frame the value of MbaffFrameFlag has no influence on the derivations in subclauses 8.2.4.2, 8.2.4.3, and 8.2.5.

– Otherwise (field_pic_flag is equal to 1), the following applies.
  – For each short-term reference field the following applies.
    – If the reference field has the same parity as the current field

      PicNum = 2 * FrameNumWrap + 1 (8-31)

    – Otherwise (the reference field has the opposite parity of the current field),

      PicNum = 2 * FrameNumWrap (8-32)

  – For each long-term reference field the following applies.
    – If the reference field has the same parity as the current field

      LongTermPicNum = 2 * LongTermFrameIdx + 1 (8-33)

    – Otherwise (the reference field has the opposite parity of the current field),

      LongTermPicNum = 2 * LongTermFrameIdx (8-34)

8.2.4.2 Initialisation process for reference picture lists

This initialisation process is invoked when decoding a P, SP, or B slice header.

RefPicList0 and RefPicList1 have initial entries as specified in subclauses 8.2.4.2.1 through 8.2.4.2.5.

When the number of entries in the initial RefPicList0 or RefPicList1 produced as specified in subclauses 8.2.4.2.1 through 8.2.4.2.5 is greater than num_ref_idx_l0_active_minus1 + 1 or num_ref_idx_l1_active_minus1 + 1, respectively, the extra entries past position num_ref_idx_l0_active_minus1 or num_ref_idx_l1_active_minus1 are discarded from the initial reference picture list.

When the number of entries in the initial RefPicList0 or RefPicList1 produced as specified in subclauses 8.2.4.2.1 through 8.2.4.2.5 is less than num_ref_idx_l0_active_minus1 + 1 or num_ref_idx_l1_active_minus1 + 1, respectively, the remaining entries in the initial reference picture list are set equal to "no reference picture".

8.2.4.2.1 Initialisation process for the reference picture list for P and SP slices in frames

This initialisation process is invoked when decoding a P or SP slice in a coded frame.

When this process is invoked, there shall be at least one reference frame or complementary reference field pair that is currently marked as "used for short-term reference" or "used for long-term reference".

The reference picture list RefPicList0 is ordered so that short-term reference frames and short-term complementary reference field pairs have lower indices than long-term reference frames and long-term complementary reference field pairs.

The short-term reference frames and complementary reference field pairs are ordered starting with the frame or complementary field pair with the highest PicNum value and proceeding through in descending order to the frame or complementary field pair with the lowest PicNum value.

The long-term reference frames and complementary reference field pairs are ordered starting with the frame or complementary field pair with the lowest LongTermPicNum value and proceeding through in ascending order to the frame or complementary field pair with the highest LongTermPicNum value.

NOTE – A non-paired reference field is not used for inter prediction for decoding a frame, regardless of the value of MbaffFrameFlag.

For example, when three reference frames are marked as "used for short-term reference" with PicNum equal to 300, 302, and 303 and two reference frames are marked as "used for long-term reference" with LongTermPicNum equal to 0 and 3, the initial index order is:

– RefPicList0[0] is set equal to the short-term reference picture with PicNum = 303,

– RefPicList0[1] is set equal to the short-term reference picture with PicNum = 302,

– RefPicList0[2] is set equal to the short-term reference picture with PicNum = 300,

– RefPicList0[3] is set equal to the long-term reference picture with LongTermPicNum = 0, and

– RefPicList0[4] is set equal to the long-term reference picture with LongTermPicNum = 3.

8.2.4.2.2 Initialisation process for the reference picture list for P and SP slices in fields

This initialisation process is invoked when decoding a P or SP slice in a coded field.

Each field included in the reference picture list RefPicList0 has a separate index in the reference picture list RefPicList0.

NOTE – When decoding a field, there are effectively at least twice as many pictures available for referencing as there would be when decoding a frame at the same position in decoding order.

Two ordered lists of reference frames, refFrameList0ShortTerm and refFrameList0LongTerm, are derived as follows. For purposes of the formation of this list of frames, decoded reference frames, complementary reference field pairs, non-paired reference fields and reference frames in which a single field is marked "used for short-term reference" or "used for long-term reference" are all considered reference frames.

– All frames having one or more fields marked "used for short-term reference" are included in the list of short-term reference frames refFrameList0ShortTerm. When the current field is the second field (in decoding order) of a complementary reference field pair and the first field is marked as "used for short-term reference", the first field is included in the list of short-term reference frames refFrameList0ShortTerm. refFrameList0ShortTerm is ordered starting with the reference frame with the highest FrameNumWrap value and proceeding through in descending order to the reference frame with the lowest FrameNumWrap value.

– All frames having one or more fields marked "used for long-term reference" are included in the list of long-term reference frames refFrameList0LongTerm. When the current field is the second field (in decoding order) of a complementary reference field pair and the first field is marked as "used for long-term reference, the first field is included in the list of long-term reference frames refFrameList0LongTerm. refFrameList0LongTerm is ordered

starting with the reference frame with the lowest LongTermFrameIdx value and proceeding through in ascending order to the reference frame with the highest LongTermFrameIdx value.

The process specified in subclause 8.2.4.2.5 is invoked with refFrameList0ShortTerm and refFrameList0LongTerm given as input and the output is assigned to RefPicList0.

8.2.4.2.3 Initialisation process for reference picture lists for B slices in frames

This initialisation process is invoked when decoding a B slice in a coded frame.

For purposes of the formation of the reference picture lists RefPicList0 and RefPicList1 the term reference entry refers in the following to decoded reference frames or complementary reference field pairs.

When this process is invoked, there shall be at least one reference entry that is currently marked as "used for short-term reference" or "used for long-term reference".

For B slices, the order of short-term reference entries in the reference picture lists RefPicList0 and RefPicList1 depends on output order, as given by PicOrderCnt( ). When pic_order_cnt_type is equal to 0, reference pictures that are marked as "non-existing" as specified in subclause 8.2.5.2 are not included in either RefPicList0 or RefPicList1.

NOTE 1 – When gaps_in_frame_num_value_allowed_flag is equal to 1, encoders should use reference picture list reordering to ensure proper operation of the decoding process (particularly when pic_order_cnt_type is equal to 0, in which case PicOrderCnt( ) is not inferred for "non-existing" frames).

The reference picture list RefPicList0 is ordered such that short-term reference entries have lower indices than long-term reference entries. It is ordered as follows.

– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt(entryShortTerm) less than PicOrderCnt(CurrPic), these values of entryShortTerm are placed at the beginning of refPicList0 in descending order of PicOrderCnt(entryShortTerm). All of the remaining values of entryShortTerm (when present) are then appended to refPicList0 in ascending order of PicOrderCnt(entryShortTerm).

– The long-term reference entries are ordered starting with the long-term reference entry that has the lowest LongTermPicNum value and proceeding through in ascending order to the long-term reference entry that has the highest LongTermPicNum value.

The reference picture list RefPicList1 is ordered so that short-term reference entries have lower indices than long-term reference entries. It is ordered as follows.

– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt(entryShortTerm) greater than PicOrderCnt(CurrPic), these values of entryShortTerm are placed at the beginning of refPicList1 in ascending order of PicOrderCnt(entryShortTerm). All of the remaining values of entryShortTerm (when present) are then appended to refPicList1 in descending order of PicOrderCnt(entryShortTerm).

– Long-term reference entries are ordered starting with the long-term reference frame or complementary reference field pair that has the lowest LongTermPicNum value and proceeding through in ascending order to the long-term reference entry that has the highest LongTermPicNum value.

– When the reference picture list RefPicList1 has more than one entry and RefPicList1 is identical to the reference picture list RefPicList0, the first two entries RefPicList1[0] and RefPicList1[1] are switched.

NOTE 2 – A non-paired reference field is not used for inter prediction of frames (independent of the value of MbaffFrameFlag).

8.2.4.2.4 Initialisation process for reference picture lists for B slices in fields

This initialisation process is invoked when decoding a B slice in a coded field.

When decoding a field, each field of a stored reference frame is identified as a separate reference picture with a unique index. The order of short-term reference pictures in the reference picture lists RefPicList0 and RefPicList1 depend on output order, as given by PicOrderCnt( ). When pic_order_cnt_type is equal to 0, reference pictures that are marked as "non-existing" as specified in subclause 8.2.5.2 are not included in either RefPicList0 or RefPicList1.

NOTE 1 – When gaps_in_frame_num_value_allowed_flag is equal to 1, encoders should use reference picture list reordering to ensure proper operation of the decoding process (particularly when pic_order_cnt_type is equal to 0, in which case PicOrderCnt( ) is not inferred for "non-existing" frames).

NOTE 2 – When decoding a field, there are effectively at least twice as many pictures available for referencing as there would be when decoding a frame at the same position in decoding order.

Three ordered lists of reference frames, refFrameList0ShortTerm, refFrameList1ShortTerm and refFrameListLongTerm, are derived as follows. For purposes of the formation of these lists of frames the term reference entry refers in the following to decoded reference frames, complementary reference field pairs, or non-paired reference

fields. When pic_order_cnt_type is equal to 0, the term reference entry does not refer to frames that are marked as "non-existing" as specified in subclause 8.2.5.2.

– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt(entryShortTerm) less than or equal to PicOrderCnt(CurrPic), these values of entryShortTerm are placed at the beginning of refFrameList0ShortTerm in descending order of PicOrderCnt(entryShortTerm). All of the remaining values of entryShortTerm (when present) are then appended to refFrameList0ShortTerm in ascending order of PicOrderCnt(entryShortTerm).

  NOTE 3 – When the current field follows in decoding order a coded field fldPrev with which together it forms a complementary reference field pair, fldPrev is included into the list refFrameList0ShortTerm using PicOrderCnt(fldPrev) and the ordering method described in the previous sentence is applied.

– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt(entryShortTerm) greater than PicOrderCnt(CurrPic), these values of entryShortTerm are placed at the beginning of refFrameList1ShortTerm in ascending order of PicOrderCnt(entryShortTerm). All of the remaining values of entryShortTerm (when present) are then appended to refFrameList1ShortTerm in descending order of PicOrderCnt(entryShortTerm).

  NOTE 4 – When the current field follows in decoding order a coded field fldPrev with which together it forms a complementary reference field pair, fldPrev is included into the list refFrameList1ShortTerm using PicOrderCnt(fldPrev) and the ordering method described in the previous sentence is applied.

– refFrameListLongTerm is ordered starting with the reference entry having the lowest LongTermFrameIdx value and proceeding through in ascending order to the reference entry having highest LongTermFrameIdx value.

  NOTE 5 – When the complementary field of the current picture is marked "used for long-term reference" it is included into the list refFrameListLongTerm. A reference entry in which only one field is marked as “used for long-term reference” is included into the list refFrameListLongTerm.

The process specified in subclause 8.2.4.2.5 is invoked with refFrameList0ShortTerm and refFrameListLongTerm given as input and the output is assigned to RefPicList0.

The process specified in subclause 8.2.4.2.5 is invoked with refFrameList1ShortTerm and refFrameListLongTerm given as input and the output is assigned to RefPicList1.

When the reference picture list RefPicList1 has more than one entry and RefPicList1 is identical to the reference picture list RefPicList0, the first two entries RefPicList1[0] and RefPicList1[1] are switched.

8.2.4.2.5 Initialisation process for reference picture lists in fields

Inputs of this process are the reference frame lists refFrameListXShortTerm (with X may be 0 or 1) and refFrameListLongTerm.

The reference picture list RefPicListX is a list ordered such that short-term reference fields have lower indices than long-term reference fields. Given the reference frame lists refFrameListXShortTerm and refFrameListLongTerm, it is derived as follows.

– Short-term reference fields are ordered by selecting reference fields from the ordered list of frames refFrameListXShortTerm by alternating between fields of differing parity, starting with a field that has the same parity as the current field (when present). When one field of a reference frame was not decoded or is not marked as “used for short-term reference”, the missing field is ignored and instead the next available stored reference field of the chosen parity from the ordered list of frames refFrameListXShortTerm is inserted into RefPicListX. When there are no more short-term reference fields of the alternate parity in the ordered list of frames refFrameListXShortTerm, the next not yet indexed fields of the available parity are inserted into RefPicListX in the order in which they occur in the ordered list of frames refFrameListXShortTerm.

– Long-term reference fields are ordered by selecting reference fields from the ordered list of frames refFrameListLongTerm by alternating between fields of differing parity, starting with a field that has the same parity as the current field (when present). When one field of a reference frame was not decoded or is not marked as “used for long-term reference”, the missing field is ignored and instead the next available stored reference field of the chosen parity from the ordered list of frames refFrameListLongTerm is inserted into RefPicListX. When there are no more long-term reference fields of the alternate parity in the ordered list of frames refFrameListLongTerm, the next not yet indexed fields of the available parity are inserted into RefPicListX in the order in which they occur in the ordered list of frames refFrameListLongTerm.

8.2.4.3 Reordering process for reference picture lists

When ref_pic_list_reordering_flag_l0 is equal to 1, the following applies.

– Let refIdxL0 be an index into the reference picture list RefPicList0. It is initially set equal to 0.

– The corresponding syntax elements reordering_of_pic_nums_idc are processed in the order they occur in the bitstream. For each of these syntax elements, the following applies.

  – If reordering_of_pic_nums_idc is equal to 0 or equal to 1, the process specified in subclause 8.2.4.3.1 is invoked with refIdxL0 as input, and the output is assigned to refIdxL0.

  – Otherwise, if reordering_of_pic_nums_idc is equal to 2, the process specified in subclause 8.2.4.3.2 is invoked with refIdxL0 as input, and the output is assigned to refIdxL0.

  – Otherwise (reordering_of_pic_nums_idc is equal to 3), the reordering process for reference picture list RefPicList0 is finished.

When ref_pic_list_reordering_flag_l1 is equal to 1, the following applies.

– Let refIdxL1 be an index into the reference picture list RefPicList1. It is initially set equal to 0.

– The corresponding syntax elements reordering_of_pic_nums_idc are processed in the order they occur in the bitstream. For each of these syntax elements, the following applies.

  – If reordering_of_pic_nums_idc is equal to 0 or equal to 1, the process specified in subclause 8.2.4.3.1 is invoked with refIdxL1 as input, and the output is assigned to refIdxL1.

  – Otherwise, if reordering_of_pic_nums_idc is equal to 2, the process specified in subclause 8.2.4.3.2 is invoked with refIdxL1 as input, and the output is assigned to refIdxL1.

  – Otherwise (reordering_of_pic_nums_idc is equal to 3), the reordering process for reference picture list RefPicList1 is finished.

8.2.4.3.1 Reordering process of reference picture lists for short-term reference pictures

Input to this process is an index refIdxLX (with X being 0 or 1).

Output of this process is an incremented index refIdxLX.

The variable picNumLXNoWrap is derived as follows.

– If reordering_of_pic_nums_idc is equal to 0

```
if( picNumLXPred – ( abs_diff_pic_num_minus1 + 1 ) < 0 )
      picNumLXNoWrap = picNumLXPred – ( abs_diff_pic_num_minus1 + 1 ) + MaxPicNum        (8-35)
else
      picNumLXNoWrap = picNumLXPred – ( abs_diff_pic_num_minus1 + 1 )
```

– Otherwise (reordering_of_pic_nums_idc is equal to 1),

```
if( picNumLXPred + ( abs_diff_pic_num_minus1 + 1 )  >=  MaxPicNum )
      picNumLXNoWrap = picNumLXPred + ( abs_diff_pic_num_minus1 + 1 ) – MaxPicNum        (8-36)
else
      picNumLXNoWrap = picNumLXPred + ( abs_diff_pic_num_minus1 + 1 )
```

picNumLXPred is the prediction value for the variable picNumLXNoWrap. When the process specified in this subclause is invoked the first time for a slice (that is, for the first occurrence of reordering_of_pic_nums_idc equal to 0 or 1 in the ref_pic_list_reordering( ) syntax), picNumL0Pred and picNumL1Pred are initially set equal to CurrPicNum. After each assignment of picNumLXNoWrap, the value of picNumLXNoWrap is assigned to picNumLXPred.

The variable picNumLX is derived as follows

```
if( picNumLXNoWrap > CurrPicNum )
      picNumLX = picNumLXNoWrap – MaxPicNum                                             (8-37)
else
      picNumLX = picNumLXNoWrap
```

picNumLX shall be equal to the PicNum of a reference picture that is marked as “used for short-term reference” and shall not be equal to the PicNum of a short-term reference picture that is marked as "non-existing".

The following procedure is conducted to place the picture with short-term picture number picNumLX into the index position refIdxLX, shift the position of any other remaining pictures to later in the list, and increment the value of refIdxLX.

```
for( cIdx = num_ref_idx_lX_active_minus1 + 1; cIdx > refIdxLX; cIdx-- )
    RefPicListX[ cIdx ] = RefPicListX[ cIdx – 1]
RefPicListX[ refIdxLX++ ] = short-term reference picture with PicNum equal to picNumLX
nIdx = refIdxLX
for( cIdx = refIdxLX; cIdx <= num_ref_idx_lX_active_minus1 + 1; cIdx++ )                    (8-38)
    if( PicNumF( RefPicListX[ cIdx ] ) != picNumLX )
        RefPicListX[ nIdx++ ] = RefPicListX[ cIdx ]
```

where the function PicNumF(RefPicListX[cIdx]) is derived as follows:

– If the picture RefPicListX[cIdx] is marked as "used for short-term reference", PicNumF(RefPicListX[cIdx]) is the PicNum of the picture RefPicListX[cIdx].

– Otherwise (the picture RefPicListX[cIdx] is not marked as "used for short-term reference"), PicNumF(RefPicListX[cIdx]) is equal to MaxPicNum.

NOTE 1 – A value of MaxPicNum can never be equal to picNumLX.

NOTE 2 – Within this pseudo-code procedure, the length of the list RefPicListX is temporarily made one element longer than the length needed for the final list. After the execution of this procedure, only elements 0 through num_ref_idx_lX_active_minus1 of the list need to be retained.

8.2.4.3.2 Reordering process of reference picture lists for long-term reference pictures

Input to this process is an index refIdxLX (with X being 0 or 1).

Output of this process is an incremented index refIdxLX.

The following procedure is conducted to place the picture with long-term picture number long_term_pic_num into the index position refIdxLX, shift the position of any other remaining pictures to later in the list, and increment the value of refIdxLX.

```
for( cIdx = num_ref_idx_lX_active_minus1 + 1; cIdx > refIdxLX; cIdx-- )
    RefPicListX[ cIdx ] = RefPicListX[ cIdx – 1]
RefPicListX[ refIdxLX++ ] = long-term reference picture with LongTermPicNum equal to long_term_pic_num
nIdx = refIdxLX
for( cIdx = refIdxLX; cIdx <= num_ref_idx_lX_active_minus1 + 1; cIdx++ )                    (8-39)
    if( LongTermPicNumF( RefPicListX[ cIdx ] ) != long_term_pic_num )
        RefPicListX[ nIdx++ ] = RefPicListX[ cIdx ]
```

where the function LongTermPicNumF(RefPicListX[cIdx]) is derived as follows:

– If the picture RefPicListX[cIdx] is marked as "used for long-term reference", LongTermPicNumF(RefPicListX[cIdx]) is the LongTermPicNum of the picture RefPicListX[cIdx].

– Otherwise (the picture RefPicListX[cIdx] is not marked as "used for long-term reference"), LongTermPicNumF(RefPicListX[cIdx]) is equal to 2 * (MaxLongTermFrameIdx + 1).

NOTE 1 – A value of 2 * (MaxLongTermFrameIdx + 1) can never be equal to long_term_pic_num.

NOTE 2 – Within this pseudo-code procedure, the length of the list RefPicListX is temporarily made one element longer than the length needed for the final list. After the execution of this procedure, only elements 0 through num_ref_idx_lX_active_minus1 of the list need to be retained.

8.2.5 Decoded reference picture marking process

This process is invoked for decoded pictures when nal_ref_idc is not equal to 0.

NOTE – The decoding process for gaps in frame_num that is specified in subclause 8.2.5.2 may also be invoked when nal_ref_idc is equal to 0, as specified in clause 8.

A decoded picture with nal_ref_idc not equal to 0, referred to as a reference picture, is marked as “used for short-term reference” or "used for long-term reference". For a decoded reference frame, both of its fields are marked the same as the frame. For a complementary reference field pair, the pair is marked the same as both of its fields. A picture that is marked as "used for short-term reference" is identified by its FrameNum and, when it is a field, by its parity. A picture that is marked as "used for long-term reference" is identified by its LongTermFrameIdx and, when it is a field, by its parity.

Frames or complementary field pairs marked as “used for short-term reference” or as "used for long-term reference" can be used as a reference for inter prediction when decoding a frame until the frame, the complementary field pair, or one of its constituent fields is marked as “unused for reference”. A field marked as “used for short-term reference” or as

"used for long-term reference" can be used as a reference for inter prediction when decoding a field until marked as “unused for reference”.

A picture can be marked as "unused for reference" by the sliding window reference picture marking process, a first-in, first-out mechanism specified in subclause 8.2.5.3 or by the adaptive memory control reference picture marking process, a customised adaptive marking operation specified in subclause 8.2.5.4.

A short-term reference picture is identified for use in the decoding process by its variables FrameNum and FrameNumWrap and its picture number PicNum, and a long-term reference picture is identified for use in the decoding process by its long-term picture number LongTermPicNum. When the current picture is not an IDR picture, subclause 8.2.4.1 is invoked to specify the assignment of the variables FrameNum, FrameNumWrap, PicNum and LongTermPicNum.

8.2.5.1 Sequence of operations for decoded reference picture marking process

Decoded reference picture marking proceeds in the following ordered steps.

1. All slices of the current picture are decoded.
2. Depending on whether the current picture is an IDR picture, the following applies.
   - If the current picture is an IDR picture, the following applies.
     - All reference pictures are marked as "unused for reference"
     - Depending on long_term_reference_flag, the following applies.
       - If long_term_reference_flag is equal to 0, the IDR picture is marked as "used for short-term reference" and MaxLongTermFrameIdx is set equal to “no long-term frame indices”.
       - Otherwise (long_term_reference_flag is equal to 1), the IDR picture is marked as "used for long-term reference", the LongTermFrameIdx for the IDR picture is set equal to 0, and MaxLongTermFrameIdx is set equal to 0.
   - Otherwise (the current picture is not an IDR picture), the following applies.
     - If adaptive_ref_pic_marking_mode_flag is equal to 0, the process specified in subclause 8.2.5.3 is invoked.
     - Otherwise (adaptive_ref_pic_marking_mode_flag is equal to 1), the process specified in subclause 8.2.5.4 is invoked.
3. When the current picture is not an IDR picture and it was not marked as "used for long-term reference" by memory_management_control_operation equal to 6, it is marked as "used for short-term reference".

After marking the current decoded reference picture, the total number of frames with at least one field marked as “used for reference”, plus the number of complementary field pairs with at least one field marked as “used for reference”, plus the number of non-paired fields marked as “used for reference” shall not be greater than Max(num_ref_frames, 1).

8.2.5.2 Decoding process for gaps in frame_num

This process is invoked when frame_num is not equal to PrevRefFrameNum and is not equal to (PrevRefFrameNum + 1) % MaxFrameNum.

NOTE 1 – Although this process is specified as a subclause within subclause 8.2.5 (which defines a process that is invoked only when nal_ref_idc is not equal to 0), this process may also be invoked when nal_ref_idc is equal to 0 (as specified in clause 8). The reasons for the location of this subclause within the structure of this Recommendation | International Standard are historical.

NOTE 2 – This process can only be invoked for a conforming bitstream when gaps_in_frame_num_value_allowed_flag is equal to 1. When gaps_in_frame_num_value_allowed_flag is equal to 0 and frame_num is not equal to PrevRefFrameNum and is not equal to (PrevRefFrameNum + 1) % MaxFrameNum, the decoding process should infer an unintentional loss of pictures.

When this process is invoked, a set of values of frame_num pertaining to “non-existing” pictures is derived as all values taken on by UnusedShortTermFrameNum in Equation 7-21 except the value of frame_num for the current picture.

The decoding process generates and marks a frame for each of the values of frame_num pertaining to “non-existing” pictures, in the order in which the values of UnusedShortTermFrameNum are generated by Equation 7-21, using the “sliding window” picture marking process as specified in subclause 8.2.5.3. The generated frames are also marked as “non-existing” and “used for short-term reference”. The sample values of the generated frames may be set to any value. The bitstream shall not contain data that results in a reference to these generated frames which are marked as “non-existing” in the inter prediction process, a reference to these frames in the reordering commands for reference picture lists for short-term reference pictures (subclause 8.2.4.3.1), or a reference to these frames in the assignment process of a LongTermFrameIdx to a short-term reference picture (subclause 8.2.5.4.3).

When pic_order_cnt_type is not equal to 0, TopFieldOrderCnt and BottomFieldOrderCnt are derived for each of the "non-existing" frames by invoking the decoding process for picture order count in subclause 8.2.1. When invoking the process in subclause 8.2.1 for a particular "non-existing" frame, the current picture is considered to be a picture considered having frame_num inferred to be equal to UnusedShortTermFrameNum, nal_ref_idc inferred to be not equal to 0, nal_unit_type inferred to be not equal to 5, field_pic_flag inferred to be equal to 0, adaptive_ref_pic_marking_mode_flag inferred to be equal to 0, delta_pic_order_cnt[0] (if needed) inferred to be equal to 0, and delta_pic_order_cnt[1] (if needed) inferred to be equal to 0.

NOTE 3 – The decoding process should infer an unintentional picture loss when any of these values of frame_num pertaining to "non-existing" pictures is referred to in the inter prediction process, is referred to in the reordering commands for reference picture lists for short-term reference pictures (subclause 8.2.4.3.1), or is referred to in the assignment process of a LongTermFrameIdx to a short-term reference picture (subclause 8.2.5.4.3). The decoding process should not infer an unintentional picture loss when a memory management control operation not equal to 3 is applied to a frame marked as "non-existing".

8.2.5.3 Sliding window decoded reference picture marking process

This process is invoked when adaptive_ref_pic_marking_mode_flag is equal to 0.

Depending on the properties of the current picture as specified below, the following applies.

– If the current picture is a coded field that is the second field in decoding order of a complementary reference field pair, and the first field has been marked as "used for short-term reference", the current picture is also marked as "used for short-term reference".

– Otherwise, the following applies.

  – Let numShortTerm be the total number of reference frames, complementary reference field pairs and non-paired reference fields for which at least one field is marked as "used for short-term reference". Let numLongTerm be the total number of reference frames, complementary reference field pairs and non-paired reference fields for which at least one field is marked as "used for long-term reference".

  – When numShortTerm + numLongTerm is equal to Max(num_ref_frames, 1), the condition that numShortTerm is greater than 0 shall be fulfilled, and the short-term reference frame, complementary reference field pair or non-paired reference field that has the smallest value of FrameNumWrap is marked as "unused for reference". When it is a frame or a complementary field pair, both of its fields are also marked as "unused for reference".

8.2.5.4 Adaptive memory control decoded reference picture marking process

This process is invoked when adaptive_ref_pic_marking_mode_flag is equal to 1.

The memory_management_control_operation commands with values of 1 to 6 are processed in the order they occur in the bitstream after the current picture has been decoded. For each of these memory_management_control_operation commands, one of the processes specified in subclauses 8.2.5.4.1 to 8.2.5.4.5 is invoked depending on the value of memory_management_control_operation. The memory_management_control_operation command with value of 0 specifies the end of memory_management_control_operation commands.

Memory management control operations are applied to pictures as follows.

– If field_pic_flag is equal to 0, memory_management_control_operation commands are applied to the frames or complementary reference field pairs specified.

– Otherwise (field_pic_flag is equal to 1), memory_management_control_operation commands are applied to the individual reference fields specified.

8.2.5.4.1 Marking process of a short-term reference picture as "unused for reference"

This process is invoked when memory_management_control_operation is equal to 1.

Let picNumX be specified by

$$picNumX = CurrPicNum - (difference\_of\_pic\_nums\_minus1 + 1). \quad (8\text{-}40)$$

Depending on field_pic_flag the value of picNumX is used to mark a short-term reference picture as "unused for reference" as follows.

– If field_pic_flag is equal to 0, the short-term reference frame or short-term complementary reference field pair specified by picNumX and both of its fields are marked as "unused for reference".

– Otherwise (field_pic_flag is equal to 1), the short-term reference field specified by picNumX is marked as "unused for reference". When that reference field is part of a reference frame or a complementary reference field pair, the

frame or complementary field pair is also marked as "unused for reference", but the marking of the other field is not changed.

8.2.5.4.2 Marking process of a long-term reference picture as “unused for reference”

This process is invoked when memory_management_control_operation is equal to 2.

Depending on field_pic_flag the value of LongTermPicNum is used to mark a long-term reference picture as “unused for reference” as follows.

– If field_pic_flag is equal to 0, the long-term reference frame or long-term complementary reference field pair having LongTermPicNum equal to long_term_pic_num and both of its fields are marked as “unused for reference”.

– Otherwise (field_pic_flag is equal to 1), the long-term reference field specified by LongTermPicNum equal to long_term_pic_num is marked as “unused for reference”. When that reference field is part of a reference frame or a complementary reference field pair, the frame or complementary field pair is also marked as "unused for reference", but the marking of the other field is not changed.

8.2.5.4.3 Assignment process of a LongTermFrameIdx to a short-term reference picture

This process is invoked when memory_management_control_operation is equal to 3.

Given the syntax element difference_of_pic_nums_minus1, the variable picNumX is obtained as specified in subclause 8.2.5.4.1. picNumX shall refer to a frame or complementary reference field pair or non-paired reference field marked as "used for short-term reference" and not marked as "non-existing".

When LongTermFrameIdx equal to long_term_frame_idx is already assigned to a long-term reference frame or a long-term complementary reference field pair, that frame or complementary field pair and both of its fields are marked as "unused for reference". When LongTermFrameIdx is already assigned to a non-paired reference field, and the field is not the complementary field of the picture specified by picNumX, that field is marked as “unused for reference”.

Depending on field_pic_flag the value of LongTermFrameIdx is used to mark a picture from "used for short-term reference" to "used for long-term reference" as follows.

– If field_pic_flag is equal to 0, the marking of the short-term reference frame or short-term complementary reference field pair specified by picNumX and both of its fields are changed from "used for short-term reference" to "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

– Otherwise (field_pic_flag is equal to 1), the marking of the short-term reference field specified by picNumX is changed from "used for short-term reference" to "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx. When the field is part of a reference frame or a complementary reference field pair, and the other field of the same reference frame or complementary reference field pair is also marked as "used for long-term reference", the reference frame or complementary reference field pair is also marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

8.2.5.4.4 Decoding process for MaxLongTermFrameIdx

This process is invoked when memory_management_control_operation is equal to 4.

All pictures for which LongTermFrameIdx is greater than max_long_term_frame_idx_plus1 – 1 and that are marked as "used for long-term reference" are marked as “unused for reference”.

The variable MaxLongTermFrameIdx is derived as follows.

– If max_long_term_frame_idx_plus1 is equal to 0, MaxLongTermFrameIdx is set equal to “no long-term frame indices”.

– Otherwise (max_long_term_frame_idx_plus1 is greater than 0), MaxLongTermFrameIdx is set equal to max_long_term_frame_idx_plus1 – 1.

NOTE – The memory_management_control_operation command equal to 4 can be used to mark long-term reference pictures as “unused for reference”. The frequency of transmitting max_long_term_frame_idx_plus1 is not specified by this Recommendation | International Standard. However, the encoder should send a memory_management_control_operation command equal to 4 upon receiving an error message, such as an intra refresh request message.

8.2.5.4.4.1 Marking process of all reference pictures as “unused for reference” and setting MaxLongTermFrameIdx to “no long-term frame indices”

This process is invoked when memory_management_control_operation is equal to 5.

All reference pictures are marked as “unused for reference” and the variable MaxLongTermFrameIdx is set equal to “no long-term frame indices”.

8.2.5.4.5 Process for assigning a long-term frame index to the current picture

This process is invoked when memory_management_control_operation is equal to 6.

When a variable LongTermFrameIdx equal to long_term_frame_idx is already assigned to a long-term reference frame or a long-term complementary reference field pair, that frame or complementary field pair and both of its fields are marked as "unused for reference". When LongTermFrameIdx is already assigned to a non-paired reference field, and the field is not the complementary field of the current picture, that field is marked as “unused for reference”.

The current picture is marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

When field_pic_flag is equal to 0, both its fields are also marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

When field_pic_flag is equal to 1 and the current picture is the second field (in decoding order) of a complementary reference field pair, and the first field of the complementary reference field pair is also currently marked as "used for long-term reference), the complementary reference field pair is also marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

After marking the current decoded reference picture, the total number of frames with at least one field marked as “used for reference”, plus the number of complementary field pairs with at least one field marked as “used for reference”, plus the number of non-paired fields marked as “used for reference” shall not be greater than Max(num_ref_frames, 1).

NOTE – Under some circumstances, the above statement may impose a constraint on the order in which a memory_management_control_operation syntax element equal to 6 can appear in the decoded reference picture marking syntax relative to a memory_management_control_operation syntax element equal to 1, 2, or 4.

8.3 Intra prediction process

This process is invoked for I and SI macroblock types.

Inputs to this process are constructed samples prior to the deblocking filter process and, for Intra_NxN prediction modes (where NxN is equal to 4x4 or 8x8), the values of IntraNxNPredMode from neighbouring macroblocks.

Outputs of this process are specified as follows.

– If the macroblock prediction mode is Intra_4x4 or Intra_8x8, the outputs are constructed luma samples prior to the deblocking filter process and (when chroma_format_idc is not equal to 0) chroma prediction samples of the macroblock $pred_C$, where C is equal to Cb and Cr.

– Otherwise, if mb_type is not equal to I_PCM, the outputs are luma prediction samples of the macroblock $pred_L$ and (when chroma_format_idc is not equal to 0) chroma prediction samples of the macroblock $pred_C$, where C is equal to Cb and Cr.

– Otherwise (mb_type is equal to I_PCM), the outputs are constructed luma and (when chroma_format_idc is not equal to 0) chroma samples prior to the deblocking filter process.

The variable MvCnt is set equal to 0.

Depending on the value of mb_type the following applies.

– If mb_type is equal to I_PCM, the process specified in subclause 8.3.5 is invoked.

– Otherwise (mb_type is not equal to I_PCM), the following applies.

  – The decoding processes for Intra prediction modes are described for the luma component as follows.

    – If the macroblock prediction mode is equal to Intra_4x4, the specification in subclause 8.3.1 applies.

    – Otherwise, if the macroblock prediction mode is equal to Intra_8x8, the specification in subclause 8.3.2 applies.

    – Otherwise (the macroblock prediction mode is equal to Intra_16x16), the specification in subclause 8.3.3 applies.

  – The decoding processes for Intra prediction modes for the chroma components are described in subclause 8.3.4. This process is only invoked when chroma_format_idc is not equal to 0 (monochrome).

Samples used in the Intra prediction process are the sample values prior to alteration by any deblocking filter operation.

8.3.1 Intra_4x4 prediction process for luma samples

This process is invoked when the macroblock prediction mode is equal to Intra_4x4.

Inputs to this process are the values of Intra4x4PredMode (if available) or Intra8x8PredMode (if available) from neighbouring macroblocks or macroblock pairs.

The luma component of a macroblock consists of 16 blocks of 4x4 luma samples. These blocks are inverse scanned using the 4x4 luma block inverse scanning process as specified in subclause 6.4.3.

For all 4x4 luma blocks of the luma component of a macroblock with luma4x4BlkIdx = 0..15, the derivation process for the Intra4x4PredMode as specified in subclause 8.3.1.1 is invoked with luma4x4BlkIdx as well as Intra4x4PredMode and Intra8x8PredMode that are previously (in decoding order) derived for adjacent macroblocks as the input and the variable Intra4x4PredMode[luma4x4BlkIdx] as the output.

For each luma block of 4x4 samples indexed using luma4x4BlkIdx = 0..15,

1. The Intra_4x4 sample prediction process in subclause 8.3.1.2 is invoked with luma4x4BlkIdx and constructed samples prior (in decoding order) to the deblocking filter process from adjacent luma blocks as the input and the output are the Intra_4x4 luma prediction samples $pred4x4_L[x, y]$ with x, y = 0..3.
2. The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the current macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (xO, yO) and x, y = 0..3.

$$pred_L[xO + x, yO + y] = pred4x4_L[x, y] \quad (8\text{-}41)$$

3. The transform coefficient decoding process and picture construction process prior to deblocking filter process in subclause 8.5 is invoked with $pred_L$ and luma4x4BlkIdx as the input and the constructed samples for the current 4x4 luma block S'_L as the output.

8.3.1.1 Derivation process for the Intra4x4PredMode

Inputs to this process are the index of the 4x4 luma block luma4x4BlkIdx and variable arrays Intra4x4PredMode (if available) and Intra8x8PredMode (if available) that are previously (in decoding order) derived for adjacent macroblocks.

Output of this process is the variable Intra4x4PredMode[luma4x4BlkIdx].

Table 8-2 specifies the values for Intra4x4PredMode[luma4x4BlkIdx] and the associated names.

Table 8-2 – Specification of Intra4x4PredMode[luma4x4BlkIdx] and associated names

Intra4x4PredMode[luma4x4BlkIdx]	Name of Intra4x4PredMode[luma4x4BlkIdx]
0	Intra_4x4_Vertical (prediction mode)
1	Intra_4x4_Horizontal (prediction mode)
2	Intra_4x4_DC (prediction mode)
3	Intra_4x4_Diagonal_Down_Left (prediction mode)
4	Intra_4x4_Diagonal_Down_Right (prediction mode)
5	Intra_4x4_Vertical_Right (prediction mode)
6	Intra_4x4_Horizontal_Down (prediction mode)
7	Intra_4x4_Vertical_Left (prediction mode)
8	Intra_4x4_Horizontal_Up (prediction mode)

Intra4x4PredMode[luma4x4BlkIdx] labelled 0, 1, 3, 4, 5, 6, 7, and 8 represent directions of predictions as illustrated in Figure 8-1.

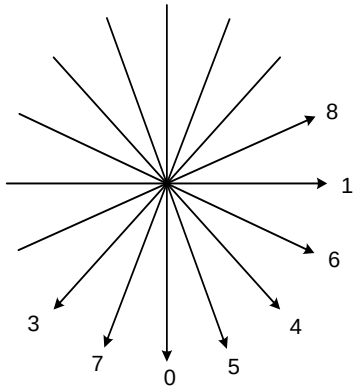


Figure 8-1 – Intra_4x4 prediction mode directions (informative)

Intra4x4PredMode[luma4x4BlkIdx] is derived as follows.

– The process specified in subclause 6.4.8.3 is invoked with luma4x4BlkIdx given as input and the output is assigned to mbAddrA, luma4x4BlkIdxA, mbAddrB, and luma4x4BlkIdxB.

– The variable dcPredModePredictedFlag is derived as follows.

  – If any of the following conditions are true, dcPredModePredictedFlag is set equal to 1

    – the macroblock with address mbAddrA is not available

    – the macroblock with address mbAddrB is not available

    – the macroblock with address mbAddrA is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1

    – the macroblock with address mbAddrB is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1

  – Otherwise, dcPredModePredictedFlag is set equal to 0.

– For N being either replaced by A or B, the variables intraMxMPredModeN are derived as follows.

  – If dcPredModePredictedFlag is equal to 1 or the macroblock with address mbAddrN is not coded in Intra_4x4 or Intra_8x8 macroblock prediction mode, intraMxMPredModeN is set equal to 2 (Intra_4x4_DC prediction mode).

  – Otherwise (dcPredModePredictedFlag is equal to 0 and (the macroblock with address mbAddrN is coded in Intra_4x4 macroblock prediction mode or the macroblock with address mbAddrN is coded in Intra_8x8 macroblock prediction mode)), the following applies.

    – If the macroblock with address mbAddrN is coded in Intra_4x4 macroblock mode, intraMxMPredModeN is set equal to Intra4x4PredMode[luma4x4BlkIdxN], where Intra4x4PredMode is the variable array assigned to the macroblock mbAddrN.

    – Otherwise (the macroblock with address mbAddrN is coded in Intra_8x8 macroblock mode), intraMxMPredModeN is set equal to Intra8x8PredMode[luma4x4BlkIdxN >> 2], where Intra8x8PredMode is the variable array assigned to the macroblock mbAddrN.

– Intra4x4PredMode[luma4x4BlkIdx] is derived by applying the following procedure.

```
predIntra4x4PredMode = Min( intraMxMPredModeA, intraMxMPredModeB )
if( prev_intra4x4_pred_mode_flag[ luma4x4BlkIdx ] )
    Intra4x4PredMode[ luma4x4BlkIdx ] = predIntra4x4PredMode
else                                                                    (8-42)
    if( rem_intra4x4_pred_mode[ luma4x4BlkIdx ] < predIntra4x4PredMode )
        Intra4x4PredMode[ luma4x4BlkIdx ] = rem_intra4x4_pred_mode[ luma4x4BlkIdx ]
    else
        Intra4x4PredMode[ luma4x4BlkIdx ] = rem_intra4x4_pred_mode[ luma4x4BlkIdx ] + 1
```

8.3.1.2 Intra_4x4 sample prediction

This process is invoked for each 4x4 luma block of a macroblock with prediction mode equal to Intra_4x4 followed by the transform decoding process and picture construction process prior to deblocking for each 4x4 luma block.

Input to this process is the index of a 4x4 luma block luma4x4BlkIdx.

Output of this process are the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 for the 4x4 luma block with index luma4x4BlkIdx.

The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the current macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (xO, yO).

The 13 neighbouring samples p[x, y] that are constructed luma samples prior to the deblocking filter process, with x = -1, y = -1..3 and x = 0..7, y = -1, are derived as follows.

– The luma location (xN, yN) is specified by

$$xN = xO + x \tag{8-43}$$

$$yN = yO + y \tag{8-44}$$

– The derivation process for neighbouring locations in subclause 6.4.9 is invoked for luma locations with (xN, yN) as input and mbAddrN and (xW, yW) as output.

– Each sample p[x, y] with x = -1, y = -1..3 and x = 0..7, y = -1 is derived as follows.

  – If any of the following conditions is true, the sample p[x, y] is marked as "not available for Intra_4x4 prediction"

    – mbAddrN is not available,

    – the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1.

    – the macroblock mbAddrN has mb_type equal to SI and constrained_intra_pred_flag is equal to 1 and the current macroblock does not have mb_type equal to SI.

    – x is greater than 3 and luma4x4BlkIdx is equal to 3 or 11

  – Otherwise, the sample p[x, y] is marked as "available for Intra_4x4 prediction" and the luma sample at luma location (xW, yW) inside the macroblock mbAddrN is assigned to p[x, y].

When samples p[x, -1], with x = 4..7 are marked as "not available for Intra_4x4 prediction," and the sample p[3, -1] is marked as "available for Intra_4x4 prediction," the sample value of p[3, -1] is substituted for sample values p[x, -1], with x = 4..7 and samples p[x, -1], with x = 4..7 are marked as "available for Intra_4x4 prediction".

NOTE – Each block is assumed to be constructed into a picture array prior to decoding of the next block.

Depending on Intra4x4PredMode[luma4x4BlkIdx], one of the Intra_4x4 prediction modes specified in subclauses 8.3.1.2.1 to 8.3.1.2.9 is invoked.

8.3.1.2.1 Specification of Intra_4x4_Vertical prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 0.

This mode shall be used only when the samples p[x, -1] with x = 0..3 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived by

$$pred4x4_L[x, y] = p[x, -1], \text{ with } x, y = 0..3 \tag{8-45}$$

8.3.1.2.2 Specification of Intra_4x4_Horizontal prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 1.

This mode shall be used only when the samples p[-1, y], with y = 0..3 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived by

$$pred4x4_L[x, y] = p[-1, y], \text{ with } x,y = 0..3 \quad (8\text{-}46)$$

8.3.1.2.3 Specification of Intra_4x4_DC prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 2.

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If all samples p[x, -1], with x = 0..3 and p[-1, y], with y = 0..3 are marked as "available for Intra_4x4 prediction", the values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived by

$$pred4x4_L[x, y] = (p[0, -1] + p[1, -1] + p[2, -1] + p[3, -1] + p[-1, 0] + p[-1, 1] + p[-1, 2] + p[-1, 3] + 4) >> 3 \quad (8\text{-}47)$$

– Otherwise, if any samples p[x, -1], with x = 0..3 are marked as "not available for Intra_4x4 prediction" and all samples p[-1, y], with y = 0..3 are marked as "available for Intra_4x4 prediction", the values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived by

$$pred4x4_L[x, y] = (p[-1, 0] + p[-1, 1] + p[-1, 2] + p[-1, 3] + 2) >> 2 \quad (8\text{-}48)$$

– Otherwise, if any samples p[-1, y], with y = 0..3 are marked as "not available for Intra_4x4 prediction" and all samples p[x, -1], with x = 0 .. 3 are marked as "available for Intra_4x4 prediction", the values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0 .. 3 are derived by

$$pred4x4_L[x, y] = (p[0, -1] + p[1, -1] + p[2, -1] + p[3, -1] + 2) >> 2 \quad (8\text{-}49)$$

– Otherwise (some samples p[x, -1], with x = 0..3 and some samples p[-1, y], with y = 0..3 are marked as "not available for Intra_4x4 prediction"), the values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived by

$$pred4x4_L[x, y] = (1 << (BitDepth_Y - 1)) \quad (8\text{-}50)$$

NOTE – A 4x4 luma block can always be predicted using this mode.

8.3.1.2.4 Specification of Intra_4x4_Diagonal_Down_Left prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 3.

This mode shall be used only when the samples p[x, -1] with x = 0..7 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If x is equal to 3 and y is equal to 3,

$$pred4x4_L[x, y] = (p[6, -1] + 3 * p[7, -1] + 2) >> 2 \quad (8\text{-}51)$$

– Otherwise (x is not equal to 3 or y is not equal to 3),

$$pred4x4_L[x, y] = (p[x + y, -1] + 2 * p[x + y + 1, -1] + p[x + y + 2, -1] + 2) >> 2 \quad (8\text{-}52)$$

8.3.1.2.5 Specification of Intra_4x4_Diagonal_Down_Right prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 4.

This mode shall be used only when the samples p[x, -1] with x = 0..3 and p[-1, y] with y = -1..3 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If x is greater than y,

$$pred4x4_L[x, y] = (p[x - y - 2, -1] + 2 * p[x - y - 1, -1] + p[x - y, -1] + 2) >> 2 \quad (8\text{-}53)$$

– Otherwise if x is less than y,

$$pred4x4_L[x, y] = (p[-1, y - x - 2] + 2 * p[-1, y - x - 1] + p[-1, y - x] + 2) >> 2 \quad (8\text{-}54)$$

– Otherwise (x is equal to y),

$$pred4x4_L[x, y] = (p[0, -1] + 2 * p[-1, -1] + p[-1, 0] + 2) >> 2 \quad (8\text{-}55)$$

8.3.1.2.6 Specification of Intra_4x4_Vertical_Right prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 5.

This mode shall be used only when the samples p[x, -1] with x = 0..3 and p[-1, y] with y = -1..3 are marked as "available for Intra_4x4 prediction".

Let the variable zVR be set equal to 2 * x – y.

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If zVR is equal to 0, 2, 4, or 6,

$$pred4x4_L[x, y] = (p[x - (y >> 1) - 1, -1] + p[x - (y >> 1), -1] + 1) >> 1 \quad (8\text{-}56)$$

– Otherwise, if zVR is equal to 1, 3, or 5,

$$pred4x4_L[x, y] = (p[x - (y >> 1) - 2, -1] + 2 * p[x - (y >> 1) - 1, -1] + p[x - (y >> 1), -1] + 2) >> 2 \quad (8\text{-}57)$$

– Otherwise, if zVR is equal to -1,

$$pred4x4_L[x, y] = (p[-1, 0] + 2 * p[-1, -1] + p[0, -1] + 2) >> 2 \quad (8\text{-}58)$$

– Otherwise (zVR is equal to -2 or -3),

$$pred4x4_L[x, y] = (p[-1, y - 1] + 2 * p[-1, y - 2] + p[-1, y - 3] + 2) >> 2 \quad (8\text{-}59)$$

8.3.1.2.7 Specification of Intra_4x4_Horizontal_Down prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 6.

This mode shall be used only when the samples p[x, -1] with x = 0..3 and p[-1, y] with y = -1..3 are marked as "available for Intra_4x4 prediction".

Let the variable zHD be set equal to 2 * y – x.

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If zHD is equal to 0, 2, 4, or 6,

$$pred4x4_L[x, y] = (p[-1, y -(x >> 1) - 1] + p[-1, y - (x >> 1)] + 1) >> 1 \quad (8\text{-}60)$$

– Otherwise, if zHD is equal to 1, 3, or 5,

$$pred4x4_L[x, y] = (p[-1, y - (x >> 1) - 2] + 2 * p[-1, y - (x >> 1) - 1] + p[-1, y - (x >> 1)] + 2) >> 2 \quad (8\text{-}61)$$

– Otherwise, if zHD is equal to -1,

$$pred4x4_L[x, y] = (p[-1, 0] + 2 * p[-1, -1] + p[0, -1] + 2) >> 2 \quad (8\text{-}62)$$

– Otherwise (zHD is equal to -2 or -3),

$$pred4x4_L[x, y] = (p[x - 1, -1] + 2 * p[x - 2, -1] + p[x - 3, -1] + 2) >> 2 \quad (8\text{-}63)$$

8.3.1.2.8 Specification of Intra_4x4_Vertical_Left prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 7.

This mode shall be used only when the samples p[x, -1] with x = 0..7 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows.

– If y is equal to 0 or 2,

$$pred4x4_L[x, y] = (p[x + (y >> 1), -1] + p[x + (y >> 1) + 1, -1] + 1) >> 1 \quad (8\text{-}64)$$

– Otherwise (y is equal to 1 or 3),

$$pred4x4_L[x, y] = (p[x + (y >> 1), -1] + 2 * p[x + (y >> 1) + 1, -1] + p[x + (y >> 1) + 2, -1] + 2) >> 2 \quad (8\text{-}65)$$

8.3.1.2.9 Specification of Intra_4x4_Horizontal_Up prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[luma4x4BlkIdx] is equal to 8.

This mode shall be used only when the samples p[-1, y] with y = 0..3 are marked as "available for Intra_4x4 prediction".

Let the variable zHU be set equal to x + 2 * y.

The values of the prediction samples $pred4x4_L[x, y]$, with x, y = 0..3 are derived as follows:

– If zHU is equal to 0, 2, or 4

$$pred4x4_L[x, y] = (p[-1, y + (x >> 1)] + p[-1, y + (x >> 1) + 1] + 1) >> 1 \quad (8\text{-}66)$$

– Otherwise, if zHU is equal to 1 or 3

$$pred4x4_L[x, y] = (p[-1, y + (x >> 1)] + 2 * p[-1, y + (x >> 1) + 1] + p[-1, y + (x >> 1) + 2] + 2) >> 2 \quad (8\text{-}67)$$

– Otherwise, if zHU is equal to 5,

$$pred4x4_L[x, y] = (p[-1, 2] + 3 * p[-1, 3] + 2) >> 2 \quad (8\text{-}68)$$

– Otherwise (zHU is greater than 5),

$$pred4x4_L[x, y] = p[-1, 3] \quad (8\text{-}69)$$

8.3.2 Intra_8x8 prediction process for luma samples

This process is invoked when the macroblock prediction mode is equal to Intra_8x8.

Inputs to this process are the values of Intra4x4PredMode (if available) or Intra8x8PredMode (if available) from the neighbouring macroblocks or macroblock pairs.

Outputs of this process are 8x8 luma sample arrays as part of the 16x16 luma array of prediction samples of the macroblock $pred_L$.

The luma component of a macroblock consists of 4 blocks of 8x8 luma samples. These blocks are inverse scanned using the inverse 8x8 luma block scanning process as specified in subclause 6.4.4.

For all 8x8 luma blocks of the luma component of a macroblock with luma8x8BlkIdx = 0..3, the derivation process for Intra8x8PredMode as specified in subclause 8.3.2.1 is invoked with luma8x8BlkIdx as well as Intra4x4PredMode and

Intra8x8PredMode that are previously (in decoding order) derived for adjacent macroblocks as the input and the variable Intra8x8PredMode[luma8x8BlkIdx] as the output.

For each luma block of 8x8 samples indexed using luma8x8BlkIdx = 0..3, the following applies.

– The Intra_8x8 sample prediction process in subclause 8.3.2.2 is invoked with luma8x8BlkIdx and constructed samples prior (in decoding order) to the deblocking filter process from adjacent luma blocks as the input and the output are the Intra_8x8 luma prediction samples $pred8x8_L[x, y]$ with x, y = 0..7.

– The position of the upper-left sample of an 8x8 luma block with index luma8x8BlkIdx inside the current macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.4 with luma8x8BlkIdx as the input and the output being assigned to (xO, yO) and x, y = 0..7.

$$pred_L[xO + x, yO + y] = pred8x8_L[x, y] \quad (8\text{-}70)$$

– The transform coefficient decoding process and picture construction process prior to deblocking filter process in subclause 8.5 is invoked with $pred_L$ and luma8x8BlkIdx as the input and the constructed samples for the current 8x8 luma block S'_L as the output.

8.3.2.1 Derivation process for Intra8x8PredMode

Inputs to this process are the index of the 8x8 luma block luma8x8BlkIdx and variable arrays Intra4x4PredMode (if available) and Intra8x8PredMode (if available) that are previously (in decoding order) derived for adjacent macroblocks.

Output of this process is the variable Intra8x8PredMode[luma8x8BlkIdx].

Table 8-3 specifies the values for Intra8x8PredMode[luma8x8BlkIdx] and the associated mnemonic names.

Table 8-3 – Specification of Intra8x8PredMode[luma8x8BlkIdx] and associated names

Intra8x8PredMode[luma8x8BlkIdx]	Name of Intra8x8PredMode[luma8x8BlkIdx]
0	Intra_8x8_Vertical (prediction mode)
1	Intra_8x8_Horizontal (prediction mode)
2	Intra_8x8_DC (prediction mode)
3	Intra_8x8_Diagonal_Down_Left (prediction mode)
4	Intra_8x8_Diagonal_Down_Right (prediction mode)
5	Intra_8x8_Vertical_Right (prediction mode)
6	Intra_8x8_Horizontal_Down (prediction mode)
7	Intra_8x8_Vertical_Left (prediction mode)
8	Intra_8x8_Horizontal_Up (prediction mode)

Intra8x8PredMode[luma8x8BlkIdx] is derived as follows.

– The process specified in subclause 6.4.8.2 is invoked with luma8x8BlkIdx given as input and the output is assigned to mbAddrA, luma8x8BlkIdxA, mbAddrB, and luma8x8BlkIdxB.

– The variable dcPredModePredictedFlag is derived as follows.

  – If any of the following conditions are true, dcPredModePredictedFlag is set equal to 1

    – the macroblock with address mbAddrA is not available

    – the macroblock with address mbAddrB is not available

    – the macroblock with address mbAddrA is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1

– the macroblock with address mbAddrB is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1

– Otherwise, dcPredModePredictedFlag is set equal to 0.

– For N being either replaced by A or B, the variables intraMxMPredModeN are derived as follows.

– If dcPredModePredictedFlag is equal to 1 or (the macroblock with address mbAddrN is not coded in Intra_4x4 macroblock prediction mode and the macroblock with address mbAddrN is not coded in Intra_8x8 macroblock prediction mode), intraMxMPredModeN is set equal to 2 (Intra_8x8_DC prediction mode).

– Otherwise (dcPredModePredictedFlag is equal to 0 and (the macroblock with address mbAddrN is coded in Intra_4x4 macroblock prediction mode or the macroblock with address mbAddrN is coded in Intra_8x8 macroblock prediction mode)), the following applies.

– If the macroblock with address mbAddrN is coded in Intra_8x8 macroblock mode, intraMxMPredModeN is set equal to Intra8x8PredMode[luma8x8BlkIdxN], where Intra8x8PredMode is the variable array assigned to the macroblock mbAddrN.

– Otherwise (the macroblock with address mbAddrN is coded in Intra_4x4 macroblock mode), intraMxMPredModeN is derived by the following procedure, where Intra4x4PredMode is the variable array assigned to the macroblock mbAddrN.

intraMxMPredModeN = Intra4x4PredMode[luma8x8BlkIdxN * 4 + n] (8-71)

where the variable n is derived as follows

– If N is equal to A, depending on the variable MbaffFrameFlag, the variable luma8x8BlkIdx, the current macroblock, and the macroblock mbAddrN, the following applies.

– If MbaffFrameFlag is equal to 1, the current macroblock is a frame coded macroblock, the macroblock mbAddrN is a field coded macroblock, and luma8x8BlkIdx is equal to 2, n is set equal to 3.

– Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a field coded macroblock or the macroblock mbAddrN is a frame coded macroblock or luma8x8BlkIdx is not equal to 2), n is set equal to 1.

– Otherwise (N is equal to B), n is set equal to 2.

– Finally, given intraMxMPredModeA and intraMxMPredModeB, the variable Intra8x8PredMode[luma8x8BlkIdx] is derived by applying the following procedure.

```
predIntra8x8PredMode = Min( intraMxMPredModeA, intraMxMPredModeB )
if( prev_intra8x8_pred_mode_flag[ luma8x8BlkIdx ] )
    Intra8x8PredMode[ luma8x8BlkIdx ] = predIntra8x8PredMode
else                                                                    (8-72)
    if( rem_intra8x8_pred_mode[ luma8x8BlkIdx ] < predIntra8x8PredMode )
        Intra8x8PredMode[ luma8x8BlkIdx ] = rem_intra8x8_pred_mode[ luma8x8BlkIdx ]
    else
        Intra8x8PredMode[ luma8x8BlkIdx ] = rem_intra8x8_pred_mode[ luma8x8BlkIdx ] + 1
```

8.3.2.2 Intra_8x8 sample prediction

This process is invoked for each 8x8 luma block of a macroblock with prediction mode equal to Intra_8x8 followed by the transform decoding process and picture construction process prior to deblocking for each 8x8 luma block.

Input to this process is the index of an 8x8 luma block luma8x8BlkIdx.

Output of this process are the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 for the 8x8 luma block with index luma8x8BlkIdx.

The position of the upper-left sample of an 8x8 luma block with index luma8x8BlkIdx inside the current macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.4 with luma8x8BlkIdx as the input and the output being assigned to (xO, yO).

The 25 neighbouring samples p[x, y] that are constructed luma samples prior to the deblocking filter process, with x = -1, y = -1..7 and x = 0..15, y = -1, are derived as follows.

– The luma location (xN, yN) is specified by

$$xN = xO + x \tag{8-73}$$

$$yN = yO + y \tag{8-74}$$

– The derivation process for neighbouring locations in subclause 6.4.9 is invoked for luma locations with (xN, yN) as input and mbAddrN and (xW, yW) as output.

– Each sample p[x, y] with x = -1, y = -1..7 and x = 0..15, y = -1 is derived as follows.

  – If any of the following conditions is true, the sample p[x, y] is marked as "not available for Intra_8x8 prediction"

    – mbAddrN is not available,

    – the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1,

  – Otherwise, the sample p[x, y] is marked as "available for Intra_8x8 prediction" and the luma sample at luma location (xW, yW) inside the macroblock mbAddrN is assigned to p[x, y].

When samples p[x, -1], with x = 8..15 are marked as "not available for Intra_8x8 prediction," and the sample p[7, -1] is marked as "available for Intra_8x8 prediction," the sample value of p[7, -1] is substituted for sample values p[x, -1], with x = 8..15 and samples p[x, -1], with x = 8..15 are marked as "available for Intra_8x8 prediction".

NOTE – Each block is assumed to be constructed into a picture array prior to decoding of the next block.

The reference sample filtering process for Intra_8x8 sample prediction in subclause 8.3.2.2.1 is invoked with the samples p[x, y] with x = -1, y = -1..7 and x = 0..15, y = -1 (if available) as input and p'[x, y] with x = -1, y = -1..7 and x = 0..15, y = -1 as output.

Depending on Intra8x8PredMode[luma8x8BlkIdx], one of the Intra_8x8 prediction modes specified in subclauses 8.3.2.2.2 to 8.3.2.2.10 is invoked.

8.3.2.2.1 Reference sample filtering process for Intra_8x8 sample prediction

Inputs to this process are the reference samples p[x, y] with x = -1, y = -1..7 and x = 0..15, y = -1 (if available) for Intra_8x8 sample prediction.

Outputs of this process are the filtered reference samples p'[x, y] with x = -1, y = -1..7 and x = 0..15, y = -1 for Intra_8x8 sample prediction.

When all samples p[x, -1] with x = 0..7 are marked as "available for Intra_8x8 prediction", the following applies.

– The value of p'[0, -1] is derived as follows.

  – If p[-1, -1] is marked as "available for Intra_8x8 prediction", p'[0, -1] is derived by

$$p'[\,0, -1\,] = (\, p[\,-1, -1\,] + 2 * p[\,0, -1\,] + p[\,1, -1\,] + 2\,) >> 2 \tag{8-75}$$

  – Otherwise (p[-1, -1] is marked as "not available for Intra_8x8 prediction"), p'[0, -1] is derived by

$$p'[\,0, -1\,] = (\, 3 * p[\,0, -1\,] + p[\,1, -1\,] + 2\,) >> 2 \tag{8-76}$$

– The values of p'[x, -1], with x = 1..7 are derived by

$$p'[\,x, -1\,] = (\, p[\,x-1, -1\,] + 2 * p[\,x, -1\,] + p[\,x+1, -1\,] + 2\,) >> 2 \tag{8-77}$$

When all samples p[x, -1] with x = 7..15 are marked as "available for Intra_8x8 prediction", the following applies.

– The values of p'[x, -1], with x = 8..14 are derived by

$$p'[\,x, -1\,] = (\, p[\,x-1, -1\,] + 2 * p[\,x, -1\,] + p[\,x+1, -1\,] + 2\,) >> 2 \tag{8-78}$$

– The value of p'[15, -1] is derived by

$$p'[\,15, -1\,] = (\, p[\,14, -1\,] + 3 * p[\,15, -1\,] + 2\,) >> 2 \tag{8-79}$$

When the sample p[-1, -1] is marked as "available for Intra_8x8 prediction", the value of p'[-1, -1] is derived as follows.

– If the sample p[0, -1] is marked as "not available for Intra_8x8 prediction" or the sample p[-1, 0] is marked as "not available for Intra_8x8 prediction", the following applies.

  – If the sample p[0, -1] is marked as "available for Intra_8x8 prediction", p'[-1, -1] is derived by

$$p'[-1, -1] = (3 * p[-1, -1] + p[0, -1] + 2) >> 2 \quad (8\text{-}80)$$

  – Otherwise (the sample p[0, -1] is marked as "not available for Intra_8x8 prediction" and the sample p[-1, 0] is marked as "available for Intra_8x8 prediction"), p'[-1, -1] is derived by

$$p'[-1, -1] = (3 * p[-1, -1] + p[-1, 0] + 2) >> 2 \quad (8\text{-}81)$$

– Otherwise (the sample p[0, -1] is marked as "available for Intra_8x8 prediction" and the sample p[-1, 0] is marked as "available for Intra_8x8 prediction"), p'[-1, -1] is derived by

$$p'[-1, -1] = (p[0, -1] + 2 * p[-1, -1] + p[-1, 0] + 2) >> 2 \quad (8\text{-}82)$$

When all samples p[-1, y] with y = 0..7 are marked as "available for Intra_8x8 prediction", the following applies.

– The value of p'[-1, 0] is derived as follows.

  – If p[-1, -1] is marked as "available for Intra_8x8 prediction", p'[-1, 0] is derived by

$$p'[-1, 0] = (p[-1, -1] + 2 * p[-1, 0] + p[-1, 1] + 2) >> 2 \quad (8\text{-}83)$$

  – Otherwise (if p[-1, -1] is marked as "not available for Intra_8x8 prediction"), p'[-1, 0] is derived by

$$p'[-1, 0] = (3 * p[-1, 0] + p[-1, 1] + 2) >> 2 \quad (8\text{-}84)$$

– The values of p'[-1, y], with y = 1..6 are derived by

$$p'[-1, y] = (p[-1, y-1] + 2 * p[-1, y] + p[-1, y+1] + 2) >> 2 \quad (8\text{-}85)$$

– The value of p'[-1, 7] is derived by

$$p'[-1, 7] = (p[-1, 6] + 3 * p[-1, 7] + 2) >> 2 \quad (8\text{-}86)$$

8.3.2.2.2 Specification of Intra_8x8_Vertical prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 0.

This mode shall be used only when the samples p[x, -1] with x = 0..7 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived by

$$pred8x8_L[x, y] = p'[x, -1], \text{ with } x, y = 0..7 \quad (8\text{-}87)$$

8.3.2.2.3 Specification of Intra_8x8_Horizontal prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 1.

This mode shall be used only when the samples p[-1, y], with y = 0..7 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived by

$$pred8x8_L[x, y] = p'[-1, y], \text{ with } x, y = 0..7 \quad (8\text{-}88)$$

8.3.2.2.4 Specification of Intra_8x8_DC prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 2.

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows.

– If all samples p[x, -1], with x = 0..7 and p[-1, y], with y = 0..7 are marked as "available for Intra_8x8 prediction," the values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived by

$$pred8x8_L[x, y] = (\sum_{x'=0}^{7} p'[x', -1] + \sum_{y'=0}^{7} p'[-1, y'] + 8) >> 4 \quad (8\text{-}89)$$

– Otherwise, if any samples p[x, -1], with x = 0..7 are marked as "not available for Intra_8x8 prediction" and all samples p[-1, y], with y = 0..7 are marked as "available for Intra_8x8 prediction", the values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived by

$$pred8x8_L[x, y] = (\sum_{y'=0}^{7} p'[-1, y'] + 4) >> 3 \quad (8\text{-}90)$$

– Otherwise, if any samples p[-1, y], with y = 0..7 are marked as "not available for Intra_8x8 prediction" and all samples p[x, -1], with x = 0..7 are marked as "available for Intra_8x8 prediction", the values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived by

$$pred8x8_L[x, y] = (\sum_{x'=0}^{7} p'[x', -1] + 4) >> 3 \quad (8\text{-}91)$$

– Otherwise (some samples p[x, -1], with x = 0..7 and some samples p[-1, y], with y = 0..7 are marked as "not available for Intra_8x8 prediction"), the values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived by

$$pred8x8_L[x, y] = (1 << (BitDepth_Y - 1)) \quad (8\text{-}92)$$

NOTE – An 8x8 luma block can always be predicted using this mode.

8.3.2.2.5 Specification of Intra_8x8_Diagonal_Down_Left prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 3.

This mode shall be used only when the samples p[x, -1] with x = 0..15 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows.

– If x is equal to 7 and y is equal to 7,

$$pred8x8_L[x, y] = (p'[14, -1] + 3 * p'[15, -1] + 2) >> 2 \quad (8\text{-}93)$$

– Otherwise (x is not equal to 7 or y is not equal to 7),

$$pred8x8_L[x, y] = (p'[x + y, -1] + 2 * p'[x + y + 1, -1] + p'[x + y + 2, -1] + 2) >> 2 \quad (8\text{-}94)$$

8.3.2.2.6 Specification of Intra_8x8_Diagonal_Down_Right prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 4.

This mode shall be used only when the samples p[x, -1] with x = 0..7 and p[-1, y] with y = -1..7 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows.

– If x is greater than y,

$$pred8x8_L[x, y] = (p'[x - y - 2, -1] + 2 * p'[x - y - 1, -1] + p'[x - y, -1] + 2) >> 2 \quad (8\text{-}95)$$

– Otherwise if x is less than y,

$$pred8x8_L[x, y] = (p'[-1, y - x - 2] + 2 * p'[-1, y - x - 1] + p'[-1, y - x] + 2) >> 2 \quad (8\text{-}96)$$

– Otherwise (x is equal to y),

$$pred8x8_L[x, y] = (p'[0, -1] + 2 * p'[-1, -1] + p'[-1, 0] + 2) >> 2 \quad (8\text{-}97)$$

8.3.2.2.7 Specification of Intra_8x8_Vertical_Right prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 5.

This mode shall be used only when the samples p[x, -1] with x = 0..7 and p[-1, y] with y = -1..7 are marked as "available for Intra_8x8 prediction".

Let the variable zVR be set equal to 2 * x – y.

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows.

– If zVR is equal to 0, 2, 4, 6, 8, 10, 12, or 14

$$pred8x8_L[x, y] = (p'[x - (y >> 1) - 1, -1] + p'[x - (y >> 1), -1] + 1) >> 1 \quad (8\text{-}98)$$

– Otherwise, if zVR is equal to 1, 3, 5, 7, 9, 11, or 13

$$pred8x8_L[x, y] = (p'[x - (y >> 1) - 2, -1] + 2 * p'[x - (y >> 1) - 1, -1] + p'[x - (y >> 1), -1] + 2) >> 2 \quad (8\text{-}99)$$

– Otherwise, if zVR is equal to -1,

$$pred8x8_L[x, y] = (p'[-1, 0] + 2 * p'[-1, -1] + p'[0, -1] + 2) >> 2 \quad (8\text{-}100)$$

– Otherwise (zVR is equal to -2, -3, -4, -5, -6, or -7),

$$pred8x8_L[x, y] = (p'[-1, y - 2*x - 1] + 2 * p'[-1, y - 2*x - 2] + p'[-1, y - 2*x - 3] + 2) >> 2 \quad (8\text{-}101)$$

8.3.2.2.8 Specification of Intra_8x8_Horizontal_Down prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 6.

This mode shall be used only when the samples p[x, -1] with x = 0..7 and p[-1, y] with y = -1..7 are marked as "available for Intra_8x8 prediction".

Let the variable zHD be set equal to 2 * y – x.

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows.

– If zHD is equal to 0, 2, 4, 6, 8, 10, 12, or 14

$$pred8x8_L[x, y] = (p'[-1, y -(x >> 1) - 1] + p'[-1, y - (x >> 1)] + 1) >> 1 \quad (8\text{-}102)$$

– Otherwise, if zHD is equal to 1, 3, 5, 7, 9, 11, or 13

$$pred8x8_L[x, y] = (p'[-1, y - (x >> 1) - 2] + 2 * p'[-1, y - (x >> 1) - 1] + p'[-1, y - (x >> 1)] + 2) >> 2 \quad (8\text{-}103)$$

– Otherwise, if zHD is equal to -1,

$$pred8x8_L[x, y] = (p'[-1, 0] + 2 * p'[-1, -1] + p'[0, -1] + 2) >> 2 \quad (8\text{-}104)$$

– Otherwise (zHD is equal to –2, -3, -4, -5, -6, -7),

$$pred8x8_L[x, y] = (p'[x - 2*y - 1, -1] + 2 * p'[x - 2*y - 2, -1] + p'[x - 2*y - 3, -1] + 2) >> 2 \quad (8\text{-}105)$$

8.3.2.2.9 Specification of Intra_8x8_Vertical_Left prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 7.

This mode shall be used only when the samples p[x, -1] with x = 0..15 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows.

– If y is equal to 0, 2, 4 or 6

$$pred8x8_L[x, y] = (p'[x + (y >> 1), -1] + p'[x + (y >> 1) + 1, -1] + 1) >> 1 \quad (8\text{-}106)$$

– Otherwise (y is equal to 1, 3, 5, 7),

$$pred8x8_L[x, y] = (p'[x + (y >> 1), -1] + 2 * p'[x + (y >> 1) + 1, -1] + p'[x + (y >> 1) + 2, -1] + 2) >>2 \quad (8\text{-}107)$$

8.3.2.2.10 Specification of Intra_8x8_Horizontal_Up prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[luma8x8BlkIdx] is equal to 8.

This mode shall be used only when the samples p[-1, y] with y = 0..7 are marked as "available for Intra_8x8 prediction".

Let the variable zHU be set equal to x + 2 * y.

The values of the prediction samples $pred8x8_L[x, y]$, with x, y = 0..7 are derived as follows:

– If zHU is equal to 0, 2, 4, 6, 8, 10, or 12

$$pred8x8_L[x, y] = (p'[-1, y + (x >> 1)] + p'[-1, y + (x >> 1) + 1] + 1) >> 1 \quad (8\text{-}108)$$

– Otherwise, if zHU is equal to 1, 3, 5, 7, 9, or 11

$$pred8x8_L[x, y] = (p'[-1, y + (x >> 1)] + 2 * p'[-1, y + (x >> 1) + 1] + p'[-1, y + (x >> 1) + 2] + 2) >>2 \quad (8\text{-}109)$$

– Otherwise, if zHU is equal to 13,

$$pred8x8_L[x, y] = (p'[-1, 6] + 3 * p'[-1, 7] + 2) >> 2 \quad (8\text{-}110)$$

– Otherwise (zHU is greater than 13),

$$pred8x8_L[x, y] = p'[-1, 7] \quad (8\text{-}111)$$

8.3.3 Intra_16x16 prediction process for luma samples

This process is invoked when the macroblock prediction mode is equal to Intra_16x16. It specifies how the Intra prediction luma samples for the current macroblock are derived.

Outputs of this process are Intra prediction luma samples for the current macroblock $pred_L[x, y]$.

The 33 neighbouring samples p[x, y] that are constructed luma samples prior to the deblocking filter process, with x = -1, y = -1..15 and with x = 0..15, y = -1, are derived as follows.

– The derivation process for neighbouring locations in subclause 6.4.9 is invoked for luma locations with (x, y) assigned to (xN, yN) as input and mbAddrN and (xW, yW) as output.

– Each sample p[x, y] with x = -1, y = -1..15 and with x = 0..15, y = -1 is derived as follows.

  – If any of the following conditions is true, the sample p[x, y] is marked as "not available for Intra_16x16 prediction"

    – mbAddrN is not available,

    – the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1.

– the macroblock mbAddrN has mb_type equal to SI and constrained_intra_pred_flag is equal to 1.

– Otherwise, the sample p[x, y] is marked as "available for Intra_16x16 prediction" and the luma sample at luma location (xW, yW) inside the macroblock mbAddrN is assigned to p[x, y].

Let $pred_L[x, y]$ with x, y = 0..15 denote the prediction samples for the 16x16 luma block samples.

Intra_16x16 prediction modes are specified in Table 8-4.

Table 8-4 – Specification of Intra16x16PredMode and associated names

Intra16x16PredMode	Name of Intra16x16PredMode
0	Intra_16x16_Vertical (prediction mode)
1	Intra_16x16_Horizontal (prediction mode)
2	Intra_16x16_DC (prediction mode)
3	Intra_16x16_Plane (prediction mode)

Depending on Intra16x16PredMode, one of the Intra_16x16 prediction modes specified in subclauses 8.3.3.1 to 8.3.3.4 is invoked.

8.3.3.1 Specification of Intra_16x16_Vertical prediction mode

This Intra_16x16 prediction mode shall be used only when the samples p[x, -1] with x = 0..15 are marked as "available for Intra_16x16 prediction".

$$pred_L[x, y] = p[x, -1], \text{ with } x, y = 0..15 \quad (8\text{-}112)$$

8.3.3.2 Specification of Intra_16x16_Horizontal prediction mode

This Intra_16x16 prediction mode shall be used only when the samples p[-1, y] with y = 0..15 are marked as "available for Intra_16x16 prediction".

$$pred_L[x, y] = p[-1, y], \text{ with } x, y = 0..15 \quad (8\text{-}113)$$

8.3.3.3 Specification of Intra_16x16_DC prediction mode

This Intra_16x16 prediction mode operates, depending on whether the neighbouring samples are marked as "available for Intra_16x16 prediction", as follows.

– If all neighbouring samples p[x, -1], with x = 0..15 and p[-1, y], with y = 0..15 are marked as "available for Intra_16x16 prediction", the prediction for all luma samples in the macroblock is given by:

$$pred_L[x, y] = (\sum_{x'=0}^{15} p[x',-1] + \sum_{y'=0}^{15} p[-1,y'] + 16) >> 5, \text{ with } x, y = 0..15 \quad (8\text{-}114)$$

– Otherwise, if any of the neighbouring samples p[x, -1], with x = 0..15 are marked as "not available for Intra_16x16 prediction" and all of the neighbouring samples p[-1, y], with y = 0..15 are marked as "available for Intra_16x16 prediction", the prediction for all luma samples in the macroblock is given by:

$$pred_L[x, y] = (\sum_{y'=0}^{15} p[-1,y'] + 8) >> 4, \text{ with } x, y = 0..15 \quad (8\text{-}115)$$

– Otherwise, if any of the neighbouring samples p[-1, y], with y = 0..15 are marked as "not available for Intra_16x16 prediction" and all of the neighbouring samples p[x, -1], with x = 0..15 are marked as "available for Intra_16x16 prediction", the prediction for all luma samples in the macroblock is given by:

$$pred_L[x, y] = (\sum_{x'=0}^{15} p[x',-1] + 8) >> 4, \text{ with } x, y = 0..15 \quad (8\text{-}116)$$

– Otherwise (some of the neighbouring samples p[x, -1], with x = 0..15 and some of the neighbouring samples p[-1, y], with y = 0..15 are marked as "not available for Intra_16x16 prediction"), the prediction for all luma samples in the macroblock is given by:

$$pred_L[x, y] = (1 << (BitDepth_Y - 1)), \text{ with } x, y = 0..15 \quad (8\text{-}117)$$

8.3.3.4 Specification of Intra_16x16_Plane prediction mode

This Intra_16x16 prediction mode shall be used only when the samples p[x, -1] with x = -1..15 and p[-1, y] with y = 0..15 are marked as "available for Intra_16x16 prediction".

$$pred_L[x, y] = Clip1_Y((a + b * (x - 7) + c * (y - 7) + 16) >> 5), \text{ with } x, y = 0..15, \quad (8\text{-}118)$$

where:

$$a = 16 * (p[-1, 15] + p[15, -1]) \quad (8\text{-}119)$$

$$b = (5 * H + 32) >> 6 \quad (8\text{-}120)$$

$$c = (5 * V + 32) >> 6 \quad (8\text{-}121)$$

and H and V are specified in Equations 8-122 and 8-123.

$$H = \sum_{x'=0}^{7} (x'+1) * (p[8 + x', -1] - p[6 - x', -1]) \quad (8\text{-}122)$$

$$V = \sum_{y'=0}^{7} (y'+1) * (p[-1, 8 + y'] - p[-1, 6 - y']) \quad (8\text{-}123)$$

8.3.4 Intra prediction process for chroma samples

This process is invoked for I and SI macroblock types. It specifies how the Intra prediction chroma samples for the current macroblock are derived.

Outputs of this process are Intra prediction chroma samples for the current macroblock $pred_{Cb}[x, y]$ and $pred_{Cr}[x, y]$.

Both chroma blocks (Cb and Cr) of the macroblock use the same prediction mode. The prediction mode is applied to each of the chroma blocks separately. The process specified in this subclause is invoked for each chroma block. In the remainder of this subclause, chroma block refers to one of the two chroma blocks and the subscript C is used as a replacement of the subscript Cb or Cr.

The neighbouring samples p[x, y] that are constructed chroma samples prior to the deblocking filter process, with x = -1, y = -1..MbHeightC - 1 and with x = 0..MbWidthC - 1, y = -1, are derived as follows.

– The derivation process for neighbouring locations in subclause 6.4.9 is invoked for chroma locations with (x, y) assigned to (xN, yN) as input and mbAddrN and (xW, yW) as output.

– Each sample p[x, y] is derived as follows.

  – If any of the following conditions is true, the sample p[x, y] is marked as "not available for Intra chroma prediction"

    – mbAddrN is not available,

    – the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1.

    – the macroblock mbAddrN has mb_type equal to SI and constrained_intra_pred_flag is equal to 1 and the current macroblock does not have mb_type equal to SI.

  – Otherwise, the sample p[x, y] is marked as "available for Intra chroma prediction" and the chroma sample of component C at chroma location (xW, yW) inside the macroblock mbAddrN is assigned to p[x, y].

Let $pred_C[x, y]$ with x = 0..MbWidthC - 1, y = 0..MbHeightC - 1 denote the prediction samples for the chroma block samples.

Intra chroma prediction modes are specified in Table 8-5.

Table 8-5 – Specification of Intra chroma prediction modes and associated names

intra_chroma_pred_mode	Name of intra_chroma_pred_mode
0	Intra_Chroma_DC (prediction mode)
1	Intra_Chroma_Horizontal (prediction mode)
2	Intra_Chroma_Vertical (prediction mode)
3	Intra_Chroma_Plane (prediction mode)

Depending on intra_chroma_pred_mode, one of the Intra chroma prediction modes specified in subclauses 8.3.4.1 to 8.3.4.4 is invoked.

8.3.4.1 Specification of Intra_Chroma_DC prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 0.

For each chroma block of 4x4 samples indexed by chroma4x4BlkIdx = 0..(1 << (chroma_format_idc + 1)) – 1, the following applies.

– Depending on chroma_format_idc, the position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx is derived as follows

  – If chroma_format_idc is equal to 1 or 2, the following applies

$$xO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 0) \quad (8\text{-}124)$$

$$yO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 1) \quad (8\text{-}125)$$

  – Otherwise (chroma_format_idc is equal to 3), the following applies

$$xO = InverseRasterScan(chroma4x4BlkIdx / 4, 8, 8, 16, 0) + InverseRasterScan(chroma4x4BlkIdx \% 4, 4, 4, 8, 0) \quad (8\text{-}126)$$

$$yO = InverseRasterScan(chroma4x4BlkIdx / 4, 8, 8, 16, 1) + InverseRasterScan(chroma4x4BlkIdx \% 4, 4, 4, 8, 1) \quad (8\text{-}127)$$

– If (xO, yO) is equal to (0, 0) or xO and yO are greater than 0, the values of the prediction samples $pred_C[x + xO, y + yO]$ with x, y = 0..3 are derived as follows.

  – If all samples p[x + xO, -1], with x = 0..3 and p[-1, y +yO], with y = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{x'=0}^{3} p[x'+xO, -1] + \sum_{y'=0}^{3} p[-1, y'+yO] + 4 \right) >> 3 \text{, with } x, y = 0..3. \quad (8\text{-}128)$$

  – Otherwise, if any samples p[x + xO, -1], with x = 0..3 are marked as "not available for Intra chroma prediction" and all samples p[-1, y +yO], with y = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{y'=0}^{3} p[-1, y'+yO] + 2 \right) >> 2 \text{, with } x, y = 0..3. \quad (8\text{-}129)$$

– Otherwise, if any samples p[-1, y +yO], with y = 0..3 are marked as "not available for Intra chroma prediction" and all samples p[x + xO, -1], with x = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{x'=0}^{3} p[x'+xO, -1] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}130)$$

– Otherwise (some samples p[x + xO, -1], with x = 0..3 and some samples p[-1, y +yO], with y = 0..3 are marked as "not available for Intra chroma prediction"), the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = (1 << (BitDepth_C - 1)), \text{ with x, y = 0..3.} \quad (8\text{-}131)$$

– Otherwise, if xO is greater than 0 and yO is equal to 0, the values of the prediction samples $pred_C[x + xO, y + yO]$ with x, y = 0..3 are derived as follows.

– If all samples p[x + xO, -1], with x = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{x'=0}^{3} p[x'+xO, -1] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}132)$$

– Otherwise, if all samples p[-1, y +yO], with y = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{y'=0}^{3} p[-1, y'+yO] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}133)$$

– Otherwise (some samples p[x + xO, -1], with x = 0..3 and some samples p[-1, y +yO], with y = 0..3 are marked as "not available for Intra chroma prediction"), the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = (1 << (BitDepth_C - 1)), \text{ with x, y = 0..3.} \quad (8\text{-}134)$$

– Otherwise (xO is equal to 0 and yO is greater than 0), the values of the prediction samples $pred_C[x + xO, y + yO]$ with x, y = 0..3 are derived as follows.

– If all samples p[-1, y +yO], with y = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{y'=0}^{3} p[-1, y'+yO] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}135)$$

– Otherwise, if all samples p[x + xO, -1], with x = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = \left(\sum_{x'=0}^{3} p[x'+xO, -1] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}136)$$

– Otherwise (some samples p[x + xO, -1], with x = 0..3 and some samples p[-1, y +yO], with y = 0..3 are marked as "not available for Intra chroma prediction"), the values of the prediction samples $pred_C[x + xO, y + yO]$, with x, y = 0..3 are derived as

$$pred_C[x + xO, y + yO] = (1 << (BitDepth_C - 1)), \text{ with x, y = 0..3.} \quad (8\text{-}137)$$

8.3.4.2 Specification of Intra_Chroma_Horizontal prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 1.

This mode shall be used only when the samples p[-1, y] with y = 0..MbHeightC - 1 are marked as "available for Intra chroma prediction".

The values of the prediction samples $pred_C$[x, y] are derived as follows.

$pred_C$[x, y] = p[-1, y], with x = 0..MbWidthC - 1 and y = 0..MbHeightC - 1 (8-138)

8.3.4.3 Specification of Intra_Chroma_Vertical prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 2.

This mode shall be used only when the samples p[x, -1] with x = 0..MbWidthC - 1 are marked as "available for Intra chroma prediction".

The values of the prediction samples $pred_C$[x, y] are derived as follows.

$pred_C$[x, y] = p[x, -1], with x = 0..MbWidthC - 1 and y = 0..MbHeightC - 1 (8-139)

8.3.4.4 Specification of Intra_Chroma_Plane prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 3.

This mode shall be used only when the samples p[x, -1], with x = 0..MbWidthC - 1 and p[-1, y], with y = -1..MbHeightC - 1 are marked as "available for Intra chroma prediction".

The values of the prediction samples $pred_C$[x, y] are derived as follows.

Let the variable xCF be set equal to 4 * (chroma_format_idc = = 3) and let the variable yCF be set equal to 4 * (chroma_format_idc != 1).

$pred_C$[x, y] = $Clip1_C$((a + b * (x – 3 – xCF) + c * (y – 3 – yCF) + 16) >> 5),
with x = 0..MbWidthC - 1 and y = 0..MbHeightC - 1 (8-140)

where:

a = 16 * (p[-1, MbHeightC - 1] + p[MbWidthC - 1, -1]) (8-141)

b = ((34 – 29 * (chroma_format_idc = = 3)) * H + 32) >> 6 (8-142)

c = ((34 – 29 * (chroma_format_idc != 1)) * V + 32) >> 6 (8-143)

and H and V are specified as

$$H = \sum_{x'=0}^{3+xCF} (x'+1) * (p[4 + xCF + x', -1] - p[2 + xCF - x', -1]) \quad (8\text{-}144)$$

$$V = \sum_{y'=0}^{3+yCF} (y'+1) * (p[-1, 4 + yCF + y'] - p[-1, 2 + yCF - y']) \quad (8\text{-}145)$$

8.3.5 Sample construction process for I_PCM macroblocks

This process is invoked when mb_type is equal to I_PCM.

The variable dy is derived as follows.

– If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock, dy is set equal to 2.

– Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock), dy is set equal to 1.

The position of the upper-left luma sample of the current macroblock is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with CurrMbAddr as input and the output being assigned to (xP, yP).

The constructed luma samples prior to the deblocking process are generated as specified by:

```
for( i = 0; i < 256; i++ )
   S'L[ xP + ( i % 16 ), yP + dy * ( i / 16 ) ) ] = pcm_sample_luma[ i ]          (8-146)
```

When chroma_format_idc is not equal to 0 (monochrome), the constructed chroma samples prior to the deblocking process are generated as specified by:

```
for( i = 0; i < MbWidthC * MbHeightC; i++ ) {
   S'Cb[ ( xP / SubWidthC ) + ( i % MbWidthC ),
            ( ( yP + SubHeightC – 1 ) / SubHeightC ) + dy * ( i / MbWidthC ) ] =
              pcm_sample_chroma[ i ]                                            (8-147)
   S'Cr[ ( xP / SubWidthC ) + ( i % MbWidthC ),
            ( ( yP + SubHeightC – 1 ) / SubHeightC ) + dy * ( i / MbWidthC ) ] =
              pcm_sample_chroma[ i + MbWidthC * MbHeightC ]
}
```

8.4 Inter prediction process

This process is invoked when decoding P and B macroblock types.

Outputs of this process are Inter prediction samples for the current macroblock that are a 16x16 array $pred_L$ of luma samples and when chroma_format_idc is not equal to 0 (monochrome) two 8x8 arrays $pred_{Cr}$ and $pred_{Cb}$ of chroma samples, one for each of the chroma components Cb and Cr.

The partitioning of a macroblock is specified by mb_type. Each macroblock partition is referred to by mbPartIdx. When the macroblock partitioning consists of partitions that are equal to sub-macroblocks, each sub-macroblock can be further partitioned into sub-macroblock partitions as specified by sub_mb_type. Each sub-macroblock partition is referred to by subMbPartIdx. When the macroblock partitioning does not consist of sub-macroblocks, subMbPartIdx is set equal to 0.

The following steps are specified for each macroblock partition or for each sub-macroblock partition.

The functions MbPartWidth( ), MbPartHeight( ), SubMbPartWidth( ), and SubMbPartHeight( ) describing the width and height of macroblock partitions and sub-macroblock partitions are specified in Tables 7-13, 7-14, 7-17, and 7-18.

The range of the macroblock partition index mbPartIdx is derived as follows.

– If mb_type is equal to B_Skip or B_Direct_16x16, mbPartIdx proceeds over values 0..3.

– Otherwise (mb_type is not equal to B_Skip or B_Direct_16x16), mbPartIdx proceeds over values 0..NumMbPart(mb_type) – 1.

For each value of mbPartIdx, the variables partWidth and partHeight for each macroblock partition or sub-macroblock partition in the macroblock are derived as follows.

– If mb_type is not equal to P_8x8, P_8x8ref0, B_Skip, B_Direct_16x16, or B_8x8, subMbPartIdx is set equal to 0, and partWidth and partHeight are derived as

```
partWidth = MbPartWidth( mb_type )                                              (8-148)
```

```
partHeight = MbPartHeight( mb_type )                                            (8-149)
```

– Otherwise, if mb_type is equal to P_8x8 or P_8x8ref0, or mb_type is equal to B_8x8 and sub_mb_type[mbPartIdx] is not equal to B_Direct_8x8, subMbPartIdx proceeds over values 0..NumSubMbPart(sub_mb_type) – 1, and partWidth and partHeight are derived as

```
partWidth = SubMbPartWidth( sub_mb_type[ mbPartIdx ] )                          (8-150)
```

```
partHeight = SubMbPartHeight( sub_mb_type[ mbPartIdx ] ).                       (8-151)
```

– Otherwise (mb_type is equal to B_Skip or B_Direct_16x16, or mb_type is equal to B_8x8 and sub_mb_type[mbPartIdx] is equal to B_Direct_8x8), subMbPartIdx proceeds over values 0..3, and partWidth and partHeight are derived as

$$partWidth = 4 \quad (8\text{-}152)$$

$$partHeight = 4 \quad (8\text{-}153)$$

When chroma_format_idc is not equal to 0 (monochrome) the variables partWidthC and partHeightC are derived as

$$partWidthC = partWidth / SubWidthC \quad (8\text{-}154)$$
$$partHeightC = partHeight / SubHeightC \quad (8\text{-}155)$$

Let the variable MvCnt be initially set equal to 0 before any invocation of subclause 8.4.1 for the macroblock.

The Inter prediction process for a macroblock partition mbPartIdx and a sub-macroblock partition subMbPartIdx consists of the following ordered steps

1. Derivation process for motion vector components and reference indices as specified in subclause 8.4.1.

   Inputs to this process are

   – a macroblock partition mbPartIdx,

   – a sub-macroblock partition subMbPartIdx.

   Outputs of this process are

   – luma motion vectors mvL0 and mvL1 and when chroma_format_idc is not equal to 0 (monochrome) the chroma motion vectors mvCL0 and mvCL1

   – reference indices refIdxL0 and refIdxL1

   – prediction list utilization flags predFlagL0 and predFlagL1

   – the sub-macroblock partition motion vector count subMvCnt.

2. The variable MvCnt is incremented by subMvCnt.

3. Decoding process for Inter prediction samples as specified in subclause 8.4.2.

   Inputs to this process are

   – a macroblock partition mbPartIdx,

   – a sub-macroblock partition subMbPartIdx.

   – variables specifying partition width and height for luma and chroma (if available), partWidth, partHeight, partWidthC (if available), and partHeightC (if available)

   – luma motion vectors mvL0 and mvL1 and when chroma_format_idc is not equal to 0 (monochrome) the chroma motion vectors mvCL0 and mvCL1

   – reference indices refIdxL0 and refIdxL1

   – prediction list utilization flags predFlagL0 and predFlagL1

   Outputs of this process are

   – inter prediction samples (pred); which are a (partWidth)x(partHeight) array $predPart_L$ of prediction luma samples and when chroma_format_idc is not equal to 0 (monochrome) two (partWidthC)x(partHeightC) arrays $predPart_{Cr}$, and $predPart_{Cb}$ of prediction chroma samples, one for each of the chroma components Cb and Cr.

For use in derivation processes of variables invoked later in the decoding process, the following assignments are made:

$$MvL0[mbPartIdx][subMbPartIdx] = mvL0 \quad (8\text{-}156)$$

$$MvL1[mbPartIdx][subMbPartIdx] = mvL1 \quad (8\text{-}157)$$

RefIdxL0[mbPartIdx] = refIdxL0 (8-158)

RefIdxL1[mbPartIdx] = refIdxL1 (8-159)

PredFlagL0[mbPartIdx] = predFlagL0 (8-160)

PredFlagL1[mbPartIdx] = predFlagL1 (8-161)

The location of the upper-left sample of the partition relative to the upper-left sample of the macroblock is derived by invoking the inverse macroblock partition scanning process as described in subclause 6.4.2.1 with mbPartIdx as the input and (xP, yP) as the output.

The location of the upper-left sample of the macroblock sub-partition relative to the upper-left sample of the macroblock partition is derived by invoking the inverse sub-macroblock partition scanning process as described in subclause 6.4.2.2 with subMbPartIdx as the input and (xS, yS) as the output.

The macroblock prediction is formed by placing the partition or sub-macroblock partition prediction samples in their correct relative positions in the macroblock, as follows.

The variable $pred_L[xP + xS + x, yP + yS + y]$ with x = 0 .. partWidth – 1, y = 0 .. partHeight – 1 is derived by

$$pred_L[xP + xS + x, yP + yS + y] = predPart_L[x, y] \quad (8\text{-}162)$$

When chroma_format_idc is not equal to 0 (monochrome) the variable $pred_C$ with x = 0..partWidthC – 1, y = 0..partHeightC – 1, and C in $pred_C$ and $predPart_C$ being replaced by Cb or Cr is derived by

$$pred_C[xP / SubWidthC + xS / SubWidthC + x, yP / SubHeightC + yS / SubHeightC + y] = predPart_C[x, y] \quad (8\text{-}163)$$

8.4.1 Derivation process for motion vector components and reference indices

Inputs to this process are

– a macroblock partition mbPartIdx,

– a sub-macroblock partition subMbPartIdx.

Outputs of this process are

– luma motion vectors mvL0 and mvL1 as well as the chroma motion vectors mvCL0 and mvCL1

– reference indices refIdxL0 and refIdxL1

– prediction list utilization flags predFlagL0 and predFlagL1

– a sub-partition macroblock motion vector count variable subMvCnt

For the derivation of the variables mvL0 and mvL1 as well as refIdxL0 and refIdxL1, the following applies.

– If mb_type is equal to P_Skip, the derivation process for luma motion vectors for skipped macroblocks in P and SP slices in subclause 8.4.1.1 is invoked with the output being the luma motion vectors mvL0 and reference indices refIdxL0, and predFlagL0 is set equal to 1. mvL1 and refIdxL1 are marked as not available and predFlagL1 is set equal to 0. The sub-partition motion vector count variable subMvCnt is set equal to 1.

– Otherwise, if mb_type is equal to B_Skip or B_Direct_16x16 or sub_mb_type[mbPartIdx] is equal to B_Direct_8x8, the derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8 in B slices in subclause 8.4.1.2 is invoked with mbPartIdx and subMbPartIdx as the input and the output being the luma motion vectors mvL0, mvL1, the reference indices refIdxL0, refIdxL1, the sub-partition motion vector count subMvCnt, and the prediction utilization flags predFlagL0 and predFlagL1.

– Otherwise, for X being replaced by either 0 or 1 in the variables predFlagLX, mvLX, refIdxLX, and in Pred_LX and in the syntax elements ref_idx_lX and mvd_lX, the following applies.

1. The variables refIdxLX and predFlagLX are derived as follows.

   – If MbPartPredMode(mb_type, mbPartIdx) or SubMbPredMode(sub_mb_type[mbPartIdx]) is equal to Pred_LX or to BiPred,

   refIdxLX = ref_idx_lX[mbPartIdx] (8-164)

   predFlagLX = 1 (8-165)

   – Otherwise, the variables refIdxLX and predFlagLX are specified by

   refIdxLX = -1 (8-166)

   predFlagLX = 0 (8-167)

2. The variable subMvCnt for sub-partition motion vector count is set equal to predFlagL0 + predFlagL1.
3. The variable currSubMbType is derived as follows.
   - If the macroblock type is equal to B_8x8, currSubMbType is set equal to sub_mb_type[mbPartIdx].
   - Otherwise (the macroblock type is not equal to B_8x8), currSubMbType is set equal to "na".
4. When predFlagLX is equal to 1, the derivation process for luma motion vector prediction in subclause 8.4.1.3 is invoked with mbPartIdx subMbPartIdx, refIdxLX, and currSubMbType as the inputs and the output being mvpLX. The luma motion vectors are derived by

   mvLX[0] = mvpLX[0] + mvd_lX[mbPartIdx][subMbPartIdx][0] (8-168)

   mvLX[1] = mvpLX[1] + mvd_lX[mbPartIdx][subMbPartIdx][1] (8-169)

For the derivation of the variables for the chroma motion vectors, the following applies. When predFlagLX (with X being either 0 or 1) is equal to 1, the derivation process for chroma motion vectors in subclause 8.4.1.4 is invoked with mvLX and refIdxLX as input and the output being mvCLX.

8.4.1.1 Derivation process for luma motion vectors for skipped macroblocks in P and SP slices

This process is invoked when mb_type is equal to P_Skip.

Outputs of this process are the motion vector mvL0 and the reference index refIdxL0.

The reference index refIdxL0 for a skipped macroblock is derived as follows.

refIdxL0 = 0. (8-170)

For the derivation of the motion vector mvL0 of a P_Skip macroblock type, the following applies.

– The process specified in subclause 8.4.1.3.2 is invoked with mbPartIdx set equal to 0, subMbPartIdx set equal to 0, currSubMbType set equal to "na", and listSuffixFlag set equal to 0 as input and the output is assigned to mbAddrA, mbAddrB, mvL0A, mvL0B, refIdxL0A, and refIdxL0B.

– The variable mvL0 is specified as follows.

  – If any of the following conditions are true, both components of the motion vector mvL0 are set equal to 0.

    – mbAddrA is not available

    – mbAddrB is not available

    – refIdxL0A is equal to 0 and both components of mvL0A are equal to 0

    – refIdxL0B is equal to 0 and both components of mvL0B are equal to 0

– Otherwise, the derivation process for luma motion vector prediction as specified in subclause 8.4.1.3 is invoked with mbPartIdx = 0, subMbPartIdx = 0, refIdxL0, and currSubMbType = "na" as inputs and the output is assigned to mvL0.

NOTE – The output is directly assigned to mvL0, since the predictor is equal to the actual motion vector.

8.4.1.2 Derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8

This process is invoked when mb_type is equal to B_Skip or B_Direct_16x16, or sub_mb_type[mbPartIdx] is equal to B_Direct_8x8.

Inputs to this process are mbPartIdx and subMbPartIdx.

Outputs of this process are the reference indices refIdxL0, refIdxL1, the motion vectors mvL0 and mvL1, the sub-partition motion vector count subMvCnt, and the prediction list utilization flags, predFlagL0 and predFlagL1.

The derivation process depends on the value of direct_spatial_mv_pred_flag, which is present in the bitstream in the slice header syntax as specified in subclause 7.3.3, and is specified as follows.

– If direct_spatial_mv_pred_flag is equal to 1, the mode in which the outputs of this process are derived is referred to as spatial direct prediction mode.

– Otherwise (direct_spatial_mv_pred_flag is equal to 0), mode in which the outputs of this process are derived is referred to as temporal direct prediction mode.

Both spatial and temporal direct prediction mode use the co-located motion vectors and reference indices as specified in subclause 8.4.1.2.1.

The motion vectors and reference indices are derived as follows.

– If spatial direct prediction mode is used, the direct motion vector and reference index prediction mode specified in subclause 8.4.1.2.2 is used, with subMvCnt being an output.

– Otherwise (temporal direct prediction mode is used), the direct motion vector and reference index prediction mode specified in subclause 8.4.1.2.3 is used and the variable subMvCnt is derived as follows.

  – If subMbPartIdx is equal to 0, subMvCnt is set equal to 2.

  – Otherwise (subMbPartIdx is not equal to 0), subMvCnt is set equal to 0.

8.4.1.2.1 Derivation process for the co-located 4x4 sub-macroblock partitions

Inputs to this process are mbPartIdx and subMbPartIdx.

Outputs of this process are the picture colPic, the co-located macroblock mbAddrCol, the motion vector mvCol, the reference index refIdxCol, and the variable vertMvScale (which can be One_To_One, Frm_To_Fld or Fld_To_Frm).

When RefPicList1[0] is a frame or a complementary field pair, let firstRefPicL1Top and firstRefPicL1Bottom be the top and bottom fields of RefPicList1[0], respectively, and let the following variables be specified as

topAbsDiffPOC = Abs(DiffPicOrderCnt(firstRefPicL1Top, CurrPic)) (8-171)

bottomAbsDiffPOC = Abs(DiffPicOrderCnt(firstRefPicL1Bottom, CurrPic)) (8-172)

The variable colPic specifies the picture that contains the co-located macroblock as specified in Table 8-6.

Table 8-6 – Specification of the variable colPic

field_pic_flag	RefPicList1[0] is …	mb_field_decoding_flag	additional condition	colPic
1	a field of a decoded frame			the frame containing RefPicList1[0]
	a decoded field			RefPicList1[0]
0	a decoded frame			RefPicList1[0]
	a complementary field pair	0	topAbsDiffPOC < bottomAbsDiffPOC	firstRefPicL1Top
			topAbsDiffPOC >= bottomAbsDiffPOC	firstRefPicL1Bottom
		1	(CurrMbAddr & 1) = = 0	firstRefPicL1Top
			(CurrMbAddr & 1) != 0	firstRefPicL1Bottom

When direct_8x8_inference_flag is equal to 1, subMbPartIdx is set as follows.

subMbPartIdx = mbPartIdx (8-173)

Let PicCodingStruct(X) be a function with the argument X being either CurrPic or colPic. It is specified in Table 8-7.

Table 8-7 – Specification of PicCodingStruct(X)

X is coded with field_pic_flag equal to …	mb_adaptive_frame_field_flag	PicCodingStruct(X)
1		FLD
0	0	FRM
0	1	AFRM

With luma4x4BlkIdx = mbPartIdx * 4 + subMbPartIdx, the inverse 4x4 luma block scanning process as specified in subclause 6.4.3 is invoked with luma4x4BlkIdx as the input and (x, y) assigned to (xCol, yCol) as the output.

Table 8-8 specifies the co-located macroblock address mbAddrCol, yM, and the variable vertMvScale in two steps:

1. Specification of a macroblock address mbAddrX depending on PicCodingStruct(CurrPic), and PicCodingStruct(colPic).

   NOTE – It is not possible for CurrPic and colPic picture coding types to be either (FRM, AFRM) or (AFRM, FRM) because these picture coding types must be separated by an IDR picture.

2. Specification of mbAddrCol, yM, and vertMvScale depending on mb_field_decoding_flag and the variable fieldDecodingFlagX, which is derived as follows.

   – If the macroblock mbAddrX in the picture colPic is a field macroblock, fieldDecodingFlagX is set equal to 1

   – Otherwise (the macroblock mbAddrX in the picture colPic is a frame macroblock), fieldDecodingFlagX is set equal to 0.

Unspecified values in Table 8-8 indicate that the value of the corresponding variable is not relevant for the current table row.

mbAddrCol is set equal to CurrMbAddr or to one of the following values.

mbAddrCol1 = 2 * PicWidthInMbs * (CurrMbAddr / PicWidthInMbs) +
(CurrMbAddr % PicWidthInMbs) + PicWidthInMbs * (yCol / 8) (8-174)

mbAddrCol2 = 2 * CurrMbAddr + (yCol / 8) (8-175)

mbAddrCol3 = 2 * CurrMbAddr + bottom_field_flag (8-176)

mbAddrCol4 = PicWidthInMbs * (CurrMbAddr / (2 * PicWidthInMbs)) +
(CurrMbAddr % PicWidthInMbs) (8-177)

mbAddrCol5 = CurrMbAddr / 2 (8-178)

mbAddrCol6 = 2 * (CurrMbAddr / 2) + ((topAbsDiffPOC < bottomAbsDiffPOC) ? 0 : 1) (8-179)

mbAddrCol7 = 2 * (CurrMbAddr / 2) + (yCol / 8) (8-180)

Table 8-8 – Specification of mbAddrCol, yM, and vertMvScale

PicCodingStruct(CurrPic)	PicCodingStruct(colPic)	mbAddrX	mb_field_decoding_flag	fieldDecodingFlagX	mbAddrCol	yM	vertMvScale
FLD	FLD				CurrMbAddr	yCol	One_To_One
	FRM				mbAddrCol1	(2 * yCol) % 16	Frm_To_Fld
	AFRM	2*CurrMbAddr		0	mbAddrCol2	(2 * yCol) % 16	Frm_To_Fld
				1	mbAddrCol3	yCol	One_To_One
FRM	FLD				mbAddrCol4	8 * ((CurrMbAddr / PicWidthInMbs) % 2) + 4 * (yCol / 8)	Fld_To_Frm
	FRM				CurrMbAddr	yCol	One_To_One
AFRM	FLD		0		mbAddrCol5	8 * (CurrMbAddr % 2) +4 * (yCol / 8)	Fld_To_Frm
			1		mbAddrCol5	yCol	One_To_One
	AFRM	CurrMbAddr	0	0	CurrMbAddr	yCol	One_To_One
				1	mbAddrCol6	8 * (CurrMbAddr % 2) + 4 * (yCol / 8)	Fld_To_Frm
		CurrMbAddr	1	0	mbAddrCol7	(2 * yCol) % 16	Frm_To_Fld
				1	CurrMbAddr	yCol	One_To_One

Let mbPartIdxCol be the macroblock partition index of the co-located partition and subMbPartIdxCol the sub-macroblock partition index of the co-located sub-macroblock partition. The partition in the macroblock mbAddrCol inside the picture colPic covering the sample (xCol, yM) is assigned to mbPartIdxCol and the sub-macroblock partition inside the partition mbPartIdxCol covering the sample (xCol, yM) in the macroblock mbAddrCol inside the picture colPic is assigned to subMbPartIdxCol.

The prediction utilization flags predFlagL0Col and predFlagL1Col are set equal to PredFlagL0[mbPartIdxCol] and PredFlagL1[mbPartIdxCol], respectively, which are the prediction utilization flags that have been assigned to the macroblock partition mbAddrCol\mbPartIdxCol inside the picture colPic.

The motion vector mvCol and the reference index refIdxCol are derived as follows.

– If the macroblock mbAddrCol is coded in Intra macroblock prediction mode or both prediction utilization flags, predFlagL0Col and predFlagL1Col are equal to 0, both components of mvCol are set equal to 0 and refIdxCol is set equal to –1.

– Otherwise, the following applies.

  – If predFlagL0Col is equal to 1, the motion vector mvCol and the reference index refIdxCol are set equal to MvL0[mbPartIdxCol][subMbPartIdxCol] and RefIdxL0[mbPartIdxCol], respectively, which are the motion vector mvL0 and the reference index refIdxL0 that have been assigned to the (sub-)macroblock partition mbAddrCol\mbPartIdxCol\subMbPartIdxCol inside the picture colPic.

  – Otherwise (predFlagL0Col is equal to 0 and predFlagL1Col is equal to 1), the motion vector mvCol and the reference index refIdxCol are set equal to MvL1[mbPartIdxCol][subMbPartIdxCol] and RefIdxL1[mbPartIdxCol], respectively, which are the motion vector mvL1 and the reference index refIdxL1 that have been assigned to the (sub-)macroblock partition mbAddrCol\mbPartIdxCol\subMbPartIdxCol inside the picture colPic.

8.4.1.2.2 Derivation process for spatial direct luma motion vector and reference index prediction mode

This process is invoked when direct_spatial_mv_pred_flag is equal to 1 and any of the following conditions is true.

– mb_type is equal to B_Skip

– mb_type is equal to B_Direct_16x16

– sub_mb_type[mbPartIdx] is equal to B_Direct_8x8.

Inputs to this process are mbPartIdx, subMbPartIdx.

Outputs of this process are the reference indices refIdxL0, refIdxL1, the motion vectors mvL0 and mvL1, the sub-partition motion vector count subMvCnt, and the prediction list utilization flags, predFlagL0 and predFlagL1.

The reference indices refIdxL0 and refIdxL1 and the variable directZeroPredictionFlag are derived by applying the following ordered steps.

1. Let the variable currSubMbType be set equal to sub_mb_type[mbPartIdx].

2. The process specified in subclause 8.4.1.3.2 is invoked with mbPartIdx = 0, subMbPartIdx = 0, currSubMbType, and listSuffixFlag = 0 as inputs and the output is assigned to the motion vectors mvL0N and the reference indices refIdxL0N with N being replaced by A, B, or C.

3. The process specified in subclause 8.4.1.3.2 is invoked with mbPartIdx = 0, subMbPartIdx = 0, currSubMbType, and listSuffixFlag = 1 as inputs and the output is assigned to the motion vectors mvL1N and the reference indices refIdxL1N with N being replaced by A, B, or C.

   NOTE 1 – The motion vectors mvL0N, mvL1N and the reference indices refIdxL0N, refIdxL1N are identical for all 4x4 sub-macroblock partitions of a macroblock.

4. The reference indices refIdxL0, refIdxL1, and directZeroPredictionFlag are derived by

$$refIdxL0 = MinPositive(refIdxL0A, MinPositive(refIdxL0B, refIdxL0C)) \quad (8\text{-}181)$$

$$refIdxL1 = MinPositive(refIdxL1A, MinPositive(refIdxL1B, refIdxL1C)) \quad (8\text{-}182)$$

$$directZeroPredictionFlag = 0 \quad (8\text{-}183)$$

where

$$MinPositive(x, y) = \begin{cases} Min(x, y) & \text{if } x >= 0 \text{ and } y >= 0 \\ Max(x, y) & \text{otherwise} \end{cases} \quad (8\text{-}184)$$

5. When both reference indices refIdxL0 and refIdxL1 are less than 0,

refIdxL0 = 0 (8-185)
refIdxL1 = 0 (8-186)
directZeroPredictionFlag = 1 (8-187)

The process specified in subclause 8.4.1.2.1 is invoked with mbPartIdx, subMbPartIdx given as input and the output is assigned to refIdxCol and mvCol.

The variable colZeroFlag is derived as follows.

– If all of the following conditions are true, colZeroFlag is set equal to 1.
  – RefPicList1[0] is currently marked as "used for short-term reference".
  – refIdxCol is equal to 0
  – both motion vector components mvCol[0] and mvCol[1] lie in the range of -1 to 1 in units specified as follows.
    – If the co-located macroblock is a frame macroblock, the units of mvCol[0] and mvCol[1] are units of quarter luma frame samples.
    – Otherwise (the co-located macroblock is a field macroblock), the units of mvCol[0] and mvCol[1] are units of quarter luma field samples.

  NOTE 2 – For purposes of determining the condition above, the value mvCol[1] is not scaled to use the units of a motion vector for the current macroblock in cases when the current macroblock is a frame macroblock and the co-located macroblock is a field macroblock or when the current macroblock is a field macroblock and the co-located macroblock is a frame macroblock. This aspect differs from the use of mvCol[1] in the temporal direct mode as specified in subclause 8.4.1.2.3, which applies scaling to the motion vector of the co-located macroblock to use the same units as the units of a motion vector for the current macroblock, using Equation 8-190 or Equation 8-191 in these cases.

– Otherwise, colZeroFlag is set equal to 0.

The motion vectors mvLX (with X being 0 or 1) are derived as follows.

– If any of the following conditions is true, both components of the motion vector mvLX are set equal to 0.
  – directZeroPredictionFlag is equal to 1
  – refIdxLX is less than 0
  – refIdxLX is equal to 0 and colZeroFlag is equal to 1
– Otherwise, the process specified in subclause 8.4.1.3 is invoked with mbPartIdx = 0, subMbPartIdx = 0, refIdxLX, and currSubMbType as inputs and the output is assigned to mvLX.

  NOTE 3 – The motion vector mvLX returned from subclause 8.4.1.3 is identical for all 4x4 sub-macroblock partitions of a macroblock for which the process is invoked.

The prediction utilization flags predFlagL0 and predFlagL1 are derived as specified using Table 8-9.

Table 8-9 – Assignment of prediction utilization flags

refIdxL0	refIdxL1	predFlagL0	predFlagL1
>= 0	>= 0	1	1
>= 0	< 0	1	0
< 0	>= 0	0	1

The variable subMvCnt is derived as follows.

– If subMbPartIdx is not equal to 0 or direct_8x8_inference_flag is equal to 0, subMvCnt is set equal to 0.
– Otherwise (subMbPartIdx is equal to 0 and direct_8x8_inference_flag is equal to 1), subMvCnt is set equal to predFlagL0 + predFLagL1.

8.4.1.2.3 Derivation process for temporal direct luma motion vector and reference index prediction mode

This process is invoked when direct_spatial_mv_pred_flag is equal to 0 and any of the following conditions is true.

- mb_type is equal to B_Skip
- mb_type is equal to B_Direct_16x16
- sub_mb_type[mbPartIdx] is equal to B_Direct_8x8.

Inputs to this process are mbPartIdx and subMbPartIdx.

Outputs of this process are the motion vectors mvL0 and mvL1, the reference indices refIdxL0 and refIdxL1, and the prediction list utilization flags, predFlagL0 and predFlagL1.

The process specified in subclause 8.4.1.2.1 is invoked with mbPartIdx, subMbPartIdx given as input and the output is assigned to colPic, mbAddrCol, mvCol, refIdxCol, and vertMvScale.

The reference indices refIdxL0 and refIdxL1 are derived as follows.

refIdxL0 = ((refIdxCol < 0) ? 0 : MapColToList0(refIdxCol)) (8-188)

refIdxL1 = 0 (8-189)

NOTE 1 – If the current macroblock is a field macroblock, refIdxL0 and refIdxL1 index a list of fields; otherwise (the current macroblock is a frame macroblock), refIdxL0 and refIdxL1 index a list of frames or complementary reference field pairs.

Let refPicCol be a frame, a field, or a complementary field pair that was referred by the reference index refIdxCol when decoding the co-located macroblock mbAddrCol inside the picture colPic. The function MapColToList0(refIdxCol) is specified as follows.

- If vertMvScale is equal to One_To_One, the following applies.
  - If field_pic_flag is equal to 0 and the current macroblock is a field macroblock, the following applies.
    - Let refIdxL0Frm be the lowest valued reference index in the current reference picture list RefPicList0 that references the frame or complementary field pair that contains the field refPicCol. RefPicList0 shall contain a frame or complementary field pair that contains the field refPicCol. The return value of MapColToList0( ) is specified as follows.
      - If the field referred to by refIdxCol has the same parity as the current macroblock, MapColToList0(refIdxCol) returns the reference index (refIdxL0Frm << 1).
      - Otherwise (the field referred by refIdxCol has the opposite parity of the current macroblock), MapColToList0(refIdxCol) returns the reference index ((refIdxL0Frm << 1) + 1).
  - Otherwise (field_pic_flag is equal to 1 or the current macroblock is a frame macroblock), MapColToList0(refIdxCol) returns the lowest valued reference index refIdxL0 in the current reference picture list RefPicList0 that references refPicCol. RefPicList0 shall contain refPicCol.
- Otherwise, if vertMvScale is equal to Frm_To_Fld, the following applies.
  - If field_pic_flag is equal to 0, let refIdxL0Frm be the lowest valued reference index in the current reference picture list RefPicList0 that references refPicCol. MapColToList0(refIdxCol) returns the reference index (refIdxL0Frm << 1). RefPicList0 shall contain refPicCol.
  - Otherwise (field_pic_flag is equal to 1), MapColToList0(refIdxCol) returns the lowest valued reference index refIdxL0 in the current reference picture list RefPicList0 that references the field of refPicCol with the same parity as the current picture CurrPic. RefPicList0 shall contain the field of refPicCol with the same parity as the current picture CurrPic.
- Otherwise (vertMvScale is equal to Fld_To_Frm), MapColToList0(refIdxCol) returns the lowest valued reference index refIdxL0 in the current reference picture list RefPicList0 that references the frame or complementary field pair that contains refPicCol. RefPicList0 shall contain a frame or complementary field pair that contains the field refPicCol.

NOTE 2 – A decoded reference picture that was marked as "used for short-term reference" when it was referenced in the decoding process of the picture containing the co-located macroblock may have been modified to be marked as "used for long-term reference" before being used for reference for inter prediction using the direct prediction mode for the current macroblock.

Depending on the value of vertMvScale the vertical component of mvCol is modified as follows.

– If vertMvScale is equal to Frm_To_Fld

$$mvCol[1] = mvCol[1] / 2 \quad (8\text{-}190)$$

– Otherwise, if vertMvScale is equal to Fld_To_Frm

$$mvCol[1] = mvCol[1] * 2 \quad (8\text{-}191)$$

– Otherwise (vertMvScale is equal to One_To_One), mvCol[1] remains unchanged.

The variables currPicOrField, pic0, and pic1, are derived as follows.

– If field_pic_flag is equal to 0 and the current macroblock is a field macroblock, the following applies.
  – currPicOrField is the field of the current picture CurrPic that has the same parity as the current macroblock.
  – pic1 is the field of RefPicList1[0] that has the same parity as the current macroblock.
  – The variable pic0 is derived as follows.
    – If refIdxL0 % 2 is equal to 0, pic0 is the field of RefPicList0[refIdxL0 / 2] that has the same parity as the current macroblock.
    – Otherwise (refIdxL0 % 2 is not equal to 0), pic0 is the field of RefPicList0[refIdxL0 / 2] that has the opposite parity of the current macroblock.
– Otherwise (field_pic_flag is equal to 1 or the current macroblock is a frame macroblock), currPicOrField is the current picture CurrPic, pic1 is the decoded reference picture RefPicList1[0], and pic0 is the decoded reference picture RefPicList0[refIdxL0].

The two motion vectors mvL0 and mvL1 for each 4x4 sub-macroblock partition of the current macroblock are derived as follows:

NOTE 3 – It is often the case that many of the 4x4 sub-macroblock partitions share the same motion vectors and reference pictures. In these cases, temporal direct mode motion compensation can calculate the inter prediction sample values in larger units than 4x4 luma sample blocks. For example, when direct_8x8_inference_flag is equal to 1, at least each 8x8 luma sample quadrant of the macroblock shares the same motion vectors and reference pictures.

– If the reference index refIdxL0 refers to a long-term reference picture, or DiffPicOrderCnt(pic1, pic0) is equal to 0, the motion vectors mvL0, mvL1 for the direct mode partition are derived by

$$mvL0 = mvCol \quad (8\text{-}192)$$

$$mvL1 = 0 \quad (8\text{-}193)$$

– Otherwise, the motion vectors mvL0, mvL1 are derived as scaled versions of the motion vector mvCol of the co-located sub-macroblock partition as specified below (see Figure 8-2)

$$tx = (16\,384 + Abs(td / 2)) / td \quad (8\text{-}194)$$

$$DistScaleFactor = Clip3(-1024, 1023, (tb * tx + 32) >> 6) \quad (8\text{-}195)$$

$$mvL0 = (DistScaleFactor * mvCol + 128) >> 8 \quad (8\text{-}196)$$

$$mvL1 = mvL0 – mvCol \quad (8\text{-}197)$$

where tb and td are derived as follows.

$$tb = Clip3(-128, 127, DiffPicOrderCnt(currPicOrField, pic0)) \quad (8\text{-}198)$$

$$td = Clip3(-128, 127, DiffPicOrderCnt(pic1, pic0)) \quad (8\text{-}199)$$

NOTE 4 – mvL0 and mvL1 cannot exceed the ranges specified in Annex A.

The prediction utilization flags predFlagL0 and predFlagL1 are both set equal to 1.

Figure 8-2 illustrates the temporal direct-mode motion vector inference when the current picture is temporally between the reference picture from reference picture list 0 and the reference picture from reference picture list 1.

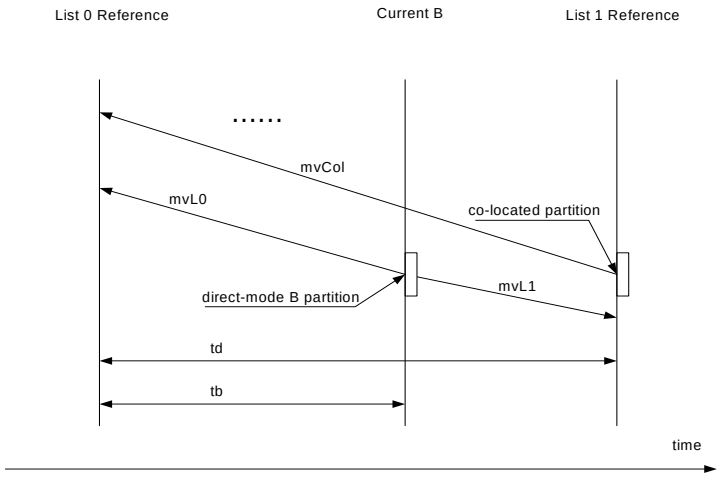


Figure 8-2 – Example for temporal direct-mode motion vector inference (informative)

8.4.1.3 Derivation process for luma motion vector prediction

Inputs to this process are

– the macroblock partition index mbPartIdx,

– the sub-macroblock partition index subMbPartIdx,

– the reference index of the current partition refIdxLX (with X being 0 or 1),

– the variable currSubMbType.

Output of this process is the prediction mvpLX of the motion vector mvLX (with X being 0 or 1).

The derivation process for the neighbouring blocks for motion data in subclause 8.4.1.3.2 is invoked with mbPartIdx, subMbPartIdx, currSubMbType, and listSuffixFlag = X (with X being 0 or 1 for refIdxLX being refIdxL0 or refIdxL1, respectively) as the input and with mbAddrN\mbPartIdxN\subMbPartIdxN, reference indices refIdxLXN and the motion vectors mvLXN with N being replaced by A, B, or C as the output.

The derivation process for median luma motion vector prediction in subclause 8.4.1.3.1 is invoked with mbAddrN\mbPartIdxN\subMbPartIdxN, mvLXN, refIdxLXN with N being replaced by A, B, or C and refIdxLX as the input and mvpLX as the output, unless one of the following is true.

– MbPartWidth(mb_type) is equal to 16, MbPartHeight(mb_type) is equal to 8, mbPartIdx is equal to 0, and refIdxLXB is equal to refIdxLX,

$$mvpLX = mvLXB \tag{8-200}$$

– MbPartWidth(mb_type) is equal to 16, MbPartHeight(mb_type) is equal to 8, mbPartIdx is equal to 1, and refIdxLXA is equal to refIdxLX,

$$mvpLX = mvLXA \tag{8-201}$$

– MbPartWidth(mb_type) is equal to 8, MbPartHeight(mb_type) is equal to 16, mbPartIdx is equal to 0, and refIdxLXA is equal to refIdxLX,

$$mvpLX = mvLXA \tag{8-202}$$

– MbPartWidth(mb_type) is equal to 8, MbPartHeight(mb_type) is equal to 16, mbPartIdx is equal to 1, and refIdxLXC is equal to refIdxLX,

$$mvpLX = mvLXC \tag{8-203}$$

Figure 8-3 illustrates the non-median prediction as described above.

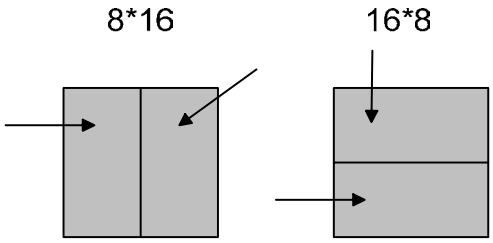


Figure 8-3 – Directional segmentation prediction (informative)

8.4.1.3.1 Derivation process for median luma motion vector prediction

Inputs to this process are

– the neighbouring partitions mbAddrN\mbPartIdxN\subMbPartIdxN (with N being replaced by A, B, or C),

– the motion vectors mvLXN (with N being replaced by A, B, or C) of the neighbouring partitions,

– the reference indices refIdxLXN (with N being replaced by A, B, or C) of the neighbouring partitions, and

– the reference index refIdxLX of the current partition.

Output of this process is the motion vector prediction mvpLX.

The variable mvpLX is derived as follows:

– When both partitions mbAddrB\mbPartIdxB\subMbPartIdxB and mbAddrC\mbPartIdxC\subMbPartIdxC are not available and mbAddrA\mbPartIdxA\subMbPartIdxA is available,

$$mvLXB = mvLXA \tag{8-204}$$

$$mvLXC = mvLXA \tag{8-205}$$

$$refIdxLXB = refIdxLXA \tag{8-206}$$

$$refIdxLXC = refIdxLXA \tag{8-207}$$

– Depending on reference indices refIdxLXA, refIdxLXB, or refIdxLXC, the following applies.

  – If one and only one of the reference indices refIdxLXA, refIdxLXB, or refIdxLXC is equal to the reference index refIdxLX of the current partition, the following applies. Let refIdxLXN be the reference index that is equal to refIdxLX, the motion vector mvLXN is assigned to the motion vector prediction mvpLX:

$$mvpLX = mvLXN \tag{8-208}$$

  – Otherwise, each component of the motion vector prediction mvpLX is given by the median of the corresponding vector components of the motion vector mvLXA, mvLXB, and mvLXC:

$$mvpLX[\ 0\ ] = Median(\ mvLXA[\ 0\ ], mvLXB[\ 0\ ], mvLXC[\ 0\ ]\ ) \tag{8-209}$$

mvpLX[1] = Median(mvLXA[1], mvLXB[1], mvLXC[1]) (8-210)

8.4.1.3.2 Derivation process for motion data of neighbouring partitions

Inputs to this process are

– the macroblock partition index mbPartIdx,

– the sub-macroblock partition index subMbPartIdx,

– the current sub-macroblock type currSubMbType,

– the list suffix flag listSuffixFlag

Outputs of this process are (with N being replaced by A, B, or C)

– mbAddrN\mbPartIdxN\subMbPartIdxN specifying neighbouring partitions,

– the motion vectors mvLXN of the neighbouring partitions, and

– the reference indices refIdxLXN of the neighbouring partitions.

Variable names that include the string "LX" are interpreted with the X being equal to listSuffixFlag.

The partitions mbAddrN\mbPartIdxN\subMbPartIdxN with N being either A, B, or C are derived in the following ordered steps.

1. Let mbAddrD\mbPartIdxD\subMbPartIdxD be variables specifying an additional neighbouring partition.
2. The process in subclause 6.4.8.5 is invoked with mbPartIdx, currSubMbType, and subMbPartIdx as input and the output is assigned to mbAddrN\mbPartIdxN\subMbPartIdxN with N being replaced by A, B, C, or D.
3. When the partition mbAddrC\mbPartIdxC\subMbPartIdxC is not available, the following applies

   mbAddrC = mbAddrD (8-211)

   mbPartIdxC = mbPartIdxD (8-212)

   subMbPartIdxC = subMbPartIdxD (8-213)

The motion vectors mvLXN and reference indices refIdxLXN (with N being A, B, or C) are derived as follows.

– If the macroblock partition or sub-macroblock partition mbAddrN\mbPartIdxN\subMbPartIdxN is not available or mbAddrN is coded in Intra prediction mode or predFlagLX of mbAddrN\mbPartIdxN\subMbPartIdxN is equal to 0, both components of mvLXN are set equal to 0 and refIdxLXN is set equal to –1.

– Otherwise, the following applies.

  – The motion vector mvLXN and reference index refIdxLXN are set equal to MvLX[mbPartIdxN][subMbPartIdxN] and RefIdxLX[mbPartIdxN], respectively, which are the motion vector mvLX and reference index refIdxLX that have been assigned to the (sub-)macroblock partition mbAddrN\mbPartIdxN\subMbPartIdxN.

  – The variables mvLXN[1] and refIdxLXN are further processed as follows.

    – If the current macroblock is a field macroblock and the macroblock mbAddrN is a frame macroblock

      mvLXN[1] = mvLXN[1] / 2 (8-214)

      refIdxLXN = refIdxLXN * 2 (8-215)

    – Otherwise, if the current macroblock is a frame macroblock and the macroblock mbAddrN is a field macroblock

      mvLXN[1] = mvLXN[1] * 2 (8-216)

refIdxLXN = refIdxLXN / 2 (8-217)

– Otherwise, the vertical motion vector component mvLXN[1] and the reference index refIdxLXN remain unchanged.

8.4.1.4 Derivation process for chroma motion vectors

This process is only invoked when chroma_format_idc is not equal to 0 (monochrome).

Inputs to this process are a luma motion vector mvLX and a reference index refIdxLX.

Output of this process is a chroma motion vector mvCLX.

A chroma motion vector is derived from the corresponding luma motion vector.

The precision of the chroma motion vector components is 1 ÷ (4 * SubWidthC) horizontally and 1 ÷ (4 * SubHeightC) vertically.

NOTE – For example, when using the 4:2:0 chroma format, since the units of luma motion vectors are one-quarter luma sample units and chroma has half horizontal and vertical resolution compared to luma, the units of chroma motion vectors are one-eighth chroma sample units, i.e., a value of 1 for the chroma motion vector refers to a one-eighth chroma sample displacement. For example, when the luma vector applies to 8x16 luma samples, the corresponding chroma vector in 4:2:0 chroma format applies to 4x8 chroma samples and when the luma vector applies to 4x4 luma samples, the corresponding chroma vector in 4:2:0 chroma format applies to 2x2 chroma samples.

For the derivation of the motion vector mvCLX, the following applies.

– If chroma_format_idc is not equal to 1 or the current macroblock is a frame macroblock, the horizontal and vertical components of the chroma motion vector mvCLX are derived as

mvCLX[0] = mvLX[0] (8-218)
mvCLX[1] = mvLX[1] (8-219)

– Otherwise (chroma_format_idc is equal to 1 and the current macroblock is a field macroblock), only the horizontal component of the chroma motion vector mvCLX[0] is derived using Equation 8-218. The vertical component of the chroma motion vector mvCLX[1] is dependent on the parity of the current field or the current macroblock and the reference picture, which is referred by the reference index refIdxLX. mvCLX[1] is derived from mvLX[1] according to Table 8-10.

Table 8-10 – Derivation of the vertical component of the chroma vector in field coding mode

Parity conditions		**mvCLX[1]**
Reference picture (refIdxLX)	Current field (picture/macroblock)	
Top field	Bottom field	mvLX[1] + 2
Bottom field	Top field	mvLX[1] – 2
Otherwise		mvLX[1]

8.4.2 Decoding process for Inter prediction samples

Inputs to this process are

– a macroblock partition mbPartIdx,

– a sub-macroblock partition subMbPartIdx.

– variables specifying partition width and height for luma and chroma (if available), partWidth, partHeight, partWidthC (if available) and partHeightC (if available)

– luma motion vectors mvL0 and mvL1 and when chroma_format_idc is not equal to 0 (monochrome) chroma motion vectors mvCL0 and mvCL1

– reference indices refIdxL0 and refIdxL1

– prediction list utilization flags, predFlagL0 and predFlagL1

Outputs of this process are

– the Inter prediction samples predPart, which are a (partWidth)x(partHeight) array $predPart_L$ of prediction luma samples, and when chroma_format_idc is not equal to 0 (monochrome) two (partWidthC)x(partHeightC) arrays $predPart_{Cb}$, $predPart_{Cr}$ of prediction chroma samples, one for each of the chroma components Cb and Cr.

Let $predPartL0_L$ and $predPartL1_L$ be (partWidth)x(partHeight) arrays of predicted luma sample values and when chroma_format_idc is not equal to 0 (monochrome) $predPartL0_{Cb}$, $predPartL1_{Cb}$, $predPartL0_{Cr}$, and $predPartL1_{Cr}$ be (partWidthC)x(partHeightC) arrays of predicted chroma sample values.

For LX being replaced by either L0 or L1 in the variables predFlagLX, RefPicListX, refIdxLX, refPicLX, predPartLX, the following is specified.

When predFlagLX is equal to 1, the following applies.

– The reference picture consisting of an ordered two-dimensional array $refPicLX_L$ of luma samples and when chroma_format_idc is not equal to 0 (monochrome) two ordered two-dimensional arrays $refPicLX_{Cb}$ and $refPicLX_{Cr}$ of chroma samples is derived by invoking the process specified in subclause 8.4.2.1 with refIdxLX and RefPicListX given as input.

– The array $predPartLX_L$ and when chroma_format_idc is not equal to 0 (monochrome) the arrays $predPartLX_{Cb}$ and $predPartLX_{Cr}$ are derived by invoking the process specified in subclause 8.4.2.2 with the current partition specified by mbPartIdx\subMbPartIdx, the motion vectors mvLX, mvCLX (if available), and the reference arrays with $refPicLX_L$, $refPicLX_{Cb}$ (if available), and $refPicLX_{Cr}$ (if available) given as input.

For C being replaced by L, Cb (if available), or Cr (if available), the array $predPart_C$ of the prediction samples of component C is derived by invoking the process specified in subclause 8.4.2.3 with the current partition specified by mbPartIdx and subMbPartIdx and the array $predPartL0_C$ and $predPartL1_C$ as well as predFlagL0 and predFlagL1 given as input.

8.4.2.1 Reference picture selection process

Input to this process is a reference index refIdxLX.

Output of this process is a reference picture consisting of a two-dimensional array of luma samples $refPicLX_L$ and two two-dimensional arrays of chroma samples $refPicLX_{Cb}$ and $refPicLX_{Cr}$.

Depending on field_pic_flag, the reference picture list RefPicListX (which has been derived as specified in subclause 8.2.4) consists of the following.

– If field_pic_flag is equal to 1, each entry of RefPicListX is a reference field or a field of a reference frame.

– Otherwise (field_pic_flag is equal to 0), each entry of RefPicListX is a reference frame or a complementary reference field pair.

For the derivation of the reference picture, the following applies.

– If field_pic_flag is equal to 1, the reference field or field of a reference frame RefPicListX[refIdxLX] is the output. The output reference field or field of a reference frame consists of a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array of luma samples $refPicLX_L$ and, when chroma_format_idc is not equal to 0 (monochrome), two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays of chroma samples $refPicLX_{Cb}$ and $refPicLX_{Cr}$.

– Otherwise (field_pic_flag is equal to 0), the following applies.

  – If the current macroblock is a frame macroblock, the reference frame or complementary reference field pair RefPicListX[refIdxLX] is the output. The output reference frame or complementary reference field pair consists of a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array of luma samples $refPicLX_L$ and, when chroma_format_idc is not equal to 0 (monochrome), two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays of chroma samples $refPicLX_{Cb}$ and $refPicLX_{Cr}$.

  – Otherwise (the current macroblock is a field macroblock), the following applies.

    – Let refFrame be the reference frame or complementary reference field pair RefPicListX[refIdxLX / 2].

    – The field of refFrame is selected as follows.

      – If refIdxLX % 2 is equal to 0, the field of refFrame that has the same parity as the current macroblock is the output.

– Otherwise (refIdxLX % 2 is equal to 1), the field of refFrame that has the opposite parity as the current macroblock is the output.

– The output reference field or field of a reference frame consists of a (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$ / 2) array of luma samples refPicLX$_L$ and, when chroma_format_idc is not equal to 0 (monochrome), two (PicWidthInSamples$_C$)x(PicHeightInSamples$_C$ / 2) arrays of chroma samples refPicLX$_{Cb}$ and refPicLX$_{Cr}$.

The reference picture sample arrays refPicLX$_L$, refPicLX$_{Cb}$ (if available), and refPicLX$_{Cr}$ (if available) correspond to decoded sample arrays S_L, S_{Cb} (if available), S_{Cr} (if available) derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.

8.4.2.2 Fractional sample interpolation process

Inputs to this process are

– the current partition given by its partition index mbPartIdx and its sub-macroblock partition index subMbPartIdx,

– the width and height partWidth, partHeight of this partition in luma-sample units,

– a luma motion vector mvLX given in quarter-luma-sample units,

– a chroma motion vector mvCLX given in eighth-chroma-sample units, and

– the selected reference picture sample arrays refPicLX$_L$, refPicLX$_{Cb}$, and refPicLX$_{Cb}$

Outputs of this process are

– a (partWidth)x(partHeight) array predPartLX$_L$ of prediction luma sample values and

– when chroma_format_idc is not equal to 0 (monochrome) two (partWidthC)x(partHeightC) arrays predPartLX$_{Cb}$, and predPartLX$_{Cr}$ of prediction chroma sample values.

Let (xA$_L$, yA$_L$) be the location given in full-sample units of the upper-left luma sample of the current partition given by mbPartIdx\subMbPartIdx relative to the upper-left luma sample location of the given two-dimensional array of luma samples.

Let (xInt$_L$, yInt$_L$) be a luma location given in full-sample units and (xFrac$_L$, yFrac$_L$) be an offset given in quarter-sample units. These variables are used only inside this subclause for specifying general fractional-sample locations inside the reference sample arrays refPicLX$_L$, refPicLX$_{Cb}$ (if available), and refPicLX$_{Cr}$ (if available).

For each luma sample location ($0 <= x_L <$ partWidth, $0 <= y_L <$ partHeight) inside the prediction luma sample array predPartLX$_L$, the corresponding prediction luma sample value predPartLX$_L$[x_L, y_L] is derived as follows:

– The variables xInt$_L$, yInt$_L$, xFrac$_L$, and yFrac$_L$ are derived by

$$xInt_L = xA_L + (mvLX[0] >> 2) + x_L \quad (8\text{-}220)$$
$$yInt_L = yA_L + (mvLX[1] >> 2) + y_L \quad (8\text{-}221)$$

$$xFrac_L = mvLX[0] \& 3 \quad (8\text{-}222)$$
$$yFrac_L = mvLX[1] \& 3 \quad (8\text{-}223)$$

– The prediction luma sample value predPartLX$_L$[x_L, y_L] is derived by invoking the process specified in subclause 8.4.2.2.1 with (xInt$_L$, yInt$_L$), (xFrac$_L$, yFrac$_L$) and refPicLX$_L$ given as input.

When chroma_format_idc is not equal to 0 (monochrome), the following applies.

Let (xInt$_C$, yInt$_C$) be a chroma location given in full-sample units and (xFrac$_C$, yFrac$_C$) be an offset given in one-eighth sample units. These variables are used only inside this subclause for specifying general fractional-sample locations inside the reference sample arrays refPicLX$_{Cb}$, and refPicLX$_{Cr}$.

For each chroma sample location ($0 <= x_C <$ partWidthC, $0 <= y_C <$ partHeightC) inside the prediction chroma sample arrays predPartLX$_{Cb}$ and predPartLX$_{Cr}$, the corresponding prediction chroma sample values predPartLX$_{Cb}$[x_C, y_C] and predPartLX$_{Cr}$[x_C, y_C] are derived as follows:

– Depending on chroma_format_idc, the variables xInt$_C$, yInt$_C$, xFrac$_C$, and yFrac$_C$ are derived as follows.

  – If chroma_format_idc is equal to 1,

$xInt_C = (xA_L / SubWidthC) + (mvCLX[0] >> 3) + x_C$ (8-224)
$yInt_C = (yA_L / SubHeightC) + (mvCLX[1] >> 3) + y_C$ (8-225)

$xFrac_C = mvCLX[0] \& 7$ (8-226)
$yFrac_C = mvCLX[1] \& 7$ (8-227)

– Otherwise, if chroma_format_idc is equal to 2,

$xInt_C = (xA_L / SubWidthC) + (mvCLX[0] >> 3) + x_C$ (8-228)
$yInt_C = (yA_L / SubHeightC) + (mvCLX[1] >> 2) + y_C$ (8-229)

$xFrac_C = mvCLX[0] \& 7$ (8-230)
$yFrac_C = (mvCLX[1] \& 3) << 1$ (8-231)

– Otherwise (chroma_format_idc is equal to 3),

$xInt_C = (xA_L / SubWidthC) + (mvCLX[0] >> 2) + x_C$ (8-232)
$yInt_C = (yA_L / SubHeightC) + (mvCLX[1] >> 2) + y_C$ (8-233)

$xFrac_C = (mvCLX[0] \& 3) << 1$ (8-234)
$yFrac_C = (mvCLX[1] \& 3) << 1$ (8-235)

– The prediction sample value $predPartLX_{Cb}[x_C, y_C]$ is derived by invoking the process specified in subclause 8.4.2.2.2 with ($xInt_C$, $yInt_C$), ($xFrac_C$, $yFrac_C$) and $refPicLX_{Cb}$ given as input.

– The prediction sample value $predPartLX_{Cr}[x_C, y_C]$ is derived by invoking the process specified in subclause 8.4.2.2.2 with ($xInt_C$, $yInt_C$), ($xFrac_C$, $yFrac_C$) and $refPicLX_{Cr}$ given as input.

8.4.2.2.1 Luma sample interpolation process

Inputs to this process are

– a luma location in full-sample units ($xInt_L$, $yInt_L$),

– a luma location offset in fractional-sample units ($xFrac_L$, $yFrac_L$), and

– the luma sample array of the selected reference picture $refPicLX_L$

Output of this process is a predicted luma sample value $predPartLX_L[x_L, y_L]$.

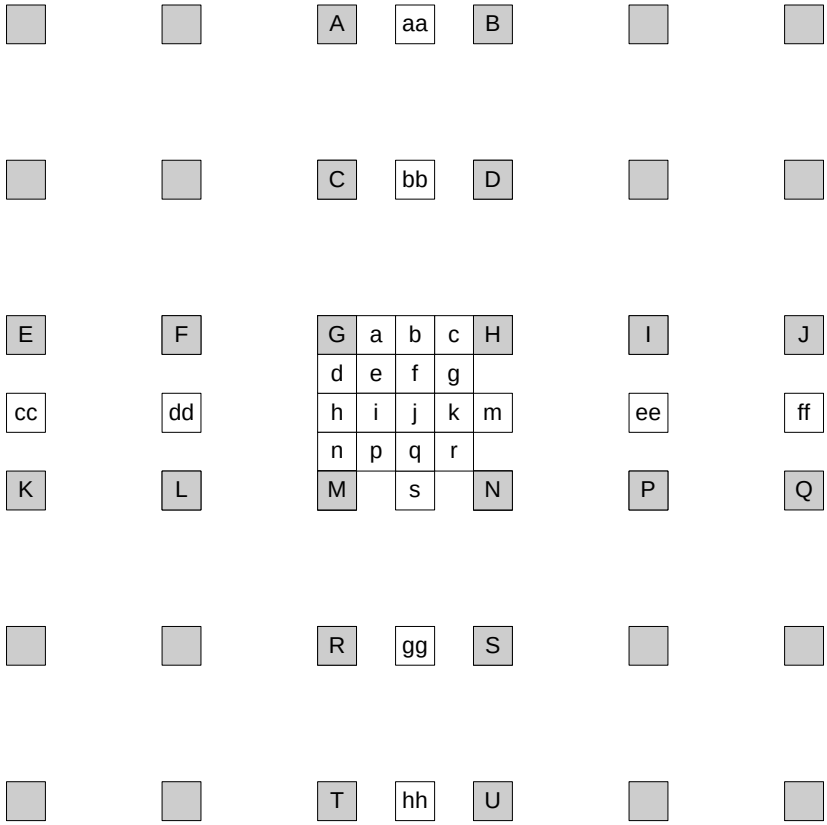


Figure 8-4 – Integer samples (shaded blocks with upper-case letters) and fractional sample positions (un-shaded blocks with lower-case letters) for quarter sample luma interpolation

The variable $refPicHeightEffective_L$, which is the height of the effective reference picture luma array, is derived as follows.

– If MbaffFrameFlag is equal to 0 or mb_field_decoding_flag is equal to 0, $refPicHeightEffective_L$ is set equal to $PicHeightInSamples_L$.

– Otherwise (MbaffFrameFlag is equal to 1 and mb_field_decoding_flag is equal to 1), $refPicHeightEffective_L$ is set equal to $PicHeightInSamples_L$ / 2.

In Figure 8-4, the positions labelled with upper-case letters within shaded blocks represent luma samples at full-sample locations inside the given two-dimensional array $refPicLX_L$ of luma samples. These samples may be used for generating the predicted luma sample value $predPartLX_L[x_L, y_L]$. The locations (xZ_L, yZ_L) for each of the corresponding luma samples Z, where Z may be A, B, C, D, E, F, G, H, I, J, K, L, M, N, P, Q, R, S, T, or U, inside the given array $refPicLX_L$ of luma samples are derived as follows:

$$xZ_L = Clip3(0, PicWidthInSamples_L - 1, xInt_L + xDZ_L)$$
$$yZ_L = Clip3(0, refPicHeightEffective_L - 1, yInt_L + yDZ_L) \quad (8\text{-}236)$$

Table 8-11 specifies (xDZ_L, yDZ_L) for different replacements of Z.

Table 8-11 – Differential full-sample luma locations

Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U
xDZ_L	0	1	0	1	-2	-1	0	1	2	3	-2	-1	0	1	2	3	0	1	0	1
yDZ_L	-2	-2	-1	-1	0	0	0	0	0	0	1	1	1	1	1	1	2	2	3	3

Given the luma samples 'A' to 'U' at full-sample locations (xA_L, yA_L) to (xU_L, yU_L), the luma samples 'a' to 's' at fractional sample positions are derived by the following rules. The luma prediction values at half sample positions are derived by applying a 6-tap filter with tap values (1, -5, 20, 20, -5, 1). The luma prediction values at quarter sample positions are derived by averaging samples at full and half sample positions. The process for each fractional position is described below.

– The samples at half sample positions labelled b are derived by first calculating intermediate values denoted as b_1 by applying the 6-tap filter to the nearest integer position samples in the horizontal direction. The samples at half sample positions labelled h are derived by first calculating intermediate values denoted as h_1 by applying the 6-tap filter to the nearest integer position samples in the vertical direction:

$$b_1 = (E - 5 * F + 20 * G + 20 * H - 5 * I + J) \quad (8\text{-}237)$$
$$h_1 = (A - 5 * C + 20 * G + 20 * M - 5 * R + T) \quad (8\text{-}238)$$

The final prediction values b and h are derived using:

$$b = Clip1_Y((b_1 + 16) >> 5) \quad (8\text{-}239)$$
$$h = Clip1_Y((h_1 + 16) >> 5) \quad (8\text{-}240)$$

– The samples at half sample position labelled as j are derived by first calculating intermediate value denoted as j_1 by applying the 6-tap filter to the intermediate values of the closest half sample positions in either the horizontal or vertical direction because these yield an equal result.

$$j_1 = cc - 5 * dd + 20 * h_1 + 20 * m_1 - 5 * ee + ff, \text{ or} \quad (8\text{-}241)$$
$$j_1 = aa - 5 * bb + 20 * b_1 + 20 * s_1 - 5 * gg + hh \quad (8\text{-}242)$$

where intermediate values denoted as aa, bb, gg, s_1 and hh are derived by applying the 6-tap filter horizontally in the same manner as the derivation of b_1 and intermediate values denoted as cc, dd, ee, m_1 and ff are derived by applying the 6-tap filter vertically in the same manner as the derivation of h_1. The final prediction value j are derived using:

$$j = Clip1_Y((j_1 + 512) >> 10) \quad (8\text{-}243)$$

– The final prediction values s and m are derived from s_1 and m_1 in the same manner as the derivation of b and h, as given by:

$$s = Clip1_Y((s_1 + 16) >> 5) \quad (8\text{-}244)$$
$$m = Clip1_Y((m_1 + 16) >> 5) \quad (8\text{-}245)$$

– The samples at quarter sample positions labelled as a, c, d, n, f, i, k, and q are derived by averaging with upward rounding of the two nearest samples at integer and half sample positions using:

$$a = (G + b + 1) >> 1 \quad (8\text{-}246)$$
$$c = (H + b + 1) >> 1 \quad (8\text{-}247)$$
$$d = (G + h + 1) >> 1 \quad (8\text{-}248)$$
$$n = (M + h + 1) >> 1 \quad (8\text{-}249)$$
$$f = (b + j + 1) >> 1 \quad (8\text{-}250)$$
$$i = (h + j + 1) >> 1 \quad (8\text{-}251)$$
$$k = (j + m + 1) >> 1 \quad (8\text{-}252)$$
$$q = (j + s + 1) >> 1. \quad (8\text{-}253)$$

– The samples at quarter sample positions labelled as e, g, p, and r are derived by averaging with upward rounding of the two nearest samples at half sample positions in the diagonal direction using

$$e = (b + h + 1) >> 1 \quad (8\text{-}254)$$
$$g = (b + m + 1) >> 1 \quad (8\text{-}255)$$
$$p = (h + s + 1) >> 1 \quad (8\text{-}256)$$
$$r = (m + s + 1) >> 1. \quad (8\text{-}257)$$

The luma location offset in fractional-sample units ($xFrac_L$, $yFrac_L$) specifies which of the generated luma samples at full-sample and fractional-sample locations is assigned to the predicted luma sample value $predPartLX_L[x_L, y_L]$. This assignment is done according to Table 8-12. The value of $predPartLX_L[x_L, y_L]$ is the output.

Table 8-12 – Assignment of the luma prediction sample predPartLX$_L$[x$_L$, y$_L$]

xFrac$_L$	0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3
yFrac$_L$	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
predPartLX$_L$[x$_L$, y$_L$]	G	d	h	n	a	e	i	p	b	f	j	q	c	g	k	r

8.4.2.2.2 Chroma sample interpolation process

This process shall only be invoked when chroma_format_idc is not equal to 0 (monochrome).

Inputs to this process are

– a chroma location in full-sample units (xInt$_C$, yInt$_C$),

– a chroma location offset in fractional-sample units (xFrac$_C$, yFrac$_C$), and

– chroma component samples from the selected reference picture refPicLX$_C$.

Output of this process is a predicted chroma sample value predPartLX$_C$[x$_C$, y$_C$].

In Figure 8-5, the positions labelled with A, B, C, and D represent chroma samples at full-sample locations inside the given two-dimensional array refPicLX$_C$ of chroma samples.

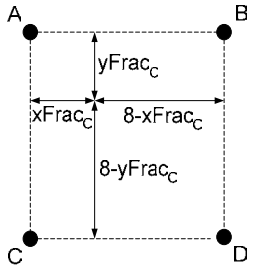


Figure 8-5 – Fractional sample position dependent variables in chroma interpolation and surrounding integer position samples A, B, C, and D

The variable refPicHeightEffective$_C$, which is the height of the effective reference picture chroma array, is derived as follows.

– If MbaffFrameFlag is equal to 0 or mb_field_decoding_flag is equal to 0, refPicHeightEffective$_C$ is set equal to PicHeightInSamples$_C$.

– Otherwise (MbaffFrameFlag is equal to 1 and mb_field_decoding_flag is equal to 1), refPicHeightEffective$_C$ is set equal to PicHeightInSamples$_C$ / 2.

The sample coordinates specified in Equations 8-258 through 8-265 are used for generating the predicted chroma sample value predPartLX$_C$[x$_C$, y$_C$].

$$xA_C = \text{Clip3}(0, \text{PicWidthInSamples}_C - 1, xInt_C) \quad (8\text{-}258)$$
$$xB_C = \text{Clip3}(0, \text{PicWidthInSamples}_C - 1, xInt_C + 1) \quad (8\text{-}259)$$
$$xC_C = \text{Clip3}(0, \text{PicWidthInSamples}_C - 1, xInt_C) \quad (8\text{-}260)$$
$$xD_C = \text{Clip3}(0, \text{PicWidthInSamples}_C - 1, xInt_C + 1) \quad (8\text{-}261)$$

$$yA_C = \text{Clip3}(0, \text{refPicHeightEffective}_C - 1, yInt_C) \quad (8\text{-}262)$$
$$yB_C = \text{Clip3}(0, \text{refPicHeightEffective}_C - 1, yInt_C) \quad (8\text{-}263)$$
$$yC_C = \text{Clip3}(0, \text{refPicHeightEffective}_C - 1, yInt_C + 1) \quad (8\text{-}264)$$
$$yD_C = \text{Clip3}(0, \text{refPicHeightEffective}_C - 1, yInt_C + 1) \quad (8\text{-}265)$$

Given the chroma samples A, B, C, and D at full-sample locations specified in Equations 8-258 through 8-265, the predicted chroma sample value $predPartLX_C[x_C, y_C]$ is derived as follows:

$$predPartLX_C[x_C, y_C] = ((8 - xFrac_C) * (8 - yFrac_C) * A + xFrac_C * (8 - yFrac_C) * B + (8 - xFrac_C) * yFrac_C * C + xFrac_C * yFrac_C * D + 32) >> 6 \quad (8\text{-}266)$$

8.4.2.3 Weighted sample prediction process

Inputs to this process are

– mbPartIdx: the current partition given by the partition index

– subMbPartIdx: the sub-macroblock partition index

– predFlagL0 and predFlagL1: prediction list utilization flags

– $predPartLX_L$: a (partWidth)x(partHeight) array of prediction luma samples (with LX being replaced by L0 or L1 depending on predFlagL0 and predFlagL1)

– when chroma_format_idc is not equal to 0 (monochrome), $predPartLX_{Cb}$ and $predPartLX_{Cr}$: (partWidthC)x(partHeightC) arrays of prediction chroma samples, one for each of the chroma components Cb and Cr (with LX being replaced by L0 or L1 depending on predFlagL0 and predFlagL1)

Outputs of this process are

– $predPart_L$: a (partWidth)x(partHeight) array of prediction luma samples and

– when chroma_format_idc is not equal to 0 (monochrome), $predPart_{Cb}$, and $predPart_{Cr}$: (partWidthC)x(partHeightC) arrays of prediction chroma samples, one for each of the chroma components Cb and Cr.

For macroblocks or partitions with predFlagL0 equal to 1 in P and SP slices, the following applies.

– If weighted_pred_flag is equal to 0, the default weighted sample prediction process as described in subclause 8.4.2.3.1 is invoked with the same inputs and outputs as the process described in this subclause.

– Otherwise (weighted_pred_flag is equal to 1), the explicit weighted prediction process as described in subclause 8.4.2.3.2 is invoked with the same inputs and outputs as the process described in this subclause.

For macroblocks or partitions with predFlagL0 or predFlagL1 equal to 1 in B slices, the following applies.

– If weighted_bipred_idc is equal to 0, the default weighted sample prediction process as described in subclause 8.4.2.3.1 is invoked with the same inputs and outputs as the process described in this subclause.

– Otherwise, if weighted_bipred_idc is equal to 1, the explicit weighted sample prediction process as described in subclause 8.4.2.3.2, for macroblocks or partitions with predFlagL0 or predFlagL1 equal to 1 with the same inputs and outputs as the process described in this subclause.

– Otherwise (weighted_bipred_idc is equal to 2), the following applies.

  – If predFlagL0 is equal to 1 and predFlagL1 is equal to 1, the implicit weighted sample prediction as described in subclause 8.4.2.3.2 is invoked with the same inputs and outputs as the process described in this subclause.

  – Otherwise (predFlagL0 or predFlagL1 are equal to 1 but not both), the default weighted sample prediction process as described in subclause 8.4.2.3.1 is invoked with the same inputs and outputs as the process described in this subclause.

8.4.2.3.1 Default weighted sample prediction process

Input to this process are the same as specified in subclause 8.4.2.3.

Output of this process are the same as specified in subclause 8.4.2.3.

Depending on the available component for which the prediction block is derived, the following applies.

– If the luma sample prediction values $predPart_L[x, y]$ are derived, the following applies with C set equal to L, x set equal to 0 .. partWidth - 1, and y set equal to 0 .. partHeight - 1.

– Otherwise, if the chroma Cb component sample prediction values $predPart_{Cb}[x, y]$ are derived, the following applies with C set equal to Cb, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

– Otherwise (the chroma Cr component sample prediction values $predPart_{Cr}[x, y]$ are derived), the following applies with C set equal to Cr, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

The prediction sample values are derived as follows.

– If predFlagL0 is equal to 1 and predFlagL1 is equal to 0 for the current partition

$$predPart_C[x, y] = predPartL0_C[x, y] \quad (8\text{-}267)$$

– Otherwise, if predFlagL0 is equal to 0 and predFlagL1 is equal to 1 for the current partition

$$predPart_C[x, y] = predPartL1_C[x, y] \quad (8\text{-}268)$$

– Otherwise (predFlagL0 and predFlagL1 are equal to 1 for the current partition),

$$predPart_C[x, y] = (predPartL0_C[x, y] + predPartL1_C[x, y] + 1) >> 1. \quad (8\text{-}269)$$

8.4.2.3.2 Weighted sample prediction process

Input to this process are the same as specified in subclause 8.4.2.3.

Output of this process are the same as specified in subclause 8.4.2.3.

Depending on the available component for which the prediction block is derived, the following applies.

– If the luma sample prediction values $predPart_L[x, y]$ are derived, the following applies with C set equal to L, x set equal to 0 .. partWidth - 1, and y set equal to 0 .. partHeight - 1.

– Otherwise, if the chroma Cb component sample prediction values $predPart_{Cb}[x, y]$ are derived, the following applies with C set equal to Cb, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

– Otherwise (the chroma Cr component sample prediction values $predPart_{Cr}[x, y]$ are derived), the following applies with C set equal to Cr, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

The prediction sample values are derived as follows

– If the partition mbPartIdx\subMbPartIdx has predFlagL0 equal to 1 and predFlagL1 equal to 0, the final predicted sample values $predPart_C[x, y]$ are derived by

$$\begin{aligned} &\text{if(logWD >= 1)} \\ &\quad predPart_C[x, y] = Clip1_C(((predPartL0_C[x, y] * w_0 + 2^{logWD - 1}) >> logWD) + o_0) \\ &\text{else} \\ &\quad predPart_C[x, y] = Clip1_C(predPartL0_C[x, y] * w_0 + o_0) \end{aligned} \quad (8\text{-}270)$$

– Otherwise, if the partition mbPartIdx\subMbPartIdx has predFlagL0 equal to 0 and predFlagL1 equal to 1, the final predicted sample values $predPart_C[x, y]$ are derived by

$$\begin{aligned} &\text{if(logWD >= 1)} \\ &\quad predPart_C[x, y] = Clip1_C(((predPartL1_C[x, y] * w_1 + 2^{logWD - 1}) >> logWD) + o_1) \\ &\text{else} \\ &\quad predPart_C[x, y] = Clip1_C(predPartL1_C[x, y] * w_1 + o_1) \end{aligned} \quad (8\text{-}271)$$

– Otherwise (the partition mbPartIdx\subMbPartIdx has both predFlagL0 and predFlagL1 equal to 1), the final predicted sample values $predPart_C[x, y]$ are derived by

$$\begin{aligned} predPart_C[x, y] = Clip1_C(((predPartL0_C[x, y] * w_0 + predPartL1_C[x, y] * w_1 + 2^{logWD}) >> \\ (logWD + 1)) + ((o_0 + o_1 + 1) >> 1)) \end{aligned} \quad (8\text{-}272)$$

The variables in the above derivation for the prediction samples are derived as follows.

– If weighted_bipred_idc is equal to 2 and the slice_type is equal to B, implicit mode weighted prediction is used as follows.

$$logWD = 5 \quad (8\text{-}273)$$

$o_0 = 0$ (8-274)

$o_1 = 0$ (8-275)

and w_0 and w_1 are derived as follows.

– The variables currPicOrField, pic0, and pic1 are derived as follows:
  – If field_pic_flag is equal to 0 and the current macroblock is a field macroblock, the following applies.
    – currPicOrField is the field of the current picture CurrPic that has the same parity as the current macroblock.
    – The variable pic0 is derived as follows.
      – If refIdxL0 % 2 is equal to 0, pic0 is the field of RefPicList0[refIdxL0 / 2] that has the same parity as the current macroblock.
      – Otherwise (refIdxL0 % 2 is not equal to 0), pic0 is the field of RefPicList0[refIdxL0 / 2] that has the opposite parity of the current macroblock.
    – The variable pic1 is derived as follows.
      – If refIdxL1 % 2 is equal to 0, pic1 is the field of RefPicList1[refIdxL1 / 2] that has the same parity as the current macroblock.
      – Otherwise (refIdxL1 % 2 is not equal to 0), pic1 is the field of RefPicList1[refIdxL1 / 2] that has the opposite parity of the current macroblock.
  – Otherwise (field_pic_flag is equal to 1 or the current macroblock is a frame macroblock), currPicOrField is the current picture CurrPic, pic1 is RefPicList1[refIdxL1], and pic0 is RefPicList0[refIdxL0].
– The variables tb, td, tx, and DistScaleFactor are derived from the values of currPicOrField, pic0, pic1 using Equations 8-198, 8-199, 8-194, and 8-195, respectively.
– If DiffPicOrderCnt(pic1, pic0) is equal to 0 or one or both of pic1 and pic0 is marked as "used for long-term reference" or (DistScaleFactor >> 2) < -64 or (DistScaleFactor >> 2) > 128, w_0 and w_1 are derived as

  $w_0 = 32$ (8-276)

  $w_1 = 32$ (8-277)

- Otherwise,

  $w_0 = 64 – (DistScaleFactor >> 2)$ (8-278)

  $w_1 = DistScaleFactor >> 2$ (8-279)

– Otherwise (weighted_pred_flag is equal to 1 in P or SP slices or weighted_bipred_idc equal to 1 in B slices), explicit mode weighted prediction is used as follows.
  – The variables refIdxL0WP and refIdxL1WP are derived as follows.
    – If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock

      refIdxL0WP = refIdxL0 >> 1 (8-280)

      refIdxL1WP = refIdxL1 >> 1 (8-281)

    – Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock),

      refIdxL0WP = refIdxL0 (8-282)

refIdxL1WP = refIdxL1 (8-283)

– The variables logWD, w_0, w_1, o_0, and o_1 are derived as follows.

– If C in $predPart_C[x, y]$ is replaced by L for luma samples

logWD = luma_log2_weight_denom (8-284)

w_0 = luma_weight_l0[refIdxL0WP] (8-285)

w_1 = luma_weight_l1[refIdxL1WP] (8-286)

o_0 = luma_offset_l0[refIdxL0WP] * (1 << ($BitDepth_Y$ – 8)) (8-287)

o_1 = luma_offset_l1[refIdxL1WP] * (1 << ($BitDepth_Y$ – 8)) (8-288)

– Otherwise (C in $predPart_C[x, y]$ is replaced by Cb or Cr for chroma samples, with iCbCr = 0 for Cb, iCbCr = 1 for Cr),

logWD = chroma_log2_weight_denom (8-289)

w_0 = chroma_weight_l0[refIdxL0WP][iCbCr] (8-290)

w_1 = chroma_weight_l1[refIdxL1WP][iCbCr] (8-291)

o_0 = chroma_offset_l0[refIdxL0WP][iCbCr] * (1 << ($BitDepth_C$ – 8)) (8-292)

o_1 = chroma_offset_l1[refIdxL1WP][iCbCr] * (1 << ($BitDepth_C$ – 8)) (8-293)

When explicit mode weighted prediction is used and the partition mbPartIdx\subMbPartIdx has both predFlagL0 and predFlagL1 equal to 1, the following constraint shall be obeyed

$-128 <= w_0 + w_1 <= ((logWD == 7) ? 127 : 128)$ (8-294)

NOTE – For implicit mode weighted prediction, weights w_0 and w_1 are each guaranteed to be in the range of -64..128 and the constraint expressed in Equation 8-294, although not explicitly imposed, will always be met. For explicit mode weighted prediction with logWD equal to 7, when one of the two weights w_0 or w_1 is inferred to be equal to 128 (as a consequence of luma_weight_l0_flag, luma_weight_l1_flag, chroma_weight_l0_flag, or chroma_weight_l1_flag equal to 0), the other weight (w_1 or w_0) must have a negative value in order for the constraint expressed in Equation 8-294 to hold (and therefore the other flag luma_weight_l0_flag, luma_weight_l1_flag, chroma_weight_l0_flag, or chroma_weight_l1_flag must be equal to 1).

8.5 Transform coefficient decoding process and picture construction process prior to deblocking filter process

Inputs to this process are Intra16x16DCLevel (if available), Intra16x16ACLevel (if available), LumaLevel (if available), LumaLevel8x8 (if available), ChromaDCLevel (if available), ChromaACLevel (if available), and available Inter or Intra prediction sample arrays for the current macroblock for the applicable components $pred_L$, $pred_{Cb}$, or $pred_{Cr}$.

NOTE 1 – When decoding a macroblock in Intra_4x4 (or Intra_8x8) prediction mode, the luma component of the macroblock prediction array may not be complete, since for each 4x4 (or 8x8) luma block, the Intra_4x4 (or Intra_8x8) prediction process for luma samples as specified in subclause 8.3.1 (or 8.3.2) and the process specified in this subclause are iterated.

Outputs of this process are the constructed sample arrays prior to the deblocking filter process for the applicable components S'_L, S'_{Cb}, or S'_{Cr}.

NOTE 2 – When decoding a macroblock in Intra_4x4 (or Intra_8x8) prediction mode, the luma component of the macroblock constructed sample arrays prior to the deblocking filter process may not be complete, since for each 4x4 (or 8x8) luma block, the

Intra_4x4 (or Intra_8x8) prediction process for luma samples as specified in subclause 8.3.1 (or 8.3.2) and the process specified in this subclause are iterated.

This subclause specifies transform coefficient decoding and picture construction prior to the deblocking filter process.

When the current macroblock is coded as P_Skip or B_Skip, all values of LumaLevel, LumaLevel8x8, ChromaDCLevel, ChromaACLevel are set equal to 0 for the current macroblock.

When residual_colour_transform_flag is equal to 1, the residual colour transform process as specified in subclause 8.5.13 is invoked.

8.5.1 Specification of transform decoding process for 4x4 luma residual blocks

This specification applies when transform_size_8x8_flag is equal to 0.

When the current macroblock prediction mode is not equal to Intra_16x16, the variable LumaLevel contains the levels for the luma transform coefficients. For a 4x4 luma block indexed by luma4x4BlkIdx = 0..15, the following ordered steps are specified.

1. The inverse transform coefficient scanning process as described in subclause 8.5.5 is invoked with LumaLevel[luma4x4BlkIdx] as the input and the two-dimensional array c as the output.
2. The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.10 is invoked with c as the input and r as the output.
3. When residual_colour_transform_flag is equal to 1, the variable $R_{Y,ij}$ is set equal to r_{ij} with i, j = 0..3 and this process is suspended until after completion of the residual colour transform process as specified in subclause 8.5.13, after the completion of which, the variable r_{ij} is set equal to $R_{G,ij}$ with i, j = 0..3 and this process is continued.
4. The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (xO, yO).
5. The 4x4 array u with elements u_{ij} for i, j = 0..3 is derived as

   $$u_{ij} = \text{Clip1}_Y(\text{pred}_L[xO + j, yO + i] + r_{ij}) \quad (8\text{-}295)$$

   When qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the bitstream shall not contain data that result in a value of u_{ij} as computed by Equation 8-295 that is not equal to $\text{pred}_L[xO + j, yO + i] + r_{ij}$.
6. The picture construction process prior to deblocking filter process in subclause 8.5.12 is invoked with luma4x4BlkIdx and u as the inputs.

8.5.2 Specification of transform decoding process for luma samples of Intra_16x16 macroblock prediction mode

When the current macroblock prediction mode is equal to Intra_16x16, the variables Intra16x16DCLevel and Intra16x16ACLevel contain the levels for the luma transform coefficients. The transform coefficient decoding proceeds in the following ordered steps:

1. The 4x4 luma DC transform coefficients of all 4x4 luma blocks of the macroblock are decoded.
   a. The inverse transform coefficient scanning process as described in subclause 8.5.5 is invoked with Intra16x16DCLevel as the input and the two-dimensional array c as the output.
   b. The scaling and transformation process for luma DC transform coefficients for Intra_16x16 macroblock type as specified in subclause 8.5.8 is invoked with c as the input and dcY as the output.
2. For a 4x4 luma block indexed by luma4x4BlkIdx = 0..15, the following ordered steps are specified.
   a. The variable lumaList, which is a list of 16 entries, is derived. The first entry of lumaList is the corresponding value from the array dcY. Figure 8-6 shows the assignment of the indices of the array dcY to the luma4x4BlkIdx. The two numbers in the small squares refer to indices i and j in dcY_{ij}, and the numbers in large squares refer to luma4x4BlkIdx.

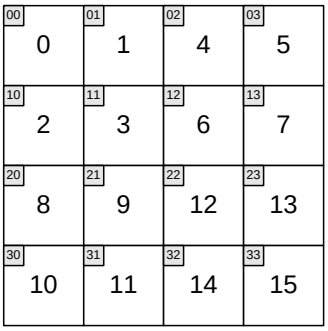


Figure 8-6 – Assignment of the indices of dcY to luma4x4BlkIdx

The elements in lumaList with index k = 1..15 are specified as

lumaList[k] = Intra16x16ACLevel[luma4x4BlkIdx][k - 1] (8-296)

b. The inverse transform coefficient scanning process as described in subclause 8.5.5 is invoked with lumaList as the input and the two-dimensional array c as the output.

c. The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.10 is invoked with c as the input and r as the output.

d. When residual_colour_transform_flag is equal to 1, the variable $R_{Y,ij}$ is set equal to r_{ij} with i, j = 0..3 and this process is suspended until after completion of the residual colour transform process as specified in subclause 8.5.13, after the completion of which, the variable r_{ij} is set equal to $R_{G,ij}$ with i, j = 0..3 and this process is continued.

e. The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (xO, yO).

f. The 4x4 array u with elements u_{ij} for i, j = 0..3 is derived as

$u_{ij} = Clip1_Y(pred_L[xO + j, yO + i] + r_{ij})$ (8-297)

When qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the bitstream shall not contain data that result in a value of u_{ij} as computed by 8-297 that is not equal to $pred_L[xO + j, yO + i] + r_{ij}$.

g. The picture construction process prior to deblocking filter process in subclause 8.5.12 is invoked with luma4x4BlkIdx and u as the inputs.

8.5.3 Specification of transform decoding process for 8x8 luma residual blocks

This specification applies when transform_size_8x8_flag is equal to 1.

The variable LumaLevel8x8[luma8x8BlkIdx] with luma8x8BlkIdx = 0..3 contains the levels for the luma transform coefficients for the luma 8x8 block with index luma8x8BlkIdx.

For an 8x8 luma block indexed by luma8x8BlkIdx = 0..3, the following ordered steps are specified.

1. The inverse scanning process for 8x8 luma transform coefficients as described in subclause 8.5.6 is invoked with LumaLevel8x8[luma8x8BlkIdx] as the input and the two-dimensional array c as the output.

2. The scaling and transformation process for residual 8x8 blocks as specified in subclause 8.5.11 is invoked with c as the input and r as the output.

3. When residual_colour_transform_flag is equal to 1, the variable $R_{Y,ij}$ is set equal to r_{ij} with i, j = 0..7 and this process is suspended until after completion of the residual colour transform process as specified in subclause 8.5.13, after the completion of which, the variable r_{ij} is set equal to $R_{G,ij}$ with i, j = 0..7 and this process is continued.

4. The position of the upper-left sample of an 8x8 luma block with index luma8x8BlkIdx inside the macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.4 with luma8x8BlkIdx as the input and the output being assigned to (xO, yO).

5. The 8x8 array u with elements u_{ij} for i, j = 0..7 is derived as

$$u_{ij} = Clip1_Y(pred_L[xO + j, yO + i] + r_{ij}) \quad (8\text{-}298)$$

When qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the bitstream shall not contain data that result in a value of u_{ij} as computed by Equation 8-298 that is not equal to $pred_L[xO + j, yO + i] + r_{ij}$.

6. The picture construction process prior to deblocking filter process in subclause 8.5.12 is invoked with luma8x8BlkIdx and u as the inputs.

8.5.4 Specification of transform decoding process for chroma samples

This process is invoked for each chroma component Cb and Cr seperately.

For each chroma component, the variables ChromaDCLevel[iCbCr] and ChromaACLevel[iCbCr], with iCbCr set equal to 0 for Cb and iCbCr set equal to 1 for Cr, contain the levels for both components of the chroma transform coefficients.

Let the variable numChroma4x4Blks be set equal to (MbWidthC / 4) * (MbHeightC / 4).

For each chroma component, the transform decoding proceeds separately in the following ordered steps:

1. The numChroma4x4Blks chroma DC transform coefficients of the 4x4 chroma blocks of the component indexed by iCbCr of the macroblock are decoded.

   a. Depending on the variable chroma_format_idc, the following applies.

   – If chroma_format_idc is equal to 1, the 2x2 array c is derived using the inverse raster scanning process applied to ChromaDCLevel as follows

$$c = \begin{bmatrix} ChromaDCLevel[iCbCr][0] & ChromaDCLevel[iCbCr][1] \\ ChromaDCLevel[iCbCr][2] & ChromaDCLevel[iCbCr][3] \end{bmatrix} \quad (8\text{-}299)$$

   – Otherwise, if chroma_format_idc is equal to 2, the 2x4 array c is derived using the inverse raster scanning process applied to ChromaDCLevel as follows

$$c = \begin{bmatrix} ChromaDCLevel[iCbCr][0] & ChromaDCLevel[iCbCr][2] \\ ChromaDCLevel[iCbCr][1] & ChromaDCLevel[iCbCr][5] \\ ChromaDCLevel[iCbCr][3] & ChromaDCLevel[iCbCr][6] \\ ChromaDCLevel[iCbCr][4] & ChromaDCLevel[iCbCr][7] \end{bmatrix} \quad (8\text{-}300)$$

   – Otherwise (chroma_format_idc is equal to 3), the inverse scanning process for transform coefficients as specified in subclause 8.5.5 is invoked with ChromaDCLevel[iCbCr] as the input and the two-dimensional 4x4 array c as the output.

   b. The scaling and transformation process for chroma DC transform coefficients as specified in subclause 8.5.9 is invoked with c as the input and dcC as the output.

2. For each 4x4 chroma block indexed by chroma4x4BlkIdx = 0..numChroma4x4Blks – 1 of the component indexed by iCbCr, the following ordered steps are specified.

   a. The variable chromaList, which is a list of 16 entries, is derived. The first entry of chromaList is the corresponding value from the array dcC. Figure 8-7 shows the assignment of the indices of the array dcC to the chroma4x4BlkIdx. The two numbers in the small squares refer to indices i and j in dcC_{ij}, and the numbers in large squares refer to chroma4x4BlkIdx.

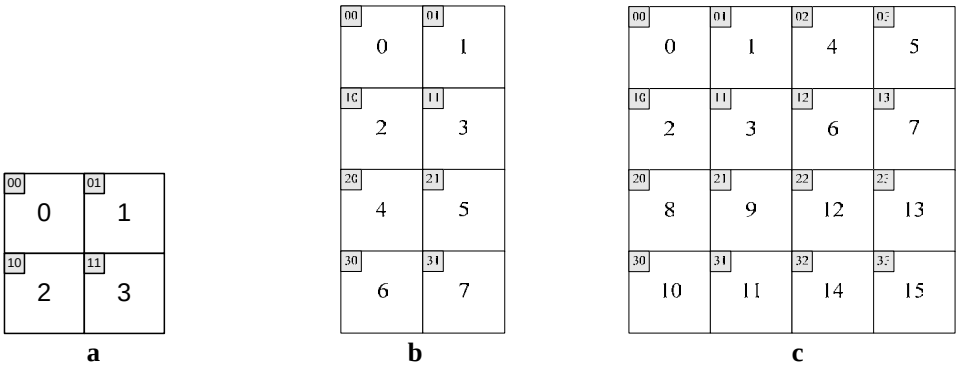


Figure 8-7 – Assignment of the indices of dcC to chroma4x4BlkIdx:
(a) chroma_format_idc equal to 1, (b) chroma_format_idc equal to 2, (c) chroma_format_idc equal to 3

The elements in chromaList with index k = 1..15 are specified as

chromaList[k] = ChromaACLevel[chroma4x4BlkIdx][k – 1] (8-301)

b. The inverse scanning process for transform coefficients as specified in subclause 8.5.9 is invoked with chromaList as the input and the two-dimensional array c as the output.

c. The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.10 is invoked with c as the input and r as the output.

d. Depending on the variable chroma_format_idc, the position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx inside the macroblock is derived as follows.

– If chroma_format_idc is equal to 1 or 2, the following applies.

xO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 0) (8-302)

yO = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 1) (8-303)

– Otherwise (chroma_format_idc is equal to 3), the following applies.

xO = InverseRasterScan(chroma4x4BlkIdx / 4, 8, 8, 16, 0) +
InverseRasterScan(chroma4x4BlkIdx % 4, 4, 4, 8, 0) (8-304)

yO =InverseRasterScan(chroma4x4BlkIdx / 4, 8, 8, 16, 1) +
InverseRasterScan(chroma4x4BlkIdx % 4, 4, 4, 8, 1) (8-305)

e. When residual_colour_transform_flag is equal to 1, the variable xO' is set equal to xO % (4 << transform_size_8x8_flag), the variable yO' is set equal to yO % (4 << transform_size_8x8_flag), and the following applies.

– If this process is invoked for the chroma component Cb, the variable $R_{Cb,mn}$ is set equal to r_{ij} with i, j = 0..3, m = xO' + i, n = yO' + j, and this process is suspended until after completion of the residual colour transform process as specified in subclause 8.5.13, after which the variable r_{ij} is set equal to $R_{B,mn}$ with i, j = 0..3, m = xO' + i, n = yO' + j and this process is continued.

– Otherwise (this process is invoked for the chroma component Cr), the variable $R_{Cr,mn}$ is set equal to r_{ij} with i, j = 0..3, m = xO' + i, n = yO' + j and this process is suspended until after the completion of the residual colour transform process as specified in subclause 8.5.13, after which the variable r_{ij} is set equal to $R_{R,mn}$ with i, j = 0..3, m = xO' + i, n = yO' + j and this process is continued.

f. The 4x4 array u with elements u_{ij} for i, j = 0..3 is derived as

$$u_{ij} = Clip1_C(pred_C[xO + j, yO + i] + r_{ij}) \quad (8\text{-}306)$$

When qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the bitstream shall not contain data that result in a value of u_{ij} as computed by Equation 8-306 that is not equal to $pred_C[xO + j, yO + i] + r_{ij}$.

g. The picture construction process prior to deblocking filter process in subclause 8.5.12 is invoked with chroma4x4BlkIdx and u as the inputs.

8.5.5 Inverse scanning process for transform coefficients

Input to this process is a list of 16 values.

Output of this process is a variable c containing a two-dimensional array of 4x4 values. In the case of transform coefficients, these 4x4 values represent levels assigned to locations in the transform block. In the case of applying the inverse scanning process to a scaling list, the output variable c contains a two-dimensional array representing a 4x4 scaling matrix.

The inverse scanning process for transform coefficients maps the sequence of transform coefficient levels to the transform coefficient level positions. Table 8-13 specifies the two mappings: inverse zig-zag scan and inverse field scan. The inverse zig-zag scan is used for transform coefficients in frame macroblocks and the inverse field scan is used for transform coefficients in field macroblocks.

The inverse scanning process for scaling lists maps the sequence of scaling list entries to the positions in the corresponding scaling matrix. For this mapping, the inverse zig-zag scan is used.

Figure 8-8 illustrates the scans.

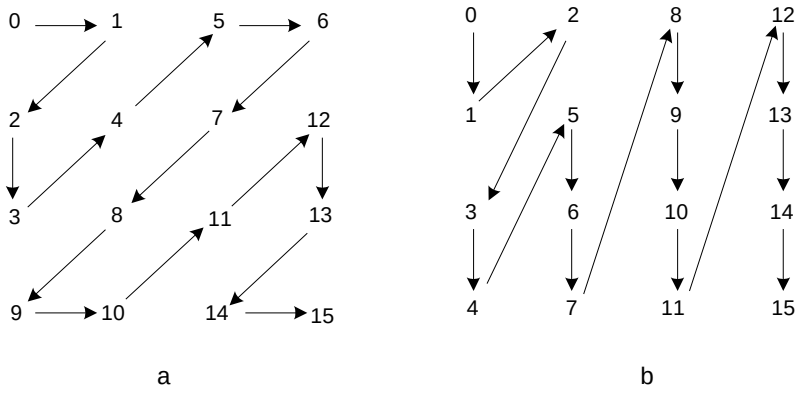


Figure 8-8 – 4x4 block scans. (a) Zig-zag scan. (b) Field scan (informative)

Table 8-13 provides the mapping from the index idx of input list of 16 elements to indices i and j of the two-dimensional array c.

Table 8-13 – Specification of mapping of idx to c_{ij} for zig-zag and field scan

idx	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
zig-zag	c_{00}	c_{01}	c_{10}	c_{20}	c_{11}	c_{02}	c_{03}	c_{12}	c_{21}	c_{30}	c_{31}	c_{22}	c_{13}	c_{23}	c_{32}	c_{33}
field	c_{00}	c_{10}	c_{01}	c_{20}	c_{30}	c_{11}	c_{21}	c_{31}	c_{02}	c_{12}	c_{22}	c_{32}	c_{03}	c_{13}	c_{23}	c_{33}

8.5.6 Inverse scanning process for 8x8 luma transform coefficients

Input to this process is a list of 64 values.

Output of this process is a variable c containing a two-dimensional array of 8x8 values. In the case of transform coefficients, these 8x8 values represent levels assigned to locations in the transform block. In the case of applying the inverse scanning process to a scaling list, the output variable c contains a two-dimensional array representing an 8x8 scaling matrix.

The inverse scanning process for transform coefficients maps the sequence of transform coefficient levels to the transform coefficient level positions. Table 8-14 specifies the two mappings: inverse 8x8 zig-zag scan and inverse 8x8 field scan. The inverse 8x8 zig-zag scan is used for transform coefficients in frame macroblocks and the inverse 8x8 field scan is used for transform coefficients in field macroblocks.

The inverse scanning process for scaling lists maps the sequence of scaling list entries to the positions in the corresponding scaling matrix. For this mapping, the inverse zig-zag scan is used.

Figure 8-9 illustrates the scans.

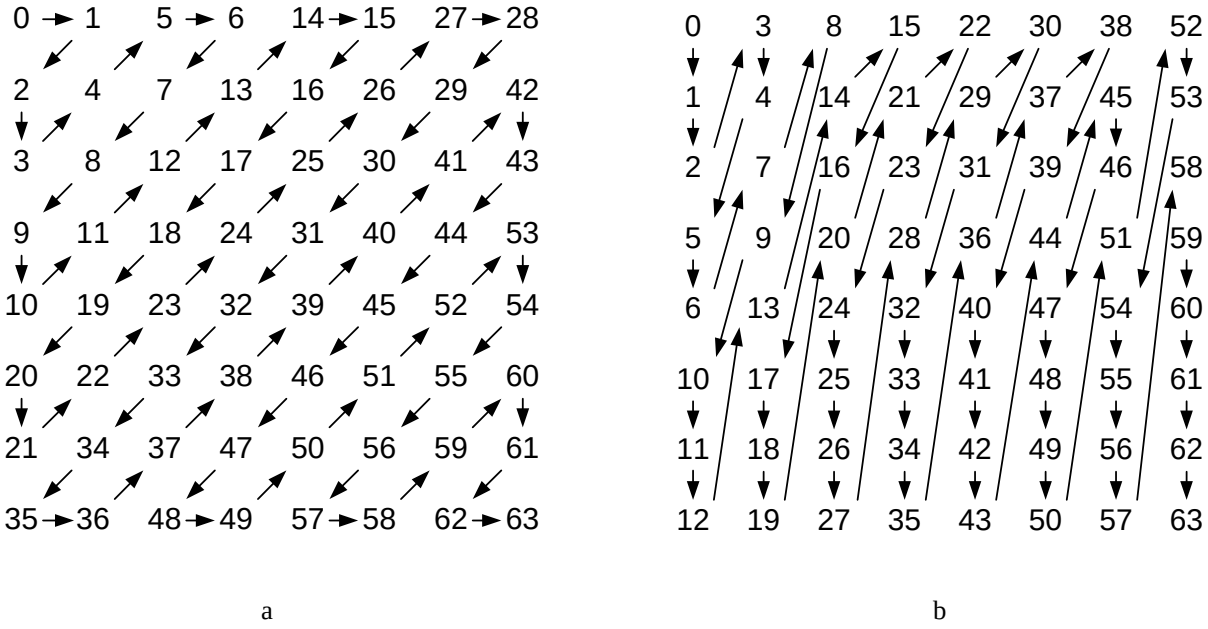


Figure 8-9 – 8x8 block scans. (a) 8x8 zig-zag scan. (b) 8x8 field scan (informative)

Table 8-14 provides the mapping from the index idx of the input list of 64 elements to indices i and j of the two-dimensional array c.

Table 8-14 – Specification of mapping of idx to c_{ij} for 8x8 zig-zag and 8x8 field scan

idx	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
zig-zag	c_{00}	c_{01}	c_{10}	c_{20}	c_{11}	c_{02}	c_{03}	c_{12}	c_{21}	c_{30}	c_{40}	c_{31}	c_{22}	c_{13}	c_{04}	c_{05}
field	c_{00}	c_{10}	c_{20}	c_{01}	c_{11}	c_{30}	c_{40}	c_{21}	c_{02}	c_{31}	c_{50}	c_{60}	c_{70}	c_{41}	c_{12}	c_{03}

Table 8-14 (continued) – Specification of mapping of idx to cij for 8x8 zig-zag and 8x8 field scan

idx	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
zig-zag	c_{14}	c_{23}	c_{32}	c_{41}	c_{50}	c_{60}	c_{51}	c_{42}	c_{33}	c_{24}	c_{15}	c_{06}	c_{07}	c_{16}	c_{25}	c_{34}
field	c_{22}	c_{51}	c_{61}	c_{71}	c_{32}	c_{13}	c_{04}	c_{23}	c_{42}	c_{52}	c_{62}	c_{72}	c_{33}	c_{14}	c_{05}	c_{24}

Table 8-14 (continued) – Specification of mapping of idx to cij for 8x8 zig-zag and 8x8 field scan

idx	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
zig-zag	c_{43}	c_{52}	c_{61}	c_{70}	c_{71}	c_{62}	c_{53}	c_{44}	c_{35}	c_{26}	c_{17}	c_{27}	c_{36}	c_{45}	c_{54}	c_{63}
field	c_{43}	c_{53}	c_{63}	c_{73}	c_{34}	c_{15}	c_{06}	c_{25}	c_{44}	c_{54}	c_{64}	c_{74}	c_{35}	c_{16}	c_{26}	c_{45}

Table 8-14 (concluded) – Specification of mapping of idx to cij for 8x8 zig-zag and 8x8 field scan

idx	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
zig-zag	c_{72}	c_{73}	c_{64}	c_{55}	c_{46}	c_{37}	c_{47}	c_{56}	c_{65}	c_{74}	c_{75}	c_{66}	c_{57}	c_{67}	c_{76}	c_{77}
field	c_{55}	c_{65}	c_{75}	c_{36}	c_{07}	c_{17}	c_{46}	c_{56}	c_{66}	c_{76}	c_{27}	c_{37}	c_{47}	c_{57}	c_{67}	c_{77}

8.5.7 Derivation process for the chroma quantisation parameters and scaling function

Outputs of this process are:

– QP_C: the chroma quantisation parameter for each chroma component Cb and Cr

– QS_C: the additional chroma quantisation parameter for each chroma component Cb and Cr required for decoding SP and SI slices (if applicable)

NOTE 1 – QP quantisation parameter values QP_Y and QS_Y are always in the range of $-QpBdOffset_Y$ to 51, inclusive. QP quantisation parameter values QP_C and QS_C are always in the range of $-QpBdOffset_C$ to 51, inclusive.

The value of QP_C for a chroma component is determined from the current value of QP_Y and the value of chroma_qp_index_offset (for Cb) or second_chroma_qp_index_offset (for Cr).

NOTE 2 – The scaling equations are specified such that the equivalent transform coefficient level scaling factor doubles for every increment of 6 in QP_Y. Thus, there is an increase in the factor used for scaling of approximately 12 % for each increase of 1 in the value of QP_Y.

The value of QP_C for each chroma component is determined as specified in Table 8-15 based on the index denoted as qP_I.

The variable qP_{Offset} for each chroma component is derived as follows.

– If the chroma component is the Cb component, qP_{Offset} is specified as

$$qP_{Offset} = \text{chroma\_qp\_index\_offset} \tag{8-307}$$

– Otherwise (the chroma component is the Cr component), qP_{Offset} is specified as

$$qP_{Offset} = \text{second\_chroma\_qp\_index\_offset} \tag{8-308}$$

The value of qP_I for each chroma component is derived as

$$qP_I = \text{Clip3}(-QpBdOffset_C, 51, QP_Y + qP_{Offset}) \tag{8-309}$$

The value of QP'_C for the chroma components is derived as

$$QP'_C = QP_C + QpBdOffset_C \tag{8-310}$$

The value of $BitDepth'_C$ for the chroma components is derived as

$$BitDepth'_C = BitDepth_C + residual\_colour\_transform\_flag \tag{8-311}$$

Table 8-15 – Specification of QP_C as a function of qP_I

qP_I	<30	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
QP_C	$=qP_I$	29	30	31	32	32	33	34	34	35	35	36	36	37	37	37	38	38	38	39	39	39	39

When the current slice is an SP or SI slice, QS_C is derived using the above process, substituting QP_Y with QS_Y and QP_C with QS_C.

The function LevelScale(m, i, j) is specified as follows.

– The 4x4 matrix weightScale(i, j) is specified as follows.
  – The variable mbIsInterFlag is derived as follows.
    – If the current macroblock is coded using Inter macroblock prediction modes, mbIsInterFlag is set equal to 1.
    – Otherwise (the current macroblock is coded using Intra macroblock prediction modes), mbIsInterFlag is set equal to 0.
  – The variable iYCbCr derived as follows.
    – If the input array c relates to a luma residual block, iYCbCr is set equal to 0.
    – Otherwise, if the input array c relates to a chroma residual block and the chroma component is equal to Cb, iYCbCr is set equal to 1.
    – Otherwise (the input array c relates to a chroma residual block and the chroma component is equal to Cr), iYCbCr is set equal to 2.
  – The inverse scanning process for transform coefficients as specified in subclause 8.5.5 is invoked with ScalingList4x4[iYCbCr + ((mbIsInterFlag == 1) ? 3 : 0)] as the input and the output is assigned to the 4x4 matrix weightScale.

$$LevelScale(m, i, j) = weightScale(i, j) * normAdjust(m, i, j) \tag{8-312}$$

where

$$normAdjust(m,i,j) = \begin{cases} v_{m0} & \text{for } (i\,\%\,2,\ j\,\%\,2) \text{ equal to } (0,0), \\ v_{m1} & \text{for } (i\,\%\,2,\ j\,\%\,2) \text{ equal to } (1,1), \\ v_{m2} & \text{otherwise;} \end{cases} \tag{8-313}$$

where the first and second subscripts of v are row and column indices, respectively, of the matrix specified as:

$$v = \begin{bmatrix} 10 & 16 & 13 \\ 11 & 18 & 14 \\ 13 & 20 & 16 \\ 14 & 23 & 18 \\ 16 & 25 & 20 \\ 18 & 29 & 23 \end{bmatrix}. \tag{8-314}$$

The function LevelScale8x8(m, i, j) is specified as follows:

– The 8x8 matrix weightScale8x8(i, j) is specified as follows.

  – The variable mbIsInterFlag is derived as follows.

    – If the current macroblock is coded using Inter macroblock prediction modes, mbIsInterFlag is set equal to 1.

    – Otherwise (the current macroblock is coded using Intra macroblock prediction modes), mbIsInterFlag is set equal to 0.

  – The inverse scanning process for 8x8 luma transform coefficients as specified in subclause 8.5.6 is invoked with ScalingList8x8[mbIsInterFlag] as the input and the output is assigned to the 8x8 matrix weightScale8x8.

$$\text{LevelScale8x8}(m, i, j) = \text{weightScale8x8}(i, j) * \text{normAdjust8x8}(m, i, j) \tag{8-315}$$

where

$$\text{normAdjust8x8}(m, i, j) = \begin{cases} v_{m0} & \text{for } (i \,\%\, 4, j \,\%\, 4) \text{ equal to } (0,0), \\ v_{m1} & \text{for } (i \,\%\, 2, j \,\%\, 2) \text{ equal to } (1,1), \\ v_{m2} & \text{for } (i \,\%\, 4, j \,\%\, 4) \text{ equal to } (2,2), \\ v_{m3} & \text{for } (i \,\%\, 4, j \,\%\, 2) \text{ equal to } (0,1) \text{ or } (i \,\%\, 2, j \,\%\, 4) \text{ equal to } (1,0), \\ v_{m4} & \text{for } (i \,\%\, 4, j \,\%\, 4) \text{ equal to } (0,2) \text{ or } (i \,\%\, 4, j \,\%\, 4) \text{ equal to } (2,0), \\ v_{m5} & \text{otherwise;} \end{cases} \tag{8-316}$$

where the first and second subscripts of v are row and column indices, respectively, of the matrix specified as:

$$v = \begin{bmatrix} 20 & 18 & 32 & 19 & 25 & 24 \\ 22 & 19 & 35 & 21 & 28 & 26 \\ 26 & 23 & 42 & 24 & 33 & 31 \\ 28 & 25 & 45 & 26 & 35 & 33 \\ 32 & 28 & 51 & 30 & 40 & 38 \\ 36 & 32 & 58 & 34 & 46 & 43 \end{bmatrix}. \tag{8-317}$$

8.5.8 Scaling and transformation process for luma DC transform coefficients for Intra_16x16 macroblock type

Inputs to this process are transform coefficient level values for luma DC transform coefficients of Intra_16x16 macroblocks as a 4x4 array c with elements c_{ij}, where i and j form a two-dimensional frequency index.

Outputs of this process are 16 scaled DC values for luma 4x4 blocks of Intra_16x16 macroblocks as a 4x4 array dcY with elements dcY_{ij}.

Depending on the values of qpprime_y_zero_transform_bypass_flag and QP'_Y, the following applies.

– If qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the output dcY is derived as

$$dcY_{ij} = c_{ij} \text{ with } i, j = 0..3 \tag{8-318}$$

– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or QP'_Y is not equal to 0), the following text of this process specifies the output.

The inverse transform for the 4x4 luma DC transform coefficients is specified by:

$$f = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} & c_{02} & c_{03} \\ c_{10} & c_{11} & c_{12} & c_{13} \\ c_{20} & c_{21} & c_{22} & c_{23} \\ c_{30} & c_{31} & c_{32} & c_{33} \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix}. \tag{8-319}$$

The bitstream shall not contain data that results in any element f_{ij} of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{BitDepth}_Y)}$ to $2^{(7 + \text{BitDepth}_Y)}-1$, inclusive.

After the inverse transform, scaling is performed as follows.

– If QP'_Y is greater than or equal to 36, the scaled result is derived as

$$dcY_{ij} = (f_{ij} * \text{LevelScale}(QP'_Y \%6, 0, 0)) << (QP'_Y / 6 - 6), \quad \text{with} \quad i, j = 0..3 \tag{8-320}$$

– Otherwise (QP'_Y is less than 36), the scaled result is derived as

$$dcY_{ij} = (f_{ij} * \text{LevelScale}(QP'_Y \% 6, 0, 0) + 2^{5-QP'_Y/6}) >> (6 - QP'_Y / 6), \quad \text{with} \quad i, j = 0..3 \tag{8-321}$$

The bitstream shall not contain data that results in any element dcY_{ij} of dcY with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{BitDepth}_Y)}$ to $2^{(7 + \text{BitDepth}_Y)}-1$, inclusive.

NOTE 1 – When entropy_coding_mode_flag is equal to 0 and QP'_Y is less than 10 and profile_idc is equal to 66, 77, or 88, the range of values that can be represented for the elements c_{ij} of c is not sufficient to represent the full range of values of the elements dcY_{ij} of dcY that could be necessary to form a close approximation of the content of any possible source picture by use of the Intra_16x16 macroblock type.

NOTE 2 – Since the range limit imposed on the elements dcY_{ij} of dcY is imposed after the right shift in Equation 8-321, a larger range of values must be supported in the decoder prior to the right shift.

8.5.9 Scaling and transformation process for chroma DC transform coefficients

Inputs to this process are transform coefficient level values for chroma DC transform coefficients of one chroma component of the macroblock as an (MbWidthC / 4)x(MbHeightC / 4) array c with elements c_{ij}, where i and j form a two-dimensional frequency index.

Outputs of this process are the scaled DC values as an (MbWidthC / 4)x(MbHeightC / 4) array dcC with elements dcC_{ij}.

Depending on the values of qpprime_y_zero_transform_bypass_flag and QP'_Y, the following applies.

– If qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the output dcC is derived as

$$dcC_{ij} = c_{ij} \quad \text{with} \quad i = 0..(\text{MbWidthC} / 4) - 1 \text{ and } j = 0..(\text{MbHeightC} / 4) - 1. \tag{8-322}$$

– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or QP'_Y is not equal to 0), the following text of this process specifies the output.

Depending on the variable chroma_format_idc, the inverse transform is specified as follows.

– If chroma_format_idc is equal to 1, the inverse transform for the 2x2 chroma DC transform coefficients is specified as

$$f = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} \\ c_{10} & c_{11} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \tag{8-323}$$

– Otherwise, if chroma_format_idc is equal to 2, the inverse transform for the 2x4 chroma DC transform coefficients is specified as

$$f = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} \\ c_{10} & c_{11} \\ c_{20} & c_{21} \\ c_{30} & c_{31} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \quad (8\text{-}324)$$

– Otherwise (chroma_format_idc is equal to 3), the inverse transform for the 4x4 chroma DC transform coefficients is specified as follows.

  – If residual_colour_transform_flag is equal to 1 and the current macroblock prediction mode MbPartPredMode(mb_type, 0) is Intra_4x4 or Intra_8x8, the inverse transform for the 4x4 chroma DC transform coefficients is specified as

$$f_{ij} = c_{ij} << 2 \quad \text{with} \quad i, j = 0..3 \quad (8\text{-}325)$$

  – Otherwise, the inverse transform for the 4x4 chroma DC transform coefficients is specified as

$$f = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} & c_{02} & c_{03} \\ c_{10} & c_{11} & c_{12} & c_{13} \\ c_{20} & c_{21} & c_{22} & c_{23} \\ c_{30} & c_{31} & c_{32} & c_{33} \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \quad (8\text{-}326)$$

The bitstream shall not contain data that results in any element f_{ij} of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{BitDepth}'_C)}$ to $2^{(7 + \text{BitDepth}'_C)}-1$, inclusive.

After the inverse transform, scaling is performed depending on the variable chroma_format_idc as follows.

– If chroma_format_idc is equal to 1, the scaled result is derived as

$$dcC_{ij} = ((f_{ij} * \text{LevelScale}(QP'_C \,\%\, 6, 0, 0)) << (QP'_C / 6)) >> 5, \quad \textit{with} \quad i, j = 0, 1 \quad (8\text{-}327)$$

– If chroma_format_idc is equal to 2, the following applies.

  – The variable $QP'_{C,DC}$ is derived as

$$QP'_{C,DC} = QP'_C + 3 \quad (8\text{-}328)$$

  – Depending on the value of $QP'_{C,DC}$, the following applies.

    – If $QP'_{C,DC}$ is greater than or equal to 36, the scaled result is derived as

$$dcC_{ij} = (f_{ij} * \text{LevelScale} (QP'_{C,DC} \,\%6, 0, 0)) << (QP'_{C,DC} / 6 - 6), \quad \text{with } i = 0..3, j = 0, 1 \quad (8\text{-}329)$$

    – Otherwise ($QP'_{C,DC}$ is less than 36), the scaled result is derived as

$$dcC_{ij} = (f_{ij} * \text{LevelScale}(QP'_{C,DC} \,\%\, 6, 0, 0) + 2^{5 - QP'_{C,DC}/6}) >> (6 - QP'_{C,DC} / 6), \quad \text{with} \quad i = 0..3, j = 0,1 \quad (8\text{-}330)$$

– Otherwise (chroma_format_idc is equal to 3), the following applies.

  – If QP'_C is greater than or equal to 36, the scaled result is derived as

$$dcC_{ij} = (f_{ij} * \text{LevelScale}(QP'_C \,\%6, 0, 0)) << (QP'_C / 6 - 6), \quad \text{with} \quad i, j = 0..3. \quad (8\text{-}331)$$

  – Otherwise (QP'_C is less than 36), the scaled result is derived as

$$dcC_{ij} = (f_{ij} * \text{LevelScale}(QP'_C \,\%\, 6,0,0) + 2^{5 - QP'_C / 6}) >> (6 - QP'_C / 6), \text{ with } i, j, = 0..3 \quad (8\text{-}332)$$

The bitstream shall not contain data that results in any element dcC_{ij} of dcC with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{BitDepth}'_C)}$ to $2^{(7 + \text{BitDepth}'_C)}-1$, inclusive.

NOTE 1 – When entropy_coding_mode_flag is equal to 0 and QP'_C is less than 4 and profile_idc is equal to 66, 77, or 88, the range of values that can be represented for the elements cij of c may not be sufficient to represent the full range of values of the elements dcCij of dcC that could be necessary to form a close approximation of the content of any possible source picture.

NOTE 2 – Since the range limit imposed on the elements dcCij of dcC is imposed after the right shift in Equation 8-327, 8-330, or 8-332, a larger range of values must be supported in the decoder prior to the right shift.

8.5.10 Scaling and transformation process for residual 4x4 blocks

Input to this process is a 4x4 array c with elements c_{ij} which is either an array relating to a residual block of the luma component or an array relating to a residual block of a chroma component.

Outputs of this process are residual sample values as 4x4 array r with elements r_{ij}.

Depending on the values of qpprime_y_zero_transform_bypass_flag and QP'_Y, the following applies.

– If qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the output r is derived as

$$r_{ij} = c_{ij} \quad \text{with} \quad i, j = 0..3 \tag{8-333}$$

– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or QP'_Y is not equal to 0), the following text of this process specifies the output.

The variable bitDepth is derived as follows.

– If the input array c relates to a luma residual block, bitDepth is set equal to $BitDepth_Y$.

– Otherwise (the input array c relates to a chroma residual block), bitDepth is set equal to $BitDepth'_C$.

The bitstream shall not contain data that results in any element c_{ij} of c with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

The variable sMbFlag is derived as follows.

- If mb_type is equal to SI or the macroblock prediction mode is equal to Inter in an SP slice, sMbFlag is set equal to 1,
- Otherwise (mb_type not equal to SI and the macroblock prediction mode is not equal to Inter in an SP slice), sMbFlag is set equal to 0.

The variable qP is derived as follows.

– If the input array c relates to a luma residual block and sMbFlag is equal to 0

$$qP = QP'_Y \tag{8-334}$$

– Otherwise, if the input array c relates to a luma residual block and sMbFlag is equal to 1

$$qP = QS_Y \tag{8-335}$$

– Otherwise, if the input array c relates to a chroma residual block and sMbFlag is equal to 0

$$qP = QP'_C \tag{8-336}$$

– Otherwise (the input array c relates to a chroma residual block and sMbFlag is equal to 1),

$$qP = QS_C \tag{8-337}$$

Scaling of 4x4 block transform coefficient levels c_{ij} proceeds as follows.

– If all of the following conditions are true

  – i is equal to 0

  – j is equal to 0

  – c relates to a luma residual block coded using Intra_16x16 prediction mode or c relates to a chroma residual block

the variable d_{00} is derived by

$$d_{00} = c_{00} \tag{8-338}$$

– Otherwise, the following applies.

  – If qP is greater than or equal to 24, the scaled result is derived as follows

$$d_{ij} = (c_{ij} * \text{LevelScale}(qP \% 6, i, j)) << (qP / 6 - 4), \text{ with } i,j = 0..3 \text{ except as noted above} \tag{8-339}$$

  – Otherwise (qP is less than 24), the scaled result is derived as follows

$$d_{ij} = (c_{ij} * \text{LevelScale}(qP \% 6, i, j) + 2^{3-qP/6}) >> (4 - qP / 6), \text{ with } i, j = 0..3 \text{ except as noted above} \tag{8-340}$$

The bitstream shall not contain data that results in any element d_{ij} of d with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 1$, inclusive.

The transform process shall convert the block of scaled transform coefficients to a block of output samples in a manner mathematically equivalent to the following.

First, each (horizontal) row of scaled transform coefficients is transformed using a one-dimensional inverse transform as follows.

A set of intermediate values is computed as follows.

$$e_{i0} = d_{i0} + d_{i2}, \quad \text{with} \quad i = 0..3 \tag{8-341}$$

$$e_{i1} = d_{i0} - d_{i2}, \quad \text{with} \quad i = 0..3 \tag{8-342}$$

$$e_{i2} = (d_{i1} >> 1) - d_{i3}, \quad \text{with} \quad i = 0..3 \tag{8-343}$$

$$e_{i3} = d_{i1} + (d_{i3} >> 1), \quad \text{with} \quad i = 0..3 \tag{8-344}$$

The bitstream shall not contain data that results in any element e_{ij} of e with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 1$, inclusive.

Then, the transformed result is computed from these intermediate values as follows.

$$f_{i0} = e_{i0} + e_{i3}, \quad \text{with} \quad i = 0..3 \tag{8-345}$$

$$f_{i1} = e_{i1} + e_{i2}, \quad \text{with} \quad i = 0..3 \tag{8-346}$$

$$f_{i2} = e_{i1} - e_{i2}, \quad \text{with} \quad i = 0..3 \tag{8-347}$$

$$f_{i3} = e_{i0} - e_{i3}, \quad \text{with} \quad i = 0..3 \tag{8-348}$$

The bitstream shall not contain data that results in any element f_{ij} of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 1$, inclusive.

Then, each (vertical) column of the resulting matrix is transformed using the same one-dimensional inverse transform as follows.

A set of intermediate values is computed as follows.

$$g_{0j} = f_{0j} + f_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-349}$$

$$g_{1j} = f_{0j} - f_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-350}$$

$$g_{2j} = (f_{1j} >> 1) - f_{3j}, \quad \text{with} \quad j = 0..3 \tag{8-351}$$

$$g_{3j} = f_{1j} + (f_{3j} >> 1), \quad \text{with} \quad j = 0..3 \tag{8-352}$$

The bitstream shall not contain data that results in any element g_{ij} of g with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 1$, inclusive.

Then, the transformed result is computed from these intermediate values as follows.

$$h_{0j} = g_{0j} + g_{3j}, \quad \text{with} \quad j = 0..3 \tag{8-353}$$

$$h_{1j} = g_{1j} + g_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-354}$$

$$h_{2j} = g_{1j} - g_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-355}$$

$$h_{3j} = g_{0j} - g_{3j}, \quad \text{with} \quad j = 0..3 \tag{8-356}$$

The bitstream shall not contain data that results in any element h_{ij} of h with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 33$, inclusive.

After performing both the one-dimensional horizontal and the one-dimensional vertical inverse transforms to produce an array of transformed samples, the final constructed residual sample values is derived as

$$r_{ij} = (h_{ij} + 2^5) >> 6 \quad \text{with} \quad i, j = 0..3 \tag{8-357}$$

8.5.11 Scaling and transformation process for residual 8x8 luma blocks

Input to this process is an 8x8 array c with elements c_{ij} which is an array relating to an 8x8 residual block of the luma component.

Outputs of this process are residual sample values as 8x8 array r with elements r_{ij}.

Depending on the values of qpprime_y_zero_transform_bypass_flag and QP'_Y, the following applies.

– If qpprime_y_zero_transform_bypass_flag is equal to 1 and QP'_Y is equal to 0, the output r is derived as

$$r_{ij} = c_{ij} \quad \text{with} \quad i, j = 0..7 \tag{8-358}$$

– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or QP'_Y is not equal to 0), the following text of this process specifies the output.

The bitstream shall not contain data that results in any element c_{ij} of c with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + \text{BitDepth}_Y)}$ to $2^{(7 + \text{BitDepth}_Y)} - 1$, inclusive.

The scaling process for 8x8 block transform coefficient levels c_{ij} proceeds as follows.

– If QP'_Y is greater than or equal to 36, the scaled result is derived as

$$d_{ij} = (c_{ij} * \text{LevelScale8x8}(QP'_Y \% 6, i, j)) << (QP'_Y / 6 - 6), \text{ with } i,j = 0..7 \tag{8-359}$$

– Otherwise (QP'_Y is less than 36), the scaled result is derived as

$$d_{ij} = (c_{ij} * \text{LevelScale8x8}(QP'_Y \% 6, i, j)) + 2^{5 - QP'_Y/6}) >> (6 - QP'_Y /6), \text{ with } i,j = 0..7 \tag{8-360}$$

The bitstream shall not contain data that results in any element d_{ij} of d with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + \text{BitDepth}_Y)}$ to $2^{(7 + \text{BitDepth}_Y)} - 1$, inclusive.

The transform process shall convert the block of scaled transform coefficients to a block of output samples in a manner mathematically equivalent to the following.

First, each (horizontal) row of scaled transform coefficients is transformed using a one-dimensional inverse transform as follows.

– A set of intermediate values e_{ij} is derived by

$$e_{i0} = d_{i0} + d_{i4}, \text{ with } i = 0..7 \quad (8\text{-}361)$$

$$e_{i1} = -d_{i3} + d_{i5} - d_{i7} - (d_{i7} >> 1), \text{ with } i = 0..7 \quad (8\text{-}362)$$

$$e_{i2} = d_{i0} - d_{i4}, \text{ with } i = 0..7 \quad (8\text{-}363)$$

$$e_{i3} = d_{i1} + d_{i7} - d_{i3} - (d_{i3} >> 1), \text{ with } i = 0..7 \quad (8\text{-}364)$$

$$e_{i4} = (d_{i2} >> 1) - d_{i6}, \text{ with } i = 0..7 \quad (8\text{-}365)$$

$$e_{i5} = -d_{i1} + d_{i7} + d_{i5} + (d_{i5} >> 1), \text{ with } i = 0..7 \quad (8\text{-}366)$$

$$e_{i6} = d_{i2} + (d_{i6} >> 1), \text{ with } i = 0..7 \quad (8\text{-}367)$$

$$e_{i7} = d_{i3} + d_{i5} + d_{i1} + (d_{i1} >> 1), \text{ with } i = 0..7 \quad (8\text{-}368)$$

– A second set of intermediate results f_{ij} is computed from the intermediate values e_{ij} as

$$f_{i0} = e_{i0} + e_{i6}, \text{ with } i = 0..7 \quad (8\text{-}369)$$

$$f_{i1} = e_{i1} + (e_{i7} >> 2), \text{ with } i = 0..7 \quad (8\text{-}370)$$

$$f_{i2} = e_{i2} + e_{i4}, \text{ with } i = 0..7 \quad (8\text{-}371)$$

$$f_{i3} = e_{i3} + (e_{i5} >> 2), \text{ with } i = 0..7 \quad (8\text{-}372)$$

$$f_{i4} = e_{i2} - e_{i4}, \text{ with } i = 0..7 \quad (8\text{-}373)$$

$$f_{i5} = (e_{i3} >> 2) - e_{i5}, \text{ with } i = 0..7 \quad (8\text{-}374)$$

$$f_{i6} = e_{i0} - e_{i6}, \text{ with } i = 0..7 \quad (8\text{-}375)$$

$$f_{i7} = e_{i7} - (e_{i1} >> 2), \text{ with } i = 0..7 \quad (8\text{-}376)$$

– Then, the transformed result g_{ij} is computed from these intermediate values f_{ij} as

$$g_{i0} = f_{i0} + f_{i7}, \text{ with } i = 0..7 \quad (8\text{-}377)$$

$$g_{i1} = f_{i2} + f_{i5}, \text{ with } i = 0..7 \quad (8\text{-}378)$$

$$g_{i2} = f_{i4} + f_{i3}, \text{ with } i = 0..7 \quad (8\text{-}379)$$

$$g_{i3} = f_{i6} + f_{i1}, \text{ with } i = 0..7 \quad (8\text{-}380)$$

$$g_{i4} = f_{i6} - f_{i1}, \text{ with } i = 0..7 \quad (8\text{-}381)$$

$$g_{i5} = f_{i4} - f_{i3}, \text{ with } i = 0..7 \quad (8\text{-}382)$$

$$g_{i6} = f_{i2} - f_{i5}, \text{ with } i = 0..7 \quad (8\text{-}383)$$

$$g_{i7} = f_{i0} - f_{i7}, \text{ with } i = 0..7 \quad (8\text{-}384)$$

Then, each (vertical) column of the resulting matrix is transformed using the same one-dimensional inverse transform as follows.

– A set of intermediate values h_{ij} is computed from the horizontally transformed value g_{ij} as

$$h_{0j} = g_{0j} + g_{4j}, \text{ with } j = 0..7 \quad (8\text{-}385)$$

$$h_{1j} = -g_{3j} + g_{5j} - g_{7j} - (g_{7j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}386)$$

$$h_{2j} = g_{0j} - g_{4j}, \text{ with } j = 0..7 \quad (8\text{-}387)$$

$$h_{3j} = g_{1j} + g_{7j} - g_{3j} - (g_{3j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}388)$$

$$h_{4j} = (g_{2j} >> 1) - g_{6j}, \text{ with } j = 0..7 \quad (8\text{-}389)$$

$$h_{5j} = -g_{1j} + g_{7j} + g_{5j} + (g_{5j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}390)$$

$$h_{6j} = g_{2j} + (g_{6j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}391)$$

$$h_{7j} = g_{3j} + g_{5j} + g_{1j} + (g_{1j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}392)$$

– A second set of intermediate results k_{ij} is computed from the intermediate values h_{ij} as

$$k_{0j} = h_{0j} + h_{6j}, \text{ with } j = 0..7 \quad (8\text{-}393)$$

$$k_{1j} = h_{1j} + (h_{7j} >> 2), \text{ with } j = 0..7 \quad (8\text{-}394)$$

$$k_{2j} = h_{2j} + h_{4j}, \text{ with } j = 0..7 \quad (8\text{-}395)$$

$$k_{3j} = h_{3j} + (h_{5j} >> 2), \text{ with } j = 0..7 \quad (8\text{-}396)$$

$$k_{4j} = h_{2j} - h_{4j}, \text{ with } j = 0..7 \quad (8\text{-}397)$$

$$k_{5j} = (h_{3j} >> 2) - h_{5j}, \text{ with } j = 0..7 \quad (8\text{-}398)$$

$$k_{6j} = h_{0j} - h_{6j}, \text{ with } j = 0..7 \quad (8\text{-}399)$$

$$k_{7j} = h_{7j} - (h_{1j} >> 2), \text{ with } j = 0..7 \quad (8\text{-}400)$$

– Then, the transformed result m_{ij} is computed from these intermediate values k_{ij} as

$$m_{0j} = k_{0j} + k_{7j}, \text{ with } j = 0..7 \quad (8\text{-}401)$$

$$m_{1j} = k_{2j} + k_{5j}, \text{ with } j = 0..7 \quad (8\text{-}402)$$

$$m_{2j} = k_{4j} + k_{3j}, \text{ with } j = 0..7 \quad (8\text{-}403)$$

$$m_{3j} = k_{6j} + k_{1j}, \text{ with } j = 0..7 \quad (8\text{-}404)$$

$$m_{4j} = k_{6j} - k_{1j}, \text{ with } j = 0..7 \quad (8\text{-}405)$$

$$m_{5j} = k_{4j} - k_{3j}, \text{ with } j = 0..7 \quad (8\text{-}406)$$

$$m_{6j} = k_{2j} - k_{5j}, \text{ with } j = 0..7 \quad (8\text{-}407)$$

$$m_{7j} = k_{0j} - k_{7j}, \text{ with } j = 0..7 \quad (8\text{-}408)$$

The bitstream shall not contain data that results in any element e_{ij}, f_{ij}, g_{ij}, h_{ij}, or k_{ij} for i and j in the range of 0..7, inclusive, that exceeds the range of integer values from $-2^{(7 + \text{BitDepth}_Y)}$ to $2^{(7 + \text{BitDepth}_Y)} - 1$, inclusive.

The bitstream shall not contain data that results in any element m_{ij} for i and j in the range of 0..7, inclusive, that exceeds the range of integer values from $-2^{(7 + \text{BitDepth}_Y)}$ to $2^{(7 + \text{BitDepth}_Y)} - 33$, inclusive.

After performing both the one-dimensional horizontal and the one-dimensional vertical inverse transforms to produce an array of transformed samples, the final constructed residual sample values are derived as

$$r_{ij} = (m_{ij} + 2^5) >> 6 \text{ with } i, j = 0..7 \quad (8\text{-}409)$$

8.5.12 Picture construction process prior to deblocking filter process

Inputs to this process are

– luma4x4BlkIdx or chroma4x4BlkIdx or luma8x8BlkIdx

– a sample array u with elements u_{ij} which is either a 4x4 luma block or a 4x4 chroma block or an 8x8 luma block

The position of the upper-left luma sample of the current macroblock is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with CurrMbAddr as input and the output being assigned to (xP, yP).

When u is a luma block, for each sample u_{ij} of the luma block, the following applies.

– Depending on the size of the block u, the following applies.

  – If u is an 4x4 luma block, the position of the upper-left sample of the 4x4 luma block with index luma4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (xO, yO), and the variable nE is set equal to 4.

  – Otherwise (u is an 8x8 luma block), the position of the upper-left sample of the 8x8 luma block with index luma8x8BlkIdx inside the macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.4 with luma8x8BlkIdx as the input and the output being assigned to (xO, yO), and the variable nE is set equal to 8.

– Depending on the variable MbaffFrameFlag and the current macroblock, the following applies.

  – If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock

$$S'_L[xP + xO + j, yP + 2 * (yO + i)] = u_{ij} \quad \text{with } i, j = 0..nE - 1 \quad (8\text{-}410)$$

– Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock),

$$S'_L[\ xP + xO + j, yP + yO + i\ ] = u_{ij} \quad \text{with } i, j = 0..nE - 1 \tag{8-411}$$

When u is a chroma block, for each sample u_{ij} of the 4x4 chroma block, the following applies.

– The subscript C in the variable S'_C is replaced with Cb for the Cb chroma component and with Cr for the Cr chroma component.

– Depending on the variable chroma_format_idc, the position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx inside the macroblock is derived as follows.

– If chroma_format_idc is equal to 1 or 2, the following applies.

$$xO = \text{InverseRasterScan}(\ \text{chroma4x4BlkIdx}, 4, 4, 8, 0\ ) \tag{8-412}$$

$$yO = \text{InverseRasterScan}(\ \text{chroma4x4BlkIdx}, 4, 4, 8, 1\ ) \tag{8-413}$$

– Otherwise (chroma_format_idc is equal to 3), the following applies.

$$xO = \text{InverseRasterScan}(\ \text{chroma4x4BlkIdx} / 4, 8, 8, 16, 0\ ) + \text{InverseRasterScan}(\ \text{chroma4x4BlkIdx} \% 4, 4, 4, 8, 0\ ) \tag{8-414}$$

$$yO = \text{InverseRasterScan}(\ \text{chroma4x4BlkIdx} / 4, 8, 8, 16, 1\ ) + \text{InverseRasterScan}(\ \text{chroma4x4BlkIdx} \% 4, 4, 4, 8, 1\ ) \tag{8-415}$$

– Depending on the variable MbaffFrameFlag and the current macroblock, the following applies.

– If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock

$$S'_C[\ (\ xP / \text{subWidthC}\ ) + xO + j, (\ (\ yP + \text{SubHeightC} - 1\ ) / \text{SubHeightC}\ ) + 2 * (\ yO + i\ )\ ] = u_{ij} \quad \text{with } i, j = 0..3 \tag{8-416}$$

– Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock),

$$S'_C[\ (\ xP/ \text{subWidthC}\ ) + xO + j, (\ yP / \text{SubHeightC}\ ) + yO + i\ ] = u_{ij} \text{ with } i, j = 0..3 \tag{8-417}$$

8.5.13 Residual colour transform process

This process is invoked when residual_colour_transform_flag is equal to 1.

After invoking, this process is suspended until the derivation of $R_{Y,ij}$, $R_{Cb,ij}$, and $R_{Cr,ij}$ has been completed for i, j = 0..ijMax, where ijMax is specified as follows.

– If transform_size_8x8_flag is equal to 0, the variable ijMax is set equal to 3.

– Otherwise (transform_size_8x8_flag is equal to 1), the variable ijMax is set equal to 7.

At the resumption of this process, all values $R_{Y,ij}$, $R_{Cb,ij}$, and $R_{Cr,ij}$ with i, j = 0..ijMax shall be available through prior invocations of the relevant processes specified in subclauses 8.5.1, 8.5.2, 8.5.3, or 8.5.4

For each i, j = 0..ijMax, the residual colour transform is computed as

$$t = R_{Y,ij} - (R_{Cb,ij} >> 1\ ) \tag{8-418}$$

$$R_{G,ij} = t + R_{Cb,ij} \tag{8-419}$$

$$R_{B,ij} = t - (R_{Cr,ij} >> 1\ ) \tag{8-420}$$

$$R_{R,ij} = R_{B,ij} + R_{Cr,ij} \tag{8-421}$$

NOTE – The residual colour transform is similar to the YCgCo transformation specified in Equations E-30 through E-33. However, the residual colour transform operates on the decoded residual difference data within the decoding process rather than operating as a post-processing step that is outside the decoding process specified in this Recommendation | International Standard.

8.6 Decoding process for P macroblocks in SP slices or SI macroblocks

This process is invoked when decoding P macroblock types in an SP slice type or an SI macroblock type in SI slices.

Inputs to this process are the prediction residual transform coefficient levels and the predicted samples for the current macroblock.

Outputs of this process are the decoded samples of the current macroblock prior to the deblocking filter process.

This subclause specifies the transform coefficient decoding process and picture construction process for P macroblock types in SP slices and SI macroblock type in SI slices.

NOTE – SP slices make use of Inter predictive coding to exploit temporal redundancy in the sequence, in a similar manner to P slice coding. Unlike P slice coding, however, SP slice coding allows identical reconstruction of a slice even when different reference pictures are being used. SI slices make use of spatial prediction, in a similar manner to I slices. SI slice coding allows identical reconstruction to a corresponding SP slice. The properties of SP and SI slices aid in providing functionalities for bitstream switching, splicing, random access, fast-forward, fast reverse, and error resilience/recovery.

An SP slice consists of macroblocks coded either as I macroblock types or P macroblock types.

An SI slice consists of macroblocks coded either as I macroblock types or SI macroblock type.

The transform coefficient decoding process and picture construction process prior to deblocking filter process for I macroblock types in SI slices is invoked as specified in subclause 8.5. SI macroblock type is decoded as described below.

When the current macroblock is coded as P_Skip, all values of LumaLevel, ChromaDCLevel, ChromaACLevel are set equal to 0 for the current macroblock.

8.6.1 SP decoding process for non-switching pictures

This process is invoked, when decoding P macroblock types in SP slices in which sp_for_switch_flag is equal to 0.

Inputs to this process are Inter prediction samples for the current macroblock from subclause 8.4 and the prediction residual transform coefficient levels.

Outputs of this process are the decoded samples of the current macroblock prior to the deblocking filter process.

This subclause applies to all macroblocks in SP slices in which sp_for_switch_flag is equal to 0, except those with macroblock prediction mode equal to Intra_4x4 or Intra_16x16. It does not apply to SI slices.

8.6.1.1 Luma transform coefficient decoding process

Inputs to this process are Inter prediction luma samples for the current macroblock $pred_L$ from subclause 8.4 and the prediction residual transform coefficient levels, LumaLevel, and the index of the 4x4 luma block luma4x4BlkIdx.

The position of the upper-left sample of the 4x4 luma block with index luma4x4BlkIdx inside the current macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to (x, y).

Let the variable p be a 4x4 array of prediction samples with element p_{ij} being derived as follows.

$$p_{ij} = pred_L[\, x + j, y + i \,] \quad \text{with } i, j = 0..3 \tag{8-422}$$

The variable p is transformed producing transform coefficients c^p according to:

$$c^p = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 1 \\ 1 & -2 & 2 & -1 \end{bmatrix} \begin{bmatrix} p_{00} & p_{01} & p_{02} & p_{03} \\ p_{10} & p_{11} & p_{12} & p_{13} \\ p_{20} & p_{21} & p_{22} & p_{23} \\ p_{30} & p_{31} & p_{32} & p_{33} \end{bmatrix} \begin{bmatrix} 1 & 2 & 1 & 1 \\ 1 & 1 & -1 & -2 \\ 1 & -1 & -1 & 2 \\ 1 & -2 & 1 & -1 \end{bmatrix} \tag{8-423}$$

The inverse transform coefficient scanning process as described in subclause 8.5.5 is invoked with LumaLevel[luma4x4BlkIdx] as the input and the two-dimensional array c^r with elements c_{ij}^r as the output.

The prediction residual transform coefficients c^r are scaled using quantisation parameter QP_Y, and added to the transform coefficients of the prediction block c^p with i, j = 0..3 as follows.

$$c_{ij}^{\,s} = c_{ij}^{\,p} + (((c_{ij}^{\,r} * \text{LevelScale}(QP_Y \,\%\, 6, i, j) * A_{ij}) << (QP_Y / 6)) >> 10) \tag{8-424}$$

where LevelScale(m, i, j) is specified in Equation 8-312, and where A_{ij} is specified as:

$$A_{ij} = \begin{cases} 16 & \text{for} \quad (i, j) \in \{(0,0), (0,2), (2,0), (2,2)\}, \\ 25 & \text{for} \quad (i, j) \in \{(1,1), (1,3), (3,1), (3,3)\}, \\ 20 & \text{otherwise;} \end{cases} \tag{8-425}$$

The function LevelScale2(m, i, j), used in the formulas below, is specified as:

$$\text{LevelScale2}(m, i, j) = \begin{cases} w_{m0} & \text{for} \quad (i, j) \in \{(0,0), (0,2), (2,0), (2,2)\}, \\ w_{m1} & \text{for} \quad (i, j) \in \{(1,1), (1,3), (3,1), (3,3)\}, \\ w_{m2} & \text{otherwise;} \end{cases} \tag{8-426}$$

where the first and second subscripts of w are row and column indices, respectively, of the matrix specified as:

$$w = \begin{bmatrix} 13107 & 5243 & 8066 \\ 11916 & 4660 & 7490 \\ 10082 & 4194 & 6554 \\ 9362 & 3647 & 5825 \\ 8192 & 3355 & 5243 \\ 7282 & 2893 & 4559 \end{bmatrix} \tag{8-427}$$

The resulting sum, c^s, is quantised with a quantisation parameter QS_Y and with i, j = 0..3 as follows.

$$c_{ij} = \text{Sign}(c_{ij}^{\,s}) * ((\text{Abs}(c_{ij}^{\,s}) * \text{LevelScale2}(QS_Y \,\%\, 6, i, j) + (1 << (14 + QS_Y / 6))) >> (15 + QS_Y / 6)) \tag{8-428}$$

The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.10 is invoked with c as the input and r as the output.

The 4x4 array u with elements u_{ij} is derived as follows.

$$u_{ij} = \text{Clip1}_Y(r_{ij}) \text{ with } i, j = 0..3 \tag{8-429}$$

The picture construction process prior to deblocking filter process in subclause 8.5.12 is invoked with luma4x4BlkIdx and u as the inputs.

8.6.1.2 Chroma transform coefficient decoding process

Inputs to this process are Inter prediction chroma samples for the current macroblock from subclause 8.4 and the prediction residual transform coefficient levels, ChromaDCLevel and ChromaACLevel.

This process is invoked twice: once for the Cb component and once for the Cr component. The component is referred to by replacing C with Cb for the Cb component and C with Cr for the Cr component. Let iCbCr select the current chroma component.

For each 4x4 block of the current chroma component indexed using chroma4x4BlkIdx with chroma4x4BlkIdx equal to 0..3, the following applies.

– The position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx inside the macroblock is derived as follows.

$$x = \text{InverseRasterScan}(\text{chroma4x4BlkIdx}, 4, 4, 8, 0) \tag{8-430}$$

$$y = InverseRasterScan(chroma4x4BlkIdx, 4, 4, 8, 1) \quad (8\text{-}431)$$

– Let p be a 4x4 array of prediction samples with elements p_{ij} being derived as follows.

$$p_{ij} = pred_C[x + j, y + i] \quad \text{with } i, j = 0..3 \quad (8\text{-}432)$$

– The 4x4 array p is transformed producing transform coefficients c^p(chroma4x4BlkIdx) using Equation 8-423.

– The variable chromaList, which is a list of 16 entries, is derived. chromaList[0] is set equal to 0. chromaList[k] with index k = 1..15 are specified as follows.

$$chromaList[k] = ChromaACLevel[iCbCr][chroma4x4BlkIdx][k - 1] \quad (8\text{-}433)$$

– The inverse transform coefficient scanning process as described in subclause 8.5.5 is invoked with chromaList as the input and the 4x4 array c^r as the output.

– The prediction residual transform coefficients c^r are scaled using quantisation parameter QPC, and added to the transform coefficients of the prediction block c^p with i, j = 0..3 except for the combination i = 0, j = 0 as follows.

$$c_{ij}^s = c_{ij}^p(chroma4x4BlkIdx) + (((c_{ij}^r * LevelScale(QP_C \% 6, i, j) * A_{ij}) << (QP_C / 6)) >> 10) \quad (8\text{-}434)$$

– The resulting sum, c^s, is quantised with a quantisation parameter QS_C and with i, j = 0..3 except for the combination i = 0, j = 0 as follows. The derivation of c_{00}(chroma4x4BlkIdx) is described below in this subclause.

$$c_{ij}(chroma4x4BlkIdx) = (Sign(c_{ij}^s) * (Abs(c_{ij}^s) * LevelScale2(QS_C \% 6, i, j) + (1 << (14 + QS_C / 6)))) >> (15 + QS_C / 6) \quad (8\text{-}435)$$

– The scaling and transformation process for residual 4x4 blocks as specified in 8.5.10 is invoked with c(chroma4x4BlkIdx) as the input and r as the output.

– The 4x4 array u with elements u_{ij} is derived as follows.

$$u_{ij} = Clip1_C(r_{ij}) \text{ with } i, j = 0..3 \quad (8\text{-}436)$$

– The picture construction process prior to deblocking filter process in subclause 8.5.12 is invoked with chroma4x4BlkIdx and u as the inputs.

The derivation of the DC transform coefficient level c_{00}(chroma4x4BlkIdx) is specified as follows. The DC transform coefficients of the 4 prediction chroma 4x4 blocks of the current component of the macroblock are assembled into a 2x2 matrix with elements c_{00}^p(chroma4x4BlkIdx) and a 2x2 transform is applied to the DC transform coefficients as follows

$$dc^p = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00}^p(0) & c_{00}^p(1) \\ c_{00}^p(2) & c_{00}^p(3) \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \quad (8\text{-}437)$$

The chroma DC prediction residual transform coefficient levels, ChromaDCLevel[iCbCr][k] with k = 0..3 are scaled using quantisation parameter QP, and added to the prediction DC transform coefficients as follows.

$$dc_{ij}^s = dc_{ij}^p + (((ChromaDCLevel[iCbCr][j * 2 + i] * LevelScale(QP_C \% 6, 0, 0) * A_{00}) << (QP_C / 6)) >> 9) \quad \text{with } i, j = 0, 1 \quad (8\text{-}438)$$

The 2x2 array dc^s, is quantised using the quantisation parameter QS_C as follows.

$$dc_{ij}^r = (Sign(dc_{ij}^s) * (Abs(dc_{ij}^s) * LevelScale2(QS_C \% 6, 0, 0) + (1 << (15 + QS_C / 6)))) >> (16 + QS_C / 6) \quad \text{with } i, j = 0, 1 \quad (8\text{-}439)$$

The 2x2 array f with elements f_{ij} and i, j = 0..1 is derived as follows.

$$f = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} dc^r_{00} & dc^r_{01} \\ dc^r_{10} & dc^r_{11} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}. \quad (8\text{-}440)$$

Scaling of the elements f_{ij} of f is performed as follows.

$$c_{00}(j * 2 + i) = ((f_{ij} * \text{LevelScale}(QS_C \% 6, 0, 0)) << (QS_C / 6)) >> 5 \text{ with i, j = 0, 1} \quad (8\text{-}441)$$

8.6.2 SP and SI slice decoding process for switching pictures

This process is invoked, when decoding P macroblock types in SP slices in which sp_for_switch_flag is equal to 1 and when decoding SI macroblock type in SI slices.

Inputs to this process are the prediction residual transform coefficient levels and the prediction sample arrays $pred_L$, $pred_{Cb}$ and $pred_{Cr}$ for the current macroblock.

8.6.2.1 Luma transform coefficient decoding process

Inputs to this process are prediction luma samples $pred_L$ and the luma prediction residual transform coefficient levels, LumaLevel.

The 4x4 array p with elements p_{ij} with i, j = 0..3 is derived as in subclause 8.6.1.1, is transformed according to Equation 8-423 to produce transform coefficients c^p. These transform coefficients are then quantised with the quantisation parameter QS_Y, as follows:

$$c_{ij}^s = \text{Sign}(c_{ij}^p) * ((\text{Abs}(c_{ij}^p) * \text{LevelScale2}(QS_Y \% 6, i, j) + (1 << (14 + QS_Y / 6))) >> (15 + QS_Y / 6)) \text{ with i, j = 0..3} \quad (8\text{-}442)$$

The inverse transform coefficient scanning process as described in subclause 8.5.5 is invoked with LumaLevel[luma4x4BlkIdx] as the input and the two-dimensional array c^r with elements c_{ij}^r as the output.

The 4x4 array c with elements c_{ij} with i, j = 0..3 is derived as follows.

$$c_{ij} = c_{ij}^r + c_{ij}^s \text{ with i, j = 0..3} \quad (8\text{-}443)$$

The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.10 is invoked with c as the input and r as the output.

The 4x4 array u with elements u_{ij} is derived as follows.

$$u_{ij} = \text{Clip1}_Y(r_{ij}) \text{ with i, j = 0..3} \quad (8\text{-}444)$$

The picture construction process prior to deblocking filter process in subclause 8.5.12 is invoked with luma4x4BlkIdx and u as the inputs.

8.6.2.2 Chroma transform coefficient decoding process

Inputs to this process are predicted chroma samples for the current macroblock from subclause 8.4 and the prediction residual transform coefficient levels, ChromaDCLevel and ChromaACLevel.

This process is invoked twice: once for the Cb component and once for the Cr component. The component is referred to by replacing C with Cb for the Cb component and C with Cr for the Cr component. Let iCbCr select the current chroma component.

For each 4x4 block of the current chroma component indexed using chroma4x4BlkIdx with chroma4x4BlkIdx equal to 0..3, the following applies.

1. The 4x4 array p with elements p_{ij} with i, j = 0..3 is derived as in subclause 8.6.1.2, is transformed according to Equation 8-423 to produce transform coefficients c^p(chroma4x4BlkIdx). These transform coefficients are then quantised with the quantisation parameter QS_C, with i, j = 0..3 except for the combination i = 0, j = 0 as follows. The processing of c_{00}^p(chroma4x4BlkIdx) is described below in this subclause.

$$c_{ij}^{s} = (Sign(c_{ij}^{p}(chroma4x4BlkIdx)) * (Abs(c_{ij}^{p}(chroma4x4BlkIdx)) * LevelScale2(QS_C \% 6, i, j) + (1 << (14 + QS_C / 6)))) >> (15 + QS_C / 6) \quad (8\text{-}445)$$

– The variable chromaList, which is a list of 16 entries, is derived. chromaList[0] is set equal to 0. chromaList[k] with index k = 1..15 are specified as follows.

$$chromaList[k] = ChromaACLevel[iCbCr][chroma4x4BlkIdx][k - 1] \quad (8\text{-}446)$$

– The inverse transform coefficient scanning process as described in subclause 8.5.5 is invoked with chromaList as the input and the two-dimensional array c^{r}(chroma4x4BlkIdx) with elements c_{ij}^{r}(chroma4x4BlkIdx) as the output.

– The 4x4 array c(chroma4x4BlkIdx) with elements c_{ij}(chroma4x4BlkIdx) with i, j = 0..3 except for the combination i = 0, j = 0 is derived as follows. The derivation of c_{00}(chroma4x4BlkIdx) is described below.

$$c_{ij}(chroma4x4BlkIdx) = c_{ij}^{r}(chroma4x4BlkIdx) + c_{ij}^{s} \quad (8\text{-}447)$$

– The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.10 is invoked with c(chroma4x4BlkIdx) as the input and r as the output.

– The 4x4 array u with elements u_{ij} is derived as follows.

$$u_{ij} = Clip1_C(r_{ij}) \text{ with } i, j = 0..3 \quad (8\text{-}448)$$

– The picture construction process prior to deblocking filter process in subclause 8.5.12 is invoked with chroma4x4BlkIdx and u as the inputs.

The derivation of the DC transform coefficient level c_{00}(chroma4x4BlkIdx) is specified as follows. The DC transform coefficients of the 4 prediction 4x4 chroma blocks of the current component of the macroblock, c_{00}^{p}(chroma4x4BlkIdx), are assembled into a 2x2 matrix, and a 2x2 transform is applied to the DC transform coefficients of these blocks according to Equation 8-437 resulting in DC transform coefficients dc_{ij}^{p}.

These DC transform coefficients are then quantised with the quantisation parameter QS_C, as given by:

$$dc_{ij}^{s} = (Sign(dc_{ij}^{p}) * (Abs(dc_{ij}^{p}) * LevelScale2(QS_C \% 6, 0, 0) + (1 << (15 + QS_C / 6)))) >> (16 + QS_C / 6) \text{ with } i, j = 0, 1 \quad (8\text{-}449)$$

The parsed chroma DC prediction residual transform coefficients, ChromaDCLevel[iCbCr][k] with k = 0..3 are added to these quantised DC transform coefficients of the prediction block, as given by:

$$dc_{ij}^{r} = dc_{ij}^{s} + ChromaDCLevel[iCbCr][j * 2 + i] \text{ with } i, j = 0, 1 \quad (8\text{-}450)$$

The 2x2 array f with elements f_{ij} and i, j = 0..1 is derived using Equation 8-440.

The 2x2 array f with elements f_{ij} and i, j = 0..1 is copied as follows.

$$c_{00}(j * 2 + i) = f_{ij} \text{ with } i, j = 0, 1 \quad (8\text{-}451)$$

8.7 Deblocking filter process

A conditional filtering process is applied to all NxN (where N = 4 or N = 8 for luma, and N = 4 for chroma) block edges of a picture, except edges at the boundary of the picture and any edges for which the deblocking filter process is disabled by disable_deblocking_filter_idc, as specified below. This filtering process is performed on a macroblock basis after the completion of the picture construction process prior to deblocking filter process (as specified in subclauses 8.5 and 8.6) for the entire decoded picture, with all macroblocks in a picture processed in order of increasing macroblock addresses.

NOTE 1 – Prior to the operation of the deblocking filter process for each macroblock, the deblocked samples of the macroblock or macroblock pair above (if any) and the macroblock or macroblock pair to the left (if any) of the current macroblock are always available because the deblocking filter process is performed after the completion of the picture construction process prior to deblocking filter process for the entire decoded picture. However, for purposes of determining which edges are to be filtered

when disable_deblocking_filter_idc is equal to 2, macroblocks in different slices are considered not available during specified steps of the operation of the deblocking filter process.

The deblocking filter process is invoked for the luma and chroma components separately. For each macroblock and each component, vertical edges are filtered first, starting with the edge on the left-hand side of the macroblock proceeding through the edges towards the right-hand side of the macroblock in their geometrical order, and then horizontal edges are filtered, starting with the edge on the top of the macroblock proceeding through the edges towards the bottom of the macroblock in their geometrical order. Figure 8-10 shows edges of a macroblock which can be interpreted as luma or chroma edges.

When interpreting the edges in Figure 8-10 as luma edges, depending on the transform_size_8x8_flag, the following applies.

– If transform_size_8x8_flag is equal to 0, both types, the solid bold and dashed bold luma edges are filtered.

– Otherwise (transform_size_8x8_flag is equal to 1), only the solid bold luma edges are filtered.

When interpreting the edges in Figure 8-10 as chroma edges, depending on chroma_format_idc, the following applies.

– If chroma_format_idc is equal to 1 (4:2:0 format), only the solid bold chroma edges are filtered.

– Otherwise, if chroma_format_idc is equal to 2 (4:2:2 format), the solid bold vertical chroma edges are filtered and both types, the solid bold and dashed bold horizontal chroma edges are filtered.

– Otherwise, if chroma_format_idc is equal to 3 (4:4:4 format), both types, the solid bold and dashed bold chroma edges are filtered.

– Otherwise (chroma_format_idc is equal to 0 (monochrome)), no chroma edges are filtered.

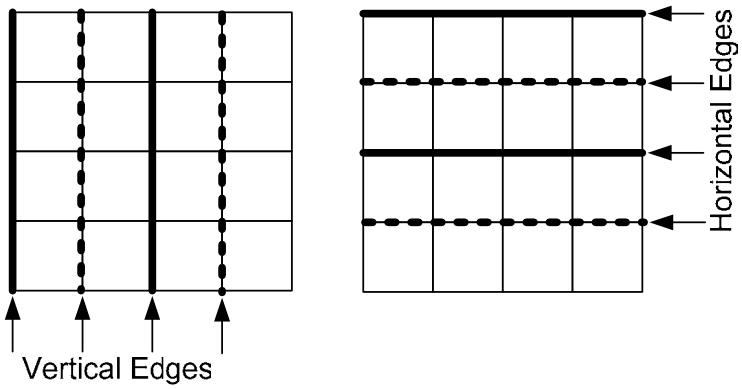


Figure 8-10 – Boundaries in a macroblock to be filtered

For the current macroblock address CurrMbAddr proceeding over values 0..PicSizeInMbs – 1, the following applies.

1. The derivation process for neighbouring macroblocks specified in subclause 6.4.8.1 is invoked and the output is assigned to mbAddrA and mbAddrB.
2. The variables fieldModeMbFlag, filterInternalEdgesFlag, filterLeftMbEdgeFlag and filterTopMbEdgeFlag are derived as follows.
   – The variable fieldModeMbFlag is derived as follows.
      – If any of the following conditions is true, fieldModeMbFlag is set equal to 1.
         – field_pic_flag is equal to 1
         – MbaffFrameFlag is equal to 1 and the macroblock CurrMbAddr is a field macroblock
      – Otherwise, fieldModeMbFlag is set equal to 0.
   – The variable filterInternalEdgesFlag is derived as follows.

- If disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 1, the variable filterInternalEdgesFlag is set equal to 0;
- Otherwise (disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is not equal to 1), the variable filterInternalEdgesFlag is set equal to 1.

– The variable filterLeftMbEdgeFlag is derived as follows.
  - If any of the following conditions is true, the variable filterLeftMbEdgeFlag is set equal to 0.
    - MbaffFrameFlag is equal to 0 and CurrMbAddr % PicWidthInMbs is equal to 0.
    - MbaffFrameFlag is equal to 1 and (CurrMbAddr >> 1) % PicWidthInMbs is equal to 0
    - disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 1
    - disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 2 and the macroblock mbAddrA is not available
  - Otherwise, the variable filterLeftMbEdgeFlag is set equal to 1.

– The variable filterTopMbEdgeFlag is derived as follows.
  - If any of the following conditions is true, the variable filterTopMbEdgeFlag is set equal to 0.
    - MbaffFrameFlag is equal to 0 and CurrMbAddr is less than PicWidthInMbs.
    - MbaffFrameFlag is equal to 1, (CurrMbAddr >> 1) is less than PicWidthInMbs, and the macroblock CurrMbAddr is a field macroblock.
    - MbaffFrameFlag is equal to 1, (CurrMbAddr >> 1) is less than PicWidthInMbs, the macroblock CurrMbAddr is a frame macroblock, and CurrMbAddr % 2 is equal to 0.
    - disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 1
    - disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 2 and the macroblock mbAddrB is not available
  - Otherwise, the variable filterTopMbEdgeFlag is set equal to 1.

3. Given the variables fieldModeMbFlag, filterInternalEdgesFlag, filterLeftMbEdgeFlag and filterTopMbEdgeFlag the deblocking filtering is controlled as follows.
   – When filterLeftMbEdgeFlag is equal to 1, the filtering of the left vertical luma edge is specified as follows.
     - The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (0, k)$ with k = 0..15 as input and S'_L as output.
   – When filterInternalEdgesFlag is equal to 1, the filtering of the internal vertical luma edges is specified as follows.
     - When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (4, k)$ with k = 0..15 as input and S'_L as output.
     - The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (8, k)$ with k = 0..15 as input and S'_L as output.
     - When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (12, k)$ with k = 0..15 as input and S'_L as output.
   – When filterTopMbEdgeFlag is equal to 1, the filtering of the top horizontal luma edge is specified as follows.
     - If MbaffFrameFlag is equal to 1, (CurrMbAddr % 2) is equal to 0, CurrMbAddr is greater than or equal to 2 * PicWidthInMbs, the macroblock CurrMbAddr is a frame macroblock, and the macroblock (CurrMbAddr - 2 * PicWidthInMbs + 1) is a field macroblock, the following applies.
       - The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 0)$ with k = 0..15 as input and S'_L as output.

– The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 1)$ with k = 0..15 as input and S'_L as output.

– Otherwise, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 0)$ with k = 0..15 as input and S'_L as output.

– When filterInternalEdgesFlag is equal to 1, the filtering of the internal horizontal luma edges is specified as follows.

– When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 4)$ with k = 0..15 as input and S'_L as output.

– The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 8)$ with k = 0..15 as input and S'_L as output.

– When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 12)$ with k = 0..15 as input and S'_L as output.

– For the filtering of both chroma components with iCbCr = 0 for Cb and iCbCr = 1 for Cr, the following applies.

– When filterLeftMbEdgeFlag is equal to 1, the filtering of the left vertical chroma edge is specified as follows.

– The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (0, k)$ with k = 0..MbHeightC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– When filterInternalEdgesFlag is equal to 1, the filtering of the internal vertical chroma edge is specified as follows.

– The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (4, k)$ with k = 0..MbHeightC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– When chroma_format_idc is equal to 3, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (8, k)$ with k = 0..MbHeightC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– When chroma_format_idc is equal to 3, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (12, k)$ with k = 0..MbHeightC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– When filterTopMbEdgeFlag is equal to 1, the filtering of the top horizontal chroma edge is specified as follows.

– If MbaffFrameFlag is equal to 1, (CurrMbAddr % 2) is equal to 0, CurrMbAddr is greater than or equal to 2 * PicWidthInMbs, the macroblock CurrMbAddr is a frame macroblock, and the macroblock (CurrMbAddr – 2 * PicWidthInMbs + 1) is a field macroblock, the following applies.

– The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 0)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 1)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– Otherwise, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 0)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– When filterInternalEdgesFlag is equal to 1, the filtering of the internal horizontal chroma edge is specified as follows.

  – The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 4)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

  – When chroma_format_idc is not equal to 1, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 8)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

  – When chroma_format_idc is not equal to 1, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 12)$ with k = 0..MbWidthC - 1 as input and S'_C with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

  NOTE 2 – When field mode filtering (fieldModeFilteringFlag is equal to 1) is applied across the top horizontal edges of a frame macroblock, this vertical filtering across the top or bottom macroblock boundary may involve some samples that extend across an internal block edge that is also filtered internally in frame mode.

  NOTE 3 – For example, in 4:2:0 chroma format when transform_size_8x8_flag is equal to 0, the following applies. 3 horizontal luma edges, 1 horizontal chroma edge for Cb, and 1 horizontal chroma edge for Cr are filtered that are internal to a macroblock. When field mode filtering (fieldModeFilteringFlag is equal to 1) is applied to the top edges of a frame macroblock, 2 horizontal luma, 2 horizontal chroma edges for Cb, and 2 horizontal chroma edges for Cr between the frame macroblock and the above macroblock pair are filtered using field mode filtering, for a total of up to 5 horizontal luma edges, 3 horizontal chroma edges for Cb, and 3 horizontal chroma edges for Cr filtered that are considered to be controlled by the frame macroblock. In all other cases, at most 4 horizontal luma, 2 horizontal chroma edges for Cb, and 2 horizontal chroma edges for Cr are filtered that are considered to be controlled by a particular macroblock.

Finally, the arrays S'_L, S'_{Cb}, S'_{Cr} are assigned to the arrays S_L, S_{Cb}, S_{Cr} (which represent the decoded picture), respectively.

8.7.1 Filtering process for block edges

Inputs to this process are chromaEdgeFlag, the chroma component index iCbCr (when chromaEdgeFlag is equal to 1), verticalEdgeFlag, fieldModeFilteringFlag, and a set of nE sample locations (xE_k, yE_k), with k = 0..nE - 1, expressed relative to the upper left corner of the macroblock CurrMbAddr. The set of sample locations (xE_k, yE_k) represent the sample locations immediately to the right of a vertical edge (when verticalEdgeFlag is equal to 1) or immediately below a horizontal edge (when verticalEdgeFlag is equal to 0).

The variable nE is derived as follows.

– If chromaEdgeFlag is equal to 0, nE is set equal to 16.

– Otherwise (chromaEdgeFlag is equal to 1), nE is set equal to (verticalEdgeFlag = = 1) ? MbHeightC : MbWidthC.

Let s' be a variable specifying a luma or chroma sample array, be derived as follows.

– If chromaEdgeFlag is equal to 0, s' represents the luma sample array S'_L of the current picture.

– Otherwise, if chromaEdgeFlag is equal to 1 and iCbCr is equal to 0, s' represents the chroma sample array S'_{Cb} of the chroma component Cb of the current picture.

– Otherwise (chromaEdgeFlag is equal to 1 and iCbCr is equal to 1), s' represents the chroma sample array S'_{Cr} of the chroma component Cr of the current picture.

The variable dy is derived as follows.

– If fieldModeFilteringFlag is equal to 1 and MbaffFrameFlag is equal to 1, dy is set equal to 2.

– Otherwise (fieldModeFilteringFlag is equal to 0 or MbaffFrameFlag is equal to 0), dy is set equal to 1.

The position of the upper-left luma sample of the macroblock CurrMbAddr is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddr = CurrMbAddr as input and the output being assigned to (xI, yI).

The variables xP and yP are derived as follows.

– If chromaEdgeFlag is equal to 0, xP is set equal to xI and yP is set equal to yI.

– Otherwise (chromaEdgeFlag is equal to 1), xP is set equal to xI / SubWidthC and yP is set equal to (yI + SubHeightC – 1) / SubHeightC.

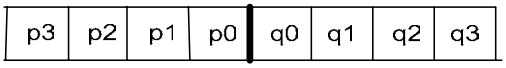


Figure 8-11 – Convention for describing samples across a 4x4 block horizontal or vertical boundary

For each sample location (xE_k, yE_k), k = 0 .. nE - 1, the following applies.

– The filtering process is applied to a set of eight samples across a 4x4 block horizontal or vertical edge denoted as p_i and q_i with i = 0..3 as shown in Figure 8-11 with the edge lying between p_0 and q_0. p_i and q_i with i = 0..3 are specified as follows.

  – If verticalEdgeFlag is equal to 1,

$$q_i = s'[\ xP + xE_k + i,\ yP + dy * yE_k\ ] \quad (8\text{-}452)$$

$$p_i = s'[\ xP + xE_k - i - 1,\ yP + dy * yE_k\ ] \quad (8\text{-}453)$$

  – Otherwise (verticalEdgeFlag is equal to 0),

$$q_i = s'[\ xP + xE_k,\ yP + dy * (\ yE_k + i\ ) - (yE_k \% 2\ )\ ] \quad (8\text{-}454)$$

$$p_i = s'[\ xP + xE_k,\ yP + dy * (\ yE_k - i - 1\ ) - (yE_k \% 2\ )\ ] \quad (8\text{-}455)$$

– The process specified in subclause 8.7.2 is invoked with the sample values p_i and q_i (i = 0..3), chromaEdgeFlag, verticalEdgeFlag, and fieldModeFilteringFlag as input, and the output is assigned to the filtered result sample values p'_i and q'_i with i = 0..2.

– The input sample values p_i and q_i with i = 0..2 are replaced by the corresponding filtered result sample values p'_i and q'_i with i = 0..2 inside the sample array s' as follows.

  – If verticalEdgeFlag is equal to 1,

$$s'[\ xP + xE_k + i,\ yP + dy * yE_k\ ] = q'_i \quad (8\text{-}456)$$

$$s'[\ xP + xE_k - i - 1,\ yP + dy * yE_k\ ] = p'_i \quad (8\text{-}457)$$

  – Otherwise (verticalEdgeFlag is equal to 0),

$$s'[\ xP + xE_k,\ yP + dy * (\ yE_k + i\ ) - (\ yE_k \% 2\ )\ ] = q'_i \quad (8\text{-}458)$$

$$s'[\ xP + xE_k,\ yP + dy * (\ yE_k - i - 1\ ) - (\ yE_k \% 2\ )\ ] = p'_i \quad (8\text{-}459)$$

8.7.2 Filtering process for a set of samples across a horizontal or vertical block edge

Inputs to this process are the input sample values p_i and q_i with i in the range of 0..3 of a single set of samples across an edge that is to be filtered, chromaEdgeFlag, verticalEdgeFlag, and fieldModeFilteringFlag.

Outputs of this process are the filtered result sample values p'_i and q'_i with i in the range of 0..2.

The content dependent boundary filtering strength variable bS is derived as follows.

– If chromaEdgeFlag is equal to 0, the derivation process for the content dependent boundary filtering strength specified in subclause 8.7.2.1 is invoked with p_0, q_0, and verticalEdgeFlag as input, and the output is assigned to bS.

– Otherwise (chromaEdgeFlag is equal to 1), the bS used for filtering a set of samples of a horizontal or vertical chroma edge is set equal to the value of bS for filtering the set of samples of a horizontal or vertical luma edge, respectively, that contains the luma sample at location (SubWidthC * x, SubHeightC * y) inside the luma array of the same field, where (x, y) is the location of the chroma sample q_0 inside the chroma array for that field.

The process specified in subclause 8.7.2.2 is invoked with p_0, q_0, p_1, q_1, chromaEdgeFlag, and bS as input, and the output is assigned to filterSamplesFlag, indexA, α, and β.

Depending on the variable filterSamplesFlag, the following applies.

– If filterSamplesFlag is equal to 1, the following applies.

  – If bS is less than 4, the process specified in subclause 8.7.2.3 is invoked with p_i and q_i (i = 0..2), chromaEdgeFlag, bS, β, and indexA given as input, and the output is assigned to p'_i and q'_i (i = 0..2).

  – Otherwise (bS is equal to 4), the process specified in subclause 8.7.2.4 is invoked with p_i and q_i (i = 0..3), chromaEdgeFlag, α, and β given as input, and the output is assigned to p'_i and q'_i (i = 0..2).

– Otherwise (filterSamplesFlag is equal to 0), the filtered result samples p'_i and q'_i (i = 0..2) are replaced by the corresponding input samples p_i and q_i:

$$\text{for } i = 0..2, \quad p'_i = p_i \tag{8-460}$$

$$\text{for } i = 0..2, \quad q'_i = q_i \tag{8-461}$$

8.7.2.1 Derivation process for the luma content dependent boundary filtering strength

Inputs to this process are the input sample values p_0 and q_0 of a single set of samples across an edge that is to be filtered and verticalEdgeFlag.

Output of this process is the variable bS.

Let the variable mixedModeEdgeFlag be derived as follows.

– If MbaffFrameFlag is equal to 1 and the samples p_0 and q_0 are in different macroblock pairs, one of which is a field macroblock pair and the other is a frame macroblock pair, mixedModeEdgeFlag is set equal to 1

– Otherwise, mixedModeEdgeFlag is set equal to 0.

The variable bS is derived as follows.

– If the block edge is also a macroblock edge and any of the following conditions are true, a value of bS equal to 4 is the output:

  – the samples p_0 and q_0 are both in frame macroblocks and either or both of the samples p_0 or q_0 is in a macroblock coded using an Intra macroblock prediction mode

  – the samples p_0 and q_0 are both in frame macroblocks and either or both of the samples p_0 or q_0 is in a macroblock that is in a slice with slice_type equal to SP or SI

  – MbaffFrameFlag is equal to 1 or field_pic_flag is equal to 1, and verticalEdgeFlag is equal to 1, and either or both of the samples p_0 or q_0 is in a macroblock coded using an Intra macroblock prediction mode

  – MbaffFrameFlag is equal to 1 or field_pic_flag is equal to 1, and verticalEdgeFlag is equal to 1, and either or both of the samples p_0 or q_0 is in a macroblock that is in a slice with slice_type equal to SP or SI

– Otherwise, if any of the following conditions are true, a value of bS equal to 3 is the output:

  – mixedModeEdgeFlag is equal to 0 and either or both of the samples p_0 or q_0 is in a macroblock coded using an Intra macroblock prediction mode

  – mixedModeEdgeFlag is equal to 0 and either or both of the samples p_0 or q_0 is in a macroblock that is in a slice with slice_type equal to SP or SI

  – mixedModeEdgeFlag is equal to 1, verticalEdgeFlag is equal to 0, and either or both of the samples p_0 or q_0 is in a macroblock coded using an Intra macroblock prediction mode

  – mixedModeEdgeFlag is equal to 1, verticalEdgeFlag is equal to 0, and either or both of the samples p_0 or q_0 is in a macroblock that is in a slice with slice_type equal to SP or SI

– Otherwise, if the following condition is true, a value of bS equal to 2 is the output:

  – the luma block containing sample p_0 or the luma block containing sample q_0 contains non-zero transform coefficient levels

– Otherwise, if any of the following conditions are true, a value of bS equal to 1 is the output:

  – mixedModeEdgeFlag is equal to 1

  – mixedModeEdgeFlag is equal to 0 and for the prediction of the macroblock/sub-macroblock partition containing the sample p_0 different reference pictures or a different number of motion vectors are used than for the prediction of the macroblock/sub-macroblock partition containing the sample q_0.

    NOTE 1 – The determination of whether the reference pictures used for the two macroblock/sub-macroblock partitions are the same or different is based only on which pictures are referenced, without regard to whether a prediction is formed using an index into reference picture list 0 or an index into reference picture list 1, and also without regard to whether or not the index position within a reference picture list is different or not.

  – mixedModeEdgeFlag is equal to 0 and one motion vector is used to predict the macroblock/sub-macroblock partition containing the sample p_0 and one motion vector is used to predict the macroblock/sub-macroblock partition containing the sample q_0 and the absolute difference between the horizontal or vertical component of the motion vectors used is greater than or equal to 4 in units of quarter luma frame samples.

  – mixedModeEdgeFlag is equal to 0 and two motion vectors and two different reference pictures are used to predict the macroblock/sub-macroblock partition containing the sample p_0 and two motion vectors for the same two reference pictures are used to predict the macroblock/sub-macroblock partition containing the sample q_0 and the absolute difference between the horizontal or vertical component of the two motion vectors used in the prediction of the two macroblock/sub-macroblock partitions for the same reference picture is greater than or equal to 4 in units of quarter luma frame samples.

  – mixedModeEdgeFlag is equal to 0 and two motion vectors for the same reference picture are used to predict the macroblock/sub-macroblock partition containing the sample p_0 and two motion vectors for the same reference picture are used to predict the macroblock/sub-macroblock partition containing the sample q_0 and both of the following conditions are true:

    – The absolute difference between the horizontal or vertical component of list 0 motion vectors used in the prediction of the two macroblock/sub-macroblock partitions is greater than or equal to 4 in quarter luma frame samples or the absolute difference between the horizontal or vertical component of the list 1 motion vectors used in the prediction of the two macroblock/sub-macroblock partitions is greater than or equal to 4 in units of quarter luma frame samples.

    – The absolute difference between the horizontal or vertical component of list 0 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample p_0 and the list 1 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample q_0 is greater than or equal to 4 in units of quarter luma frame samples or the absolute difference between the horizontal or vertical component of the list 1 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample p_0 and list 0 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample q_0 is greater than or equal to 4 in units of quarter luma frame samples.

      NOTE 2 – A vertical difference of 4 in units of quarter luma frame samples is a difference of 2 in units of quarter luma field samples

– Otherwise, a value of bS equal to 0 is the output.

8.7.2.2 Derivation process for the thresholds for each block edge

Inputs to this process are the input sample values p_0, q_0, p_1 and q_1 of a single set of samples across an edge that is to be filtered, chromaEdgeFlag, and bS, for the set of input samples, as specified in 8.7.2.

Outputs of this process are the variable filterSamplesFlag, which indicates whether the input samples are filtered, the value of indexA, and the values of the threshold variables α and β.

Let qP_p and qP_q be variables specifying quantisation parameter values for the macroblocks containing the samples p_0 and q_0, respectively. The variables qP_z (with z being replaced by p or q) are derived as follows.

– If chromaEdgeFlag is equal to 0, the following applies.

  – If the macroblock containing the sample z_0 is an I_PCM macroblock, qP_z is set to 0.

  – Otherwise (the macroblock containing the sample z_0 is not an I_PCM macroblock), qP_z is set to the value of QP_Y of the macroblock containing the sample z_0.

– Otherwise (chromaEdgeFlag is equal to 1), the following applies.

  – If the macroblock containing the sample z_0 is an I_PCM macroblock, qP_z is set to the value of QP_C that corresponds to a value of 0 for QP_Y as specified in subclause 8.5.7.

  – Otherwise (the macroblock containing the sample z_0 is not an I_PCM macroblock), qP_z is set to the value of QP_C that corresponds to the value QP_Y of the macroblock containing the sample z_0 as specified in subclause 8.5.7.

Let qP_{av} be a variable specifying an average quantisation parameter. It is derived as follows.

$$qP_{av} = (qP_p + qP_q + 1) >> 1 \quad (8\text{-}462)$$

NOTE – In SP and SI slices, qP_{av} is derived in the same way as in other slice types. QS_Y from Equation 7-28 is not used in the deblocking filter.

Let indexA be a variable that is used to access the α table (Table 8-16) as well as the t_{C0} table (Table 8-17), which is used in filtering of edges with bS less than 4 as specified in subclause 8.7.2.3, and let indexB be a variable that is used to access the β table (Table 8-16). The variables indexA and indexB are derived as follows, where the values of FilterOffsetA and FilterOffsetB are the values of those variables specified in subclause 7.4.3 for the slice that contains the macroblock containing sample q_0.

$$indexA = Clip3(0, 51, qP_{av} + FilterOffsetA) \quad (8\text{-}463)$$

$$indexB = Clip3(0, 51, qP_{av} + FilterOffsetB) \quad (8\text{-}464)$$

The variables α' and β' depending on the values of indexA and indexB are specified in Table 8-16. Depending on chromaEdgeFlag, the corresponding threshold variables α and β are derived as follows.

– If chromaEdgeFlag is equal to 0,

$$\alpha = \alpha' * (1 << (BitDepth_Y – 8)) \quad (8\text{-}465)$$

$$\beta = \beta' * (1 << (BitDepth_Y – 8)) \quad (8\text{-}466)$$

– Otherwise (chromaEdgeFlag is equal to 1),

$$\alpha = \alpha' * (1 << (BitDepth_C – 8)) \quad (8\text{-}467)$$

$$\beta = \beta' * (1 << (BitDepth_C – 8)) \quad (8\text{-}468)$$

The variable filterSamplesFlag is derived by

$$filterSamplesFlag = (bS != 0 \ \&\& \ Abs(p_0 – q_0) < \alpha \ \&\& \ Abs(p_1 – p_0) < \beta \ \&\& \ Abs(q_1 – q_0) < \beta) \quad (8\text{-}469)$$

Table 8-16 – Derivation of offset dependent threshold variables α' and β' from indexA and indexB

	indexA (for α') or indexB (for β')																									
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
α'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	5	6	7	8	9	10	12	13
β'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	3	3	3	3	4	4	4

Table 8-16 (concluded) – Derivation of indexA and indexB from offset dependent threshold variables α' and β'

	indexA (for α') or indexB (for β')																									
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
α'	15	17	20	22	25	28	32	36	40	45	50	56	63	71	80	90	101	113	127	144	162	182	203	226	255	255
β'	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18

8.7.2.3 Filtering process for edges with bS less than 4

Inputs to this process are the input sample values p_i and q_i (i = 0..2) of a single set of samples across an edge that is to be filtered, chromaEdgeFlag, bS, β, and indexA, for the set of input samples, as specified in 8.7.2.

Outputs of this process are the filtered result sample values p'_i and q'_i (i = 0..2) for the set of input sample values.

The filtered result samples p'_0 and q'_0 are derived by

$$\Delta = \text{Clip3}(-t_C, t_C, ((((q_0 - p_0) << 2) + (p_1 - q_1) + 4) >> 3)) \quad (8\text{-}470)$$

$$p'_0 = \text{Clip1}(p_0 + \Delta) \quad (8\text{-}471)$$

$$q'_0 = \text{Clip1}(q_0 - \Delta) \quad (8\text{-}472)$$

where the threshold t_C is determined as follows.

– If chromaEdgeFlag is equal to 0,

$$t_C = t_{C0} + ((a_p < \beta) ? 1 : 0) + ((a_q < \beta) ? 1 : 0) \quad (8\text{-}473)$$

– Otherwise (chromaEdgeFlag is equal to 1),

$$t_C = t_{C0} + 1 \quad (8\text{-}474)$$

Depending on the values of indexA and bS the variable t'_{C0} is specified in Table 8-17. Depending on chromaEdgeFlag, the corresponding threshold variable t_{C0} is derived as follows.

– If chromaEdgeFlag is equal to 0,

$$t_{C0} = t'_{C0} * (1 << (\text{BitDepth}_Y - 8)) \quad (8\text{-}475)$$

– Otherwise (chromaEdgeFlag is equal to 1),

$$t_{C0} = t'_{C0} * (1 << (\text{BitDepth}_C - 8)) \quad (8\text{-}476)$$

Let a_p and a_q be two threshold variables specified by

$$a_p = Abs(p_2 – p_0) \quad (8\text{-}477)$$

$$a_q = Abs(q_2 – q_0) \quad (8\text{-}478)$$

The filtered result sample p'_1 is derived as follows

– If chromaEdgeFlag is equal to 0 and a_p is less than β,

$$p'_1 = p_1 + Clip3(–t_{C0}, t_{C0}, (p_2 + ((p_0 + q_0 + 1) >> 1) – (p_1 << 1)) >> 1) \quad (8\text{-}479)$$

– Otherwise (chromaEdgeFlag is equal to 1 or a_p is greater than or equal to β),

$$p'_1 = p_1 \quad (8\text{-}480)$$

The filtered result sample q'_1 is derived as follows

– If chromaEdgeFlag is equal to 0 and a_q is less than β,

$$q'_1 = q_1 + Clip3(–t_{C0}, t_{C0}, (q_2 + ((p_0 + q_0 + 1) >> 1) – (q_1 << 1)) >> 1) \quad (8\text{-}481)$$

– Otherwise (chromaEdgeFlag is equal to 1 or a_q is greater than or equal to β),

$$q'_1 = q_1 \quad (8\text{-}482)$$

The filtered result samples p'_2 and q'_2 are always set equal to the input samples p_2 and q_2:

$$p'_2 = p_2 \quad (8\text{-}483)$$

$$q'_2 = q_2 \quad (8\text{-}484)$$

Table 8-17 – Value of variable t'_{C0} as a function of indexA and bS

	indexA																									
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
bS = 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
bS = 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
bS = 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1

Table 8-17 (concluded) – Value of variable t'_{C0} as a function of indexA and bS

	indexA																									
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
bS = 1	1	1	1	1	1	1	1	2	2	2	2	3	3	3	4	4	4	5	6	6	7	8	9	10	11	13
bS = 2	1	1	1	1	1	2	2	2	2	3	3	3	4	4	5	5	6	7	8	8	10	11	12	13	15	17
bS = 3	1	2	2	2	2	3	3	3	4	4	4	5	6	6	7	8	9	10	11	13	14	16	18	20	23	25

8.7.2.4 Filtering process for edges for bS equal to 4

Inputs to this process are the input sample values p_i and q_i (i = 0..3) of a single set of samples across an edge that is to be filtered, the variable chromaEdgeFlag, and the values of the threshold variables α and β for the set of samples, as specified in subclause 8.7.2.

Outputs of this process are the filtered result sample values p'_i and q'_i (i = 0..2) for the set of input sample values.

Let a_p and a_q be two threshold variables as specified in Equations 8-477 and 8-478, respectively, in subclause 8.7.2.3.

The filtered result samples p'_i (i = 0..2) are derived as follows.

– If chromaEdgeFlag is equal to 0 and the following condition holds,

$$a_p < \beta \;\&\&\; Abs(p_0 - q_0) < ((\alpha >> 2) + 2) \tag{8-485}$$

then the variables p'_0, p'_1, and p'_2 are derived by

$$p'_0 = (p_2 + 2*p_1 + 2*p_0 + 2*q_0 + q_1 + 4) >> 3 \tag{8-486}$$

$$p'_1 = (p_2 + p_1 + p_0 + q_0 + 2) >> 2 \tag{8-487}$$

$$p'_2 = (2*p_3 + 3*p_2 + p_1 + p_0 + q_0 + 4) >> 3 \tag{8-488}$$

– Otherwise (chromaEdgeFlag is equal to 1 or the condition in Equation 8-485 does not hold), the variables p'_0, p'_1, and p'_2 are derived by

$$p'_0 = (2*p_1 + p_0 + q_1 + 2) >> 2 \tag{8-489}$$

$$p'_1 = p_1 \tag{8-490}$$

$$p'_2 = p_2 \tag{8-491}$$

The filtered result samples q'_i (i = 0..2) are derived as follows.

– If chromaEdgeFlag is equal to 0 and the following condition holds,

$$a_q < \beta \;\&\&\; Abs(p_0 - q_0) < ((\alpha >> 2) + 2) \tag{8-492}$$

then the variables q'_0, q'_1, and q'_2 are derived by

$$q'_0 = (p_1 + 2*p_0 + 2*q_0 + 2*q_1 + q_2 + 4) >> 3 \tag{8-493}$$

$$q'_1 = (p_0 + q_0 + q_1 + q_2 + 2) >> 2 \tag{8-494}$$

$$q'_2 = (2*q_3 + 3*q_2 + q_1 + q_0 + p_0 + 4) >> 3 \tag{8-495}$$

– Otherwise (chromaEdgeFlag is equal to 1 or the condition in Equation 8-492 does not hold), the variables q'_0, q'_1, and q'_2 are derived by

$$q'_0 = (2*q_1 + q_0 + p_1 + 2) >> 2 \tag{8-496}$$

$$q'_1 = q_1 \tag{8-497}$$

$$q'_2 = q_2 \tag{8-498}$$

9 Parsing process

Inputs to this process are bits from the RBSP.

Outputs of this process are syntax element values.

This process is invoked when the descriptor of a syntax element in the syntax tables in subclause 7.3 is equal to ue(v), me(v), se(v), te(v) (see subclause 9.1), ce(v) (see subclause 9.2), or ae(v) (see subclause 9.3).

9.1 Parsing process for Exp-Golomb codes

This process is invoked when the descriptor of a syntax element in the syntax tables in subclause 7.3 is equal to ue(v), me(v), se(v), or te(v). For syntax elements in subclauses 7.3.4 and 7.3.5, this process is invoked only when entropy_coding_mode_flag is equal to 0.

Inputs to this process are bits from the RBSP.

Outputs of this process are syntax element values.

Syntax elements coded as ue(v), me(v), or se(v) are Exp-Golomb-coded. Syntax elements coded as te(v) are truncated Exp-Golomb-coded. The parsing process for these syntax elements begins with reading the bits starting at the current location in the bitstream up to and including the first non-zero bit, and counting the number of leading bits that are equal to 0. This process is specified as follows:

```
leadingZeroBits = -1;
for( b = 0; !b; leadingZeroBits++ )
    b = read_bits( 1 )
```

The variable codeNum is then assigned as follows:

$$codeNum = 2^{leadingZeroBits} - 1 + read\_bits(leadingZeroBits)$$

where the value returned from read_bits(leadingZeroBits) is interpreted as a binary representation of an unsigned integer with most significant bit written first.

Table 9-1 illustrates the structure of the Exp-Golomb code by separating the bit string into “prefix” and “suffix” bits. The “prefix” bits are those bits that are parsed in the above pseudo-code for the computation of leadingZeroBits, and are shown as either 0 or 1 in the bit string column of Table 9-1. The “suffix” bits are those bits that are parsed in the computation of codeNum and are shown as x_i in Table 9-1, with i being in the range 0 to leadingZeroBits - 1, inclusive. Each x_i can take on values 0 or 1.

Table 9-1 – Bit strings with “prefix” and “suffix” bits and assignment to codeNum ranges (informative)

Bit string form	Range of codeNum
1	0
0 1 x_0	1-2
0 0 1 x_1 x_0	3-6
0 0 0 1 x_2 x_1 x_0	7-14
0 0 0 0 1 x_3 x_2 x_1 x_0	15-30
0 0 0 0 0 1 x_4 x_3 x_2 x_1 x_0	31-62
…	…

Table 9-2 illustrates explicitly the assignment of bit strings to codeNum values.

Table 9-2 – Exp-Golomb bit strings and codeNum in explicit form and used as ue(v) (informative)

Bit string	codeNum
1	0
0 1 0	1
0 1 1	2
0 0 1 0 0	3
0 0 1 0 1	4
0 0 1 1 0	5
0 0 1 1 1	6
0 0 0 1 0 0 0	7
0 0 0 1 0 0 1	8
0 0 0 1 0 1 0	9
…	…

Depending on the descriptor, the value of a syntax element is derived as follows.

– If the syntax element is coded as ue(v), the value of the syntax element is equal to codeNum.

– Otherwise, if the syntax element is coded as se(v), the value of the syntax element is derived by invoking the mapping process for signed Exp-Golomb codes as specified in subclause 9.1.1 with codeNum as the input.

– Otherwise, if the syntax element is coded as me(v), the value of the syntax element is derived by invoking the mapping process for coded block pattern as specified in subclause 9.1.2 with codeNum as the input.

– Otherwise (the syntax element is coded as te(v)), the range of possible values for the syntax element is determined first. The range of this syntax element may be between 0 and x, with x being greater than or equal to 1 and the range is used in the derivation of the value of the syntax element value as follows

  – If x is greater than 1, codeNum and the value of the syntax element is derived in the same way as for syntax elements coded as ue(v)

  – Otherwise (x is equal to 1), the parsing process for codeNum which is equal to the value of the syntax element is given by a process equivalent to:

```
b = read_bits( 1 )
codeNum = !b
```

9.1.1 Mapping process for signed Exp-Golomb codes

Input to this process is codeNum as specified in subclause 9.1.

Output of this process is a value of a syntax element coded as se(v).

The syntax element is assigned to the codeNum by ordering the syntax element by its absolute value in increasing order and representing the positive value for a given absolute value with the lower codeNum. Table 9-3 provides the assignment rule.

Table 9-3 – Assignment of syntax element to codeNum for signed Exp-Golomb coded syntax elements se(v)

codeNum	syntax element value
0	0
1	1
2	–1
3	2
4	–2
5	3
6	–3
k	$(-1)^{k+1}$ Ceil(k÷2)

9.1.2 Mapping process for coded block pattern

Input to this process is codeNum as specified in subclause 9.1.

Output of this process is a value of the syntax element coded_block_pattern coded as me(v).

Table 9-4 shows the assignment of coded_block_pattern to codeNum depending on whether the macroblock prediction mode is equal to Intra_4x4, Intra_8x8 or Inter.

Table 9-4 – Assignment of codeNum to values of coded_block_pattern for macroblock prediction modes

(a) chroma_format_idc is not equal to 0

codeNum	coded_block_pattern	
	Intra_4x4, Intra_8x8	Inter
0	47	0
1	31	16
2	15	1
3	0	2
4	23	4
5	27	8
6	29	32
7	30	3
8	7	5
9	11	10
10	13	12
11	14	15
12	39	47
13	43	7
14	45	11

codeNum	coded_block_pattern	
	Intra_4x4, Intra_8x8	Inter
15	46	13
16	16	14
17	3	6
18	5	9
19	10	31
20	12	35
21	19	37
22	21	42
23	26	44
24	28	33
25	35	34
26	37	36
27	42	40
28	44	39
29	1	43
30	2	45
31	4	46
32	8	17
33	17	18
34	18	20
35	20	24
36	24	19
37	6	21
38	9	26
39	22	28
40	25	23
41	32	27
42	33	29
43	34	30
44	36	22
45	40	25
46	38	38
47	41	41

(b) chroma_format_idc is equal to 0

codeNum	coded_block_pattern	
	Intra_4x4, Intra_8x8	Inter
0	15	0
1	0	1
2	7	2
3	11	4
4	13	8
5	14	3
6	3	5
7	5	10
8	10	12
9	12	15
10	1	7
11	2	11
12	4	13
13	8	14
14	6	6
15	9	9

9.2 CAVLC parsing process for transform coefficient levels

This process is invoked when parsing syntax elements with descriptor equal to ce(v) in subclause 7.3.5.3.1 and when entropy_coding_mode_flag is equal to 0.

Inputs to this process are bits from slice data, a maximum number of non-zero transform coefficient levels maxNumCoeff, the luma block index luma4x4BlkIdx or the chroma block index chroma4x4BlkIdx of the current block of transform coefficient levels.

Output of this process is the list coeffLevel containing transform coefficient levels of the luma block with block index luma4x4BlkIdx or the chroma block with block index chroma4x4BlkIdx.

The process is specified in the following ordered steps:

1. All transform coefficient levels, with indices from 0 to maxNumCoeff - 1, in the list coeffLevel are set equal to 0.
2. The total number of non-zero transform coefficient levels TotalCoeff(coeff_token) and the number of trailing one transform coefficient levels TrailingOnes(coeff_token) are derived by parsing coeff_token (see subclause 9.2.1) as follows.
   - If the number of non-zero transform coefficient levels TotalCoeff(coeff_token) is equal to 0, the list coeffLevel containing 0 values is returned and no further step is carried out.
   - Otherwise, the following steps are carried out.
     a. The non-zero transform coefficient levels are derived by parsing trailing_ones_sign_flag, level_prefix, and level_suffix (see subclause 9.2.2).
     b. The runs of zero transform coefficient levels before each non-zero transform coefficient level are derived by parsing total_zeros and run_before (see subclause 9.2.3).

c. The level and run information are combined into the list coeffLevel (see subclause 9.2.4).

9.2.1 Parsing process for total number of transform coefficient levels and trailing ones

Inputs to this process are bits from slice data, a maximum number of non-zero transform coefficient levels maxNumCoeff, the luma block index luma4x4BlkIdx or the chroma block index chroma4x4BlkIdx of the current block of transform.

Outputs of this process are TotalCoeff(coeff_token) and TrailingOnes(coeff_token).

The syntax element coeff_token is decoded using one of the six VLCs specified in the six right-most columns of Table 9-5. Each VLC specifies both TotalCoeff(coeff_token) and TrailingOnes(coeff_token) for a given codeword coeff_token. VLC selection is dependent upon a variable nC that is derived as follows.

– If the CAVLC parsing process is invoked for ChromaDCLevel, nC is derived as follows.
  – If chroma_format_idc is equal to 1, nC is set equal to -1,
  – Otherwise, if chroma_format_idc is equal to 2, nC is set equal to -2,
  – Otherwise (chroma_format_idc is equal to 3), nC is set equal to 0.
– Otherwise, the following applies.
  – When the CAVLC parsing process is invoked for Intra16x16DCLevel, luma4x4BlkIdx is set equal to 0.
  – The variables blkA and blkB are derived as follows.
    – If the CAVLC parsing process is invoked for Intra16x16DCLevel, Intra16x16ACLevel, or LumaLevel, the process specified in subclause 6.4.8.3 is invoked with luma4x4BlkIdx as the input, and the output is assigned to mbAddrA, mbAddrB, luma4x4BlkIdxA, and luma4x4BlkIdxB. The 4x4 luma block specified by mbAddrA\luma4x4BlkIdxA is assigned to blkA, and the 4x4 luma block specified by mbAddrB\luma4x4BlkIdxB is assigned to blkB.
    – Otherwise (the CAVLC parsing process is invoked for ChromaACLevel), the process specified in subclause 6.4.8.4 is invoked with chroma4x4BlkIdx as input, and the output is assigned to mbAddrA, mbAddrB, chroma4x4BlkIdxA, and chroma4x4BlkIdxB. The 4x4 chroma block specified by mbAddrA\iCbCr\chroma4x4BlkIdxA is assigned to blkA, and the 4x4 chroma block specified by mbAddrB\iCbCr\chroma4x4BlkIdxB is assigned to blkB.
  – Let nA and nB be the number of non-zero transform coefficient levels (given by TotalCoeff(coeff_token)) in the block of transform coefficient levels blkA located to the left of the current block and the block of transform coefficient levels blkB located above the current block, respectively.
  – With N replaced by A and B, in mbAddrN, blkN, and nN the following applies.
    – If any of the following conditions is true, nN is set equal to 0.
      – mbAddrN is not available
      – The current macroblock is coded using an Intra prediction mode, constrained_intra_pred_flag is equal to 1 and mbAddrN is coded using Inter prediction and slice data partitioning is in use (nal_unit_type is in the range of 2 to 4, inclusive).
      – The macroblock mbAddrN has mb_type equal to P_Skip or B_Skip
      – All AC residual transform coefficient levels of the neighbouring block blkN are equal to 0 due to the corresponding bit of CodedBlockPatternLuma or CodedBlockPatternChroma being equal to 0
    – Otherwise, if mbAddrN is an I_PCM macroblock, nN is set equal to 16.
    – Otherwise, nN is set equal to the value TotalCoeff(coeff_token) of the neighbouring block blkN.

      NOTE 1 – The values nA and nB that are derived using TotalCoeff(coeff_token) do not include the DC transform coefficient levels in Intra_16x16 macroblocks or DC transform coefficient levels in chroma blocks, because these transform coefficient levels are decoded separately. When the block above or to the left belongs to an Intra_16x16 macroblock, or is a chroma block, nA and nB is the number of decoded non-zero AC transform coefficient levels.

      NOTE 2 – When parsing for Intra16x16DCLevel, the values nA and nB are based on the number of non-zero transform coefficient levels in adjacent 4x4 blocks and not on the number of non-zero DC transform coefficient levels in adjacent 16x16 blocks.
  – Given the values of nA and nB, the variable nC is derived as follows.

– If both mbAddrA and mbAddrB are available, the variable nC is set equal to (nA + nB + 1) >> 1.

– Otherwise (mbAddrA is not available or mbAddrB is not available), the variable nC is set equal to nA + nB.

The value of TotalCoeff(coeff_token) resulting from decoding coeff_token shall be in the range of 0 to maxNumCoeff, inclusive.

Table 9-5 – coeff_token mapping to TotalCoeff(coeff_token) and TrailingOnes(coeff_token)

TrailingOnes (coeff_token)	TotalCoeff (coeff_token)	0 <= nC < 2	2 <= nC < 4	4 <= nC < 8	8 <= nC	nC = = -1	nC = = -2
0	0	1	11	1111	0000 11	01	1
0	1	0001 01	0010 11	0011 11	0000 00	0001 11	0001 111
1	1	01	10	1110	0000 01	1	01
0	2	0000 0111	0001 11	0010 11	0001 00	0001 00	0001 110
1	2	0001 00	0011 1	0111 1	0001 01	0001 10	0001 101
2	2	001	011	1101	0001 10	001	001
0	3	0000 0011 1	0000 111	0010 00	0010 00	0000 11	0000 0011 1
1	3	0000 0110	0010 10	0110 0	0010 01	0000 011	0001 100
2	3	0000 101	0010 01	0111 0	0010 10	0000 010	0001 011
3	3	0001 1	0101	1100	0010 11	0001 01	0000 1
0	4	0000 0001 11	0000 0111	0001 111	0011 00	0000 10	0000 0011 0
1	4	0000 0011 0	0001 10	0101 0	0011 01	0000 0011	0000 0010 1
2	4	0000 0101	0001 01	0101 1	0011 10	0000 0010	0001 010
3	4	0000 11	0100	1011	0011 11	0000 000	0000 01
0	5	0000 0000 111	0000 0100	0001 011	0100 00	-	0000 0001 11
1	5	0000 0001 10	0000 110	0100 0	0100 01	-	0000 0001 10
2	5	0000 0010 1	0000 101	0100 1	0100 10	-	0000 0010 0
3	5	0000 100	0011 0	1010	0100 11	-	0001 001
0	6	0000 0000 0111 1	0000 0011 1	0001 001	0101 00	-	0000 0000 111
1	6	0000 0000 110	0000 0110	0011 10	0101 01	-	0000 0000 110
2	6	0000 0001 01	0000 0101	0011 01	0101 10	-	0000 0001 01
3	6	0000 0100	0010 00	1001	0101 11	-	0001 000
0	7	0000 0000 0101 1	0000 0001 111	0001 000	0110 00	-	0000 0000 0111
1	7	0000 0000 0111 0	0000 0011 0	0010 10	0110 01	-	0000 0000 0110
2	7	0000 0000 101	0000 0010 1	0010 01	0110 10	-	0000 0000 101
3	7	0000 0010 0	0001 00	1000	0110 11	-	0000 0001 00
0	8	0000 0000 0100 0	0000 0001 011	0000 1111	0111 00	-	0000 0000 0011 1
1	8	0000 0000 0101 0	0000 0001 110	0001 110	0111 01	-	0000 0000 0101
2	8	0000 0000 0110 1	0000 0001 101	0001 101	0111 10	-	0000 0000 0100
3	8	0000 0001 00	0000 100	0110 1	0111 11	-	0000 0000 100
0	9	0000 0000 0011 11	0000 0000 1111	0000 1011	1000 00	-	

TrailingOnes (coeff_token)	TotalCoeff (coeff_token)	0 <= nC < 2	2 <= nC < 4	4 <= nC < 8	8 <= nC	nC = = -1	nC = = -2
1	9	0000 0000 0011 10	0000 0001 010	0000 1110	1000 01	-	
2	9	0000 0000 0100 1	0000 0001 001	0001 010	1000 10	-	
3	9	0000 0000 100	0000 0010 0	0011 00	1000 11	-	
0	10	0000 0000 0010 11	0000 0000 1011	0000 0111 1	1001 00	-	
1	10	0000 0000 0010 10	0000 0000 1110	0000 1010	1001 01	-	
2	10	0000 0000 0011 01	0000 0000 1101	0000 1101	1001 10	-	
3	10	0000 0000 0110 0	0000 0001 100	0001 100	1001 11	-	
0	11	0000 0000 0001 111	0000 0000 1000	0000 0101 1	1010 00	-	
1	11	0000 0000 0001 110	0000 0000 1010	0000 0111 0	1010 01	-	
2	11	0000 0000 0010 01	0000 0000 1001	0000 1001	1010 10	-	
3	11	0000 0000 0011 00	0000 0001 000	0000 1100	1010 11	-	
0	12	0000 0000 0001 011	0000 0000 0111 1	0000 0100 0	1011 00	-	
1	12	0000 0000 0001 010	0000 0000 0111 0	0000 0101 0	1011 01	-	
2	12	0000 0000 0001 101	0000 0000 0110 1	0000 0110 1	1011 10	-	
3	12	0000 0000 0010 00	0000 0000 1100	0000 1000	1011 11	-	
0	13	0000 0000 0000 1111	0000 0000 0101 1	0000 0011 01	1100 00	-	
1	13	0000 0000 0000 001	0000 0000 0101 0	0000 0011 1	1100 01	-	
2	13	0000 0000 0001 001	0000 0000 0100 1	0000 0100 1	1100 10	-	
3	13	0000 0000 0001 100	0000 0000 0110 0	0000 0110 0	1100 11	-	
0	14	0000 0000 0000 1011	0000 0000 0011 1	0000 0010 01	1101 00	-	
1	14	0000 0000 0000 1110	0000 0000 0010 11	0000 0011 00	1101 01	-	
2	14	0000 0000 0000 1101	0000 0000 0011 0	0000 0010 11	1101 10	-	
3	14	0000 0000 0001 000	0000 0000 0100 0	0000 0010 10	1101 11	-	
0	15	0000 0000 0000 0111	0000 0000 0010 01	0000 0001 01	1110 00	-	
1	15	0000 0000 0000 1010	0000 0000 0010 00	0000 0010 00	1110 01	-	
2	15	0000 0000 0000 1001	0000 0000 0010 10	0000 0001 11	1110 10	-	
3	15	0000 0000 0000 1100	0000 0000 0000 1	0000 0001 10	1110 11	-	
0	16	0000 0000 0000 0100	0000 0000 0001 11	0000 0000 01	1111 00	-	
1	16	0000 0000 0000 0110	0000 0000 0001 10	0000 0001 00	1111 01	-	
2	16	0000 0000 0000 0101	0000 0000 0001 01	0000 0000 11	1111 10	-	
3	16	0000 0000 0000 1000	0000 0000 0001 00	0000 0000 10	1111 11	-	

9.2.2 Parsing process for level information

Inputs to this process are bits from slice data, the number of non-zero transform coefficient levels TotalCoeff(coeff_token), and the number of trailing one transform coefficient levels TrailingOnes(coeff_token).

Output of this process is a list with name level containing transform coefficient levels.

Initially an index i is set equal to 0. Then the following procedure is iteratively applied TrailingOnes(coeff_token) times to decode the trailing one transform coefficient levels (if any):

– A 1-bit syntax element trailing_ones_sign_flag is decoded and evaluated as follows.
  – If trailing_ones_sign_flag is equal to 0, the value +1 is assigned to level[i].
  – Otherwise (trailing_ones_sign_flag is equal to 1), the value -1 is assigned to level[i].
– The index i is incremented by 1.

Following the decoding of the trailing one transform coefficient levels, a variable suffixLength is initialised as follows.

– If TotalCoeff(coeff_token) is greater than 10 and TrailingOnes(coeff_token) is less than 3, suffixLength is set equal to 1.
– Otherwise (TotalCoeff(coeff_token) is less than or equal to 10 or TrailingOnes(coeff_token) is equal to 3), suffixLength is set equal to 0.

The following procedure is then applied iteratively (TotalCoeff(coeff_token) – TrailingOnes(coeff_token)) times to decode the remaining levels (if any):

– The syntax element level_prefix is decoded as specified in subclause 9.2.2.1.
– The variable levelSuffixSize is set equal to the variable suffixLength with the exception of the following two cases.
– When level_prefix is equal to 14 and suffixLength is equal to 0, levelSuffixSize is set equal to 4.
– When level_prefix is greater than or equal to 15, levelSuffixSize is set equal to level_prefix - 3.
– The syntax element level_suffix is decoded as follows.
  – If levelSuffixSize is greater than 0, the syntax element level_suffix is decoded as unsigned integer representation u(v) with levelSuffixSize bits.
  – Otherwise (levelSuffixSize is equal to 0), the syntax element level_suffix is inferred to be equal to 0.
– A variable levelCode is set equal to (Min(15, level_prefix) << suffixLength) + level_suffix.
– When level_prefix is greater than or equal to 15 and suffixLength is equal to 0, levelCode is incremented by 15.
– When level_prefix is greater than or equal to 16, levelCode is incremented by (1<<(level_prefix – 3)) – 4096.
– When the index i is equal to TrailingOnes(coeff_token) and TrailingOnes(coeff_token) is less than 3, levelCode is incremented by 2.
– The variable level[i] is derived as follows.
  – If levelCode is an even number, the value (levelCode + 2) >> 1 is assigned to level[i].
  – Otherwise (levelCode is an odd number), the value (-levelCode – 1) >> 1 is assigned to level[i].
– When suffixLength is equal to 0, suffixLength is set equal to 1.
– When the absolute value of level[i] is greater than (3 << (suffixLength – 1)) and suffixLength is less than 6, suffixLength is incremented by 1.
– The index i is incremented by 1.

9.2.2.1 Parsing process for level_prefix

Inputs to this process are bits from slice data.

Output of this process is level_prefix.

The parsing process for this syntax element consists in reading the bits starting at the current location in the bitstream up to and including the first non-zero bit, and counting the number of leading bits that are equal to 0. This process is specified as follows:

```
leadingZeroBits = -1
for( b = 0; !b; leadingZeroBits++ )
    b = read_bits( 1 )
level_prefix = leadingZeroBits
```

Table 9-6 illustrates the codeword table for level_prefix.

Table 9-6 – Codeword table for level_prefix (informative)

level_prefix	bit string
0	1
1	01
2	001
3	0001
4	0000 1
5	0000 01
6	0000 001
7	0000 0001
8	0000 0000 1
9	0000 0000 01
10	0000 0000 001
11	0000 0000 0001
12	0000 0000 0000 1
13	0000 0000 0000 01
14	0000 0000 0000 001
15	0000 0000 0000 0001
…	…

9.2.3 Parsing process for run information

Inputs to this process are bits from slice data, the number of non-zero transform coefficient levels TotalCoeff(coeff_token), and the maximum number of non-zero transform coefficient levels maxNumCoeff.

Output of this process is a list of runs of zero transform coefficient levels preceding non-zero transform coefficient levels called run.

Initially, an index i is set equal to 0.

The variable zerosLeft is derived as follows.

– If the number of non-zero transform coefficient levels TotalCoeff(coeff_token) is equal to the maximum number of non-zero transform coefficient levels maxNumCoeff, a variable zerosLeft is set equal to 0.

– Otherwise (the number of non-zero transform coefficient levels TotalCoeff(coeff_token) is less than the maximum number of non-zero transform coefficient levels maxNumCoeff), total_zeros is decoded and zerosLeft is set equal to its value.

The VLC used to decode total_zeros is derived as follows:

If maxNumCoeff is equal to 4, one of the VLCs specified in Table 9-9 (a) is used.

– Otherwise, if maxNumCoeff is equal to 8, one of the VLCs specified in Table 9-9 (b) is used.

– Otherwise (maxNumCoeff is not equal to 4 and not equal to 8), VLCs from Tables 9-7 and 9-8 are used.

The following procedure is then applied iteratively (TotalCoeff(coeff_token) – 1) times:

– The variable run[i] is derived as follows.
  – If zerosLeft is greater than zero, a value run_before is decoded based on Table 9-10 and zerosLeft. run[i] is set equal to run_before.
  – Otherwise (zerosLeft is equal to 0), run[i] is set equal to 0.
– The value of run[i] is subtracted from zerosLeft and the result assigned to zerosLeft. The result of the subtraction shall be greater than or equal to 0.
– The index i is incremented by 1.

Finally the value of zerosLeft is assigned to run[i].

Table 9-7 – total_zeros tables for 4x4 blocks with TotalCoeff(coeff_token) 1 to 7

total_zeros	TotalCoeff(coeff_token)						
	1	2	3	4	5	6	7
0	1	111	0101	0001 1	0101	0000 01	0000 01
1	011	110	111	111	0100	0000 1	0000 1
2	010	101	110	0101	0011	111	101
3	0011	100	101	0100	111	110	100
4	0010	011	0100	110	110	101	011
5	0001 1	0101	0011	101	101	100	11
6	0001 0	0100	100	100	100	011	010
7	0000 11	0011	011	0011	011	010	0001
8	0000 10	0010	0010	011	0010	0001	001
9	0000 011	0001 1	0001 1	0010	0000 1	001	0000 00
10	0000 010	0001 0	0001 0	0001 0	0001	0000 00	
11	0000 0011	0000 11	0000 01	0000 1	0000 0		
12	0000 0010	0000 10	0000 1	0000 0			
13	0000 0001 1	0000 01	0000 00				
14	0000 0001 0	0000 00					
15	0000 0000 1						

Table 9-8 – total_zeros tables for 4x4 blocks with TotalCoeff(coeff_token) 8 to 15

total_zeros	TotalCoeff(coeff_token)							
	8	9	10	11	12	13	14	15
0	0000 01	0000 01	0000 1	0000	0000	000	00	0
1	0001	0000 00	0000 0	0001	0001	001	01	1
2	0000 1	0001	001	001	01	1	1	
3	011	11	11	010	1	01		
4	11	10	10	1	001			
5	10	001	01	011				
6	010	01	0001					
7	001	0000 1						
8	0000 00							

Table 9-9 – total_zeros tables for chroma DC 2x2 and 2x4 blocks

(a) Chroma DC 2x2 block (4:2:0 chroma sampling)

total_zeros	TotalCoeff(coeff_token)		
	1	2	3
0	1	1	1
1	01	01	0
2	001	00	
3	000		

(b) Chroma DC 2x4 block (4:2:2 chroma sampling)

total_zeros	TotalCoeff(coeff_token)						
	1	2	3	4	5	6	7
0	1	000	000	110	00	00	0
1	010	01	001	00	01	01	1
2	011	001	01	01	10	1	
3	0010	100	10	10	11		
4	0011	101	110	111			
5	0001	110	111				
6	0000 1	111					
7	0000 0						

Table 9-10 – Tables for run_before

run_before	zerosLeft						
	1	2	3	4	5	6	>6
0	1	1	11	11	11	11	111
1	0	01	10	10	10	000	110
2	-	00	01	01	011	001	101
3	-	-	00	001	010	011	100
4	-	-	-	000	001	010	011
5	-	-	-	-	000	101	010
6	-	-	-	-	-	100	001
7	-	-	-	-	-	-	0001
8		-	-	-	-	-	00001
9	-	-	-	-	-	-	000001
10	-	-	-	-	-	-	0000001
11	-	-	-	-	-	-	00000001
12	-	-	-	-	-	-	000000001
13	-	-	-	-	-	-	0000000001
14	-	-	-	-	-	-	00000000001

9.2.4 Combining level and run information

Input to this process are a list of transform coefficient levels called level, a list of runs called run, and the number of non-zero transform coefficient levels TotalCoeff(coeff_token).

Output of this process is an list coeffLevel of transform coefficient levels.

A variable coeffNum is set equal to -1 and an index i is set equal to (TotalCoeff(coeff_token) – 1). The following procedure is iteratively applied TotalCoeff(coeff_token) times:

– coeffNum is incremented by run[i] + 1.

– coeffLevel[coeffNum] is set equal to level[i].

– The index i is decremented by 1.

9.3 CABAC parsing process for slice data

This process is invoked when parsing syntax elements with descriptor ae(v) in subclauses 7.3.4 and 7.3.5 when entropy_coding_mode_flag is equal to 1.

Inputs to this process are a request for a value of a syntax element and values of prior parsed syntax elements.

Output of this process is the value of the syntax element.

When starting the parsing of the slice data of a slice in subclause 7.3.4, the initialisation process of the CABAC parsing process is invoked as specified in subclause 9.3.1.

The parsing of syntax elements proceeds as follows:

For each requested value of a syntax element a binarization is derived as described in subclause 9.3.2.

The binarization for the syntax element and the sequence of parsed bins determines the decoding process flow as described in subclause 9.3.3.

For each bin of the binarization of the syntax element, which is indexed by the variable binIdx, a context index ctxIdx is derived as specified in subclause 9.3.3.1.

For each ctxIdx the arithmetic decoding process is invoked as specified in subclause 9.3.3.2.

The resulting sequence (b_0 .. b_{binIdx}) of parsed bins is compared to the set of bin strings given by the binarization process after decoding of each bin. When the sequence matches a bin string in the given set, the corresponding value is assigned to the syntax element.

In case the request for a value of a syntax element is processed for the syntax element mb_type and the decoded value of mb_type is equal to I_PCM, the decoding engine is initialised after the decoding of any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data as specified in subclause 9.3.1.2.

The whole CABAC parsing process is illustrated in the flowchart of Figure 9-1 with the abbreviation SE for syntax element.

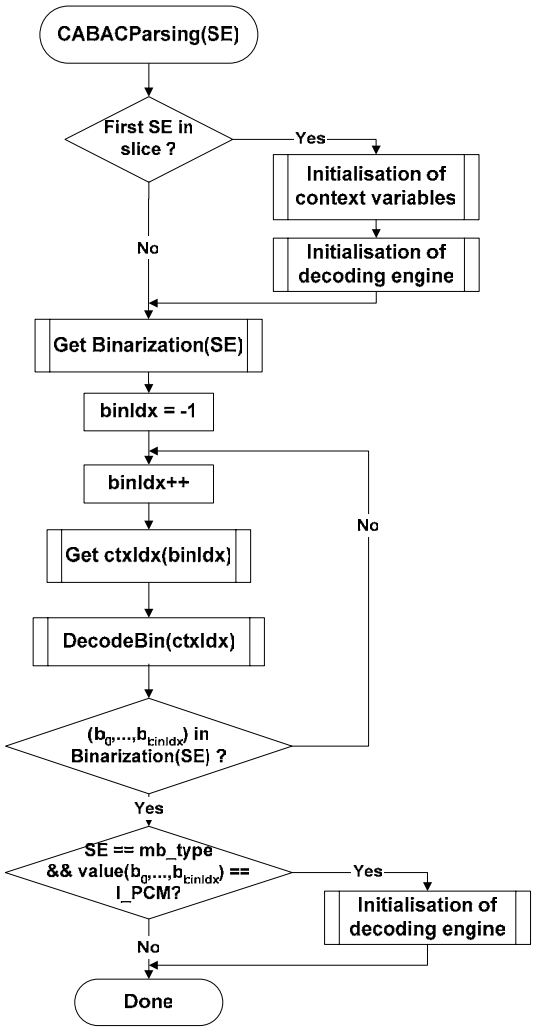


Figure 9-1 – Illustration of CABAC parsing process for a syntax element SE (informative)

9.3.1 Initialisation process

Outputs of this process are initialised CABAC internal variables.

The processes in subclauses 9.3.1.1 and 9.3.1.2 are invoked when starting the parsing of the slice data of a slice in subclause 7.3.4.

The process in subclause 9.3.1.2 is also invoked after decoding any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data for a macroblock of type I_PCM.

9.3.1.1 Initialisation process for context variables

Outputs of this process are the initialised CABAC context variables indexed by ctxIdx.

Table 9-12 to Table 9-23 contain the values of the variables n and m used in the initialisation of context variables that are assigned to all syntax elements in subclauses 7.3.4 and 7.3.5 except for the end-of-slice flag.

For each context variable, the two variables pStateIdx and valMPS are initialised.

NOTE 1 – The variable pStateIdx corresponds to a probability state index and the variable valMPS corresponds to the value of the most probable symbol as further described in subclause 9.3.3.2.

The two values assigned to pStateIdx and valMPS for the initialisation are derived from $SliceQP_Y$, which is derived in Equation 7-27. Given the two table entries (m, n),

1. preCtxState = Clip3(1, 126, ((m * Clip3(0, 51, $SliceQP_Y$)) >> 4) + n)
2. if(preCtxState <= 63) {

   pStateIdx = 63 - preCtxState

   valMPS = 0

   } else {

   pStateIdx = preCtxState - 64

   valMPS = 1

   }

In Table 9-11, the ctxIdx for which initialisation is needed for each of the slice types are listed. Also listed is the table number that includes the values of m and n needed for the initialisation. For P, SP and B slice type, the initialisation depends also on the value of the cabac_init_idc syntax element. Note that the syntax element names do not affect the initialisation process.

Table 9-11 – Association of ctxIdx and syntax elements for each slice type in the initialisation process

	Syntax element	Table	Slice type			
			SI	I	P, SP	B
slice_data( )	mb_skip_flag	Table 9-13 Table 9-14			11-13	24-26
	mb_field_decoding_flag	Table 9-18	70-72	70-72	70-72	70-72
macroblock_layer( )	mb_type	Table 9-12 Table 9-13 Table 9-14	0-10	3-10	14-20	27-35
	transform_size_8x8_flag	Table 9-16	na	399-401	399-401	399-401
	coded_block_pattern (luma)	Table 9-18	73-76	73-76	73-76	73-76
	coded_block_pattern (chroma)	Table 9-18	77-84	77-84	77-84	77-84
	mb_qp_delta	Table 9-17	60-63	60-63	60-63	60-63
mb_pred( )	prev_intra4x4_pred_mode_flag	Table 9-17	68	68	68	68
	rem_intra4x4_pred_mode	Table 9-17	69	69	69	69
	prev_intra8x8_pred_mode_flag	Table 9-17	na	68	68	68
	rem_intra8x8_pred_mode	Table 9-17	na	69	69	69
	intra_chroma_pred_mode	Table 9-17	64-67	64-67	64-67	64-67

Table 9-11 – Association of ctxIdx and syntax elements for each slice type in the initialisation process

	Syntax element	Table	Slice type			
			SI	I	P, SP	B
mb_pred( ) and sub_mb_pred( )	ref_idx_l0	Table 9-16			54-59	54-59
	ref_idx_l1	Table 9-16				54-59
	mvd_l0[ ][ ][0]	Table 9-15			40-46	40-46
	mvd_l1[ ][ ][0]	Table 9-15				40-46
	mvd_l0[ ][ ][1]	Table 9-15			47-53	47-53
	mvd_l1[ ][ ][1]	Table 9-15				47-53
sub_mb_pred( )	sub_mb_type	Table 9-13 Table 9-14			21-23	36-39
residual_block_cabac( )	coded_block_flag	Table 9-18	85-104	85-104	85-104	85-104
	significant_coeff_flag[ ]	Table 9-19 Table 9-22 Table 9-24 Table 9-24	105-165 277-337	105-165 277-337 402-416 436-450	105-165 277-337 402-416 436-450	105-165 277-337 402-416 436-450
	last_significant_coeff_flag[ ]	Table 9-20 Table 9-23 Table 9-24 Table 9-24	166-226 338-398	166-226 338-398 417-425 451-459	166-226 338-398 417-425 451-459	166-226 338-398 417-425 451-459
	coeff_abs_level_minus1[ ]	Table 9-21 Table 9-24	227-275	227-275 426-435	227-275 426-435	227-275 426-435

NOTE 2 – ctxIdx equal to 276 is associated with the end_of_slice_flag and the bin of mb_type, which specifies the I_PCM macroblock type. The decoding process specified in subclause 9.3.3.2.4 applies to ctxIdx equal to 276. This decoding process, however, may also be implemented by using the decoding process specified in subclause 9.3.3.2.1. In this case, the initial values associated with ctxIdx equal to 276 are specified to be pStateIdx = 63 and valMPS = 0, where pStateIdx = 63 represents a non-adapting probability state.

Table 9-12 – Values of variables m and n for ctxIdx from 0 to 10

Initialisation variables	ctxIdx										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
m	20	2	3	20	2	3	-28	-23	-6	-1	7
n	-15	54	74	-15	54	74	127	104	53	54	51

Table 9-13 – Values of variables m and n for ctxIdx from 11 to 23

Value of cabac_init_idc	Initialisation variables	ctxIdx												
		11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
0	**m**	23	23	21	1	0	-37	5	-13	-11	1	12	-4	17
	n	33	2	0	9	49	118	57	78	65	62	49	73	50
1	**m**	22	34	16	-2	4	-29	2	-6	-13	5	9	-3	10
	n	25	0	0	9	41	118	65	71	79	52	50	70	54
2	**m**	29	25	14	-10	-3	-27	26	-4	-24	5	6	-17	14
	n	16	0	0	51	62	99	16	85	102	57	57	73	57

Table 9-14 – Values of variables m and n for ctxIdx from 24 to 39

Value of cabac_init_idc	Initialisation variables	ctxIdx															
		24	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
0	**m**	18	9	29	26	16	9	-46	-20	1	-13	-11	1	-6	-17	-6	9
	n	64	43	0	67	90	104	127	104	67	78	65	62	86	95	61	45
1	**m**	26	19	40	57	41	26	-45	-15	-4	-6	-13	5	6	-13	0	8
	n	34	22	0	2	36	69	127	101	76	71	79	52	69	90	52	43
2	**m**	20	20	29	54	37	12	-32	-22	-2	-4	-24	5	-6	-14	-6	4
	n	40	10	0	0	42	97	127	117	74	85	102	57	93	88	44	55

Table 9-15 – Values of variables m and n for ctxIdx from 40 to 53

Value of cabac_init_idc	Initialisation variables	ctxIdx													
		40	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**
0	**m**	-3	-6	-11	6	7	-5	2	0	-3	-10	5	4	-3	0
	n	69	81	96	55	67	86	88	58	76	94	54	69	81	88
1	**m**	-2	-5	-10	2	2	-3	-3	1	-3	-6	0	-3	-7	-5
	n	69	82	96	59	75	87	100	56	74	85	59	81	86	95
2	**m**	-11	-15	-21	19	20	4	6	1	-5	-13	5	6	-3	-1
	n	89	103	116	57	58	84	96	63	85	106	63	75	90	101

Table 9-16 – Values of variables m and n for ctxIdx from 54 to 59, and 399 to 401

Value of cabac_init_idc	Initialisation variables	ctxIdx								
		54	**55**	**56**	**57**	**58**	**59**	**399**	**400**	**401**
I slices	**m**	na	na	na	na	na	na	31	31	25
	n	na	na	na	na	na	na	21	31	50
0	**m**	-7	-5	-4	-5	-7	1	12	11	14
	n	67	74	74	80	72	58	40	51	59
1	**m**	-1	-1	1	-2	-5	0	25	21	21
	n	66	77	70	86	72	61	32	49	54
2	**m**	3	-4	-2	-12	-7	1	21	19	17
	n	55	79	75	97	50	60	33	50	61

Table 9-17 – Values of variables m and n for ctxIdx from 60 to 69

Initialisation variables	ctxIdx									
	60	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**
m	0	0	0	0	-9	4	0	-7	13	3
n	41	63	63	63	83	86	97	72	41	62

Table 9-18 – Values of variables m and n for ctxIdx from 70 to 104

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
70	0	11	0	45	13	15	7	34	**88**	-11	115	-13	108	-4	92	5	78
71	1	55	-4	78	7	51	-9	88	**89**	-12	63	-3	46	0	39	-6	55
72	0	69	-3	96	2	80	-20	127	**90**	-2	68	-1	65	0	65	4	61
73	-17	127	-27	126	-39	127	-36	127	**91**	-15	84	-1	57	-15	84	-14	83
74	-13	102	-28	98	-18	91	-17	91	**92**	-13	104	-9	93	-35	127	-37	127
75	0	82	-25	101	-17	96	-14	95	**93**	-3	70	-3	74	-2	73	-5	79
76	-7	74	-23	67	-26	81	-25	84	**94**	-8	93	-9	92	-12	104	-11	104
77	-21	107	-28	82	-35	98	-25	86	**95**	-10	90	-8	87	-9	91	-11	91
78	-27	127	-20	94	-24	102	-12	89	**96**	-30	127	-23	126	-31	127	-30	127
79	-31	127	-16	83	-23	97	-17	91	**97**	-1	74	5	54	3	55	0	65
80	-24	127	-22	110	-27	119	-31	127	**98**	-6	97	6	60	7	56	-2	79
81	-18	95	-21	91	-24	99	-14	76	**99**	-7	91	6	59	7	55	0	72
82	-27	127	-18	102	-21	110	-18	103	**100**	-20	127	6	69	8	61	-4	92
83	-21	114	-13	93	-18	102	-13	90	**101**	-4	56	-1	48	-3	53	-6	56
84	-30	127	-29	127	-36	127	-37	127	**102**	-5	82	0	68	0	68	3	68
85	-17	123	-7	92	0	80	11	80	**103**	-7	76	-4	69	-7	74	-8	71
86	-12	115	-5	89	-5	89	5	76	**104**	-22	125	-8	88	-9	88	-13	98
87	-16	122	-7	96	-7	94	2	84									

Table 9-19 – Values of variables m and n for ctxIdx from 105 to 165

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
105	-7	93	-2	85	-13	103	-4	86	**136**	-13	101	5	53	0	58	-5	75
106	-11	87	-6	78	-13	91	-12	88	**137**	-13	91	-2	61	-1	60	-8	80
107	-3	77	-1	75	-9	89	-5	82	**138**	-12	94	0	56	-3	61	-21	83
108	-5	71	-7	77	-14	92	-3	72	**139**	-10	88	0	56	-8	67	-21	64
109	-4	63	2	54	-8	76	-4	67	**140**	-16	84	-13	63	-25	84	-13	31
110	-4	68	5	50	-12	87	-8	72	**141**	-10	86	-5	60	-14	74	-25	64
111	-12	84	-3	68	-23	110	-16	89	**142**	-7	83	-1	62	-5	65	-29	94
112	-7	62	1	50	-24	105	-9	69	**143**	-13	87	4	57	5	52	9	75
113	-7	65	6	42	-10	78	-1	59	**144**	-19	94	-6	69	2	57	17	63
114	8	61	-4	81	-20	112	5	66	**145**	1	70	4	57	0	61	-8	74
115	5	56	1	63	-17	99	4	57	**146**	0	72	14	39	-9	69	-5	35
116	-2	66	-4	70	-78	127	-4	71	**147**	-5	74	4	51	-11	70	-2	27
117	1	64	0	67	-70	127	-2	71	**148**	18	59	13	68	18	55	13	91
118	0	61	2	57	-50	127	2	58	**149**	-8	102	3	64	-4	71	3	65
119	-2	78	-2	76	-46	127	-1	74	**150**	-15	100	1	61	0	58	-7	69
120	1	50	11	35	-4	66	-4	44	**151**	0	95	9	63	7	61	8	77
121	7	52	4	64	-5	78	-1	69	**152**	-4	75	7	50	9	41	-10	66
122	10	35	1	61	-4	71	0	62	**153**	2	72	16	39	18	25	3	62
123	0	44	11	35	-8	72	-7	51	**154**	-11	75	5	44	9	32	-3	68
124	11	38	18	25	2	59	-4	47	**155**	-3	71	4	52	5	43	-20	81
125	1	45	12	24	-1	55	-6	42	**156**	15	46	11	48	9	47	0	30
126	0	46	13	29	-7	70	-3	41	**157**	-13	69	-5	60	0	44	1	7
127	5	44	13	36	-6	75	-6	53	**158**	0	62	-1	59	0	51	-3	23
128	31	17	-10	93	-8	89	8	76	**159**	0	65	0	59	2	46	-21	74
129	1	51	-7	73	-34	119	-9	78	**160**	21	37	22	33	19	38	16	66
130	7	50	-2	73	-3	75	-11	83	**161**	-15	72	5	44	-4	66	-23	124
131	28	19	13	46	32	20	9	52	**162**	9	57	14	43	15	38	17	37
132	16	33	9	49	30	22	0	67	**163**	16	54	-1	78	12	42	44	-18
133	14	62	-7	100	-44	127	-5	90	**164**	0	62	0	60	9	34	50	-34
134	-13	108	9	53	0	54	1	67	**165**	12	72	9	69	0	89	-22	127
135	-15	100	2	53	-5	61	-15	72									

Table 9-20 – Values of variables m and n for ctxIdx from 166 to 226

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
166	24	0	11	28	4	45	4	39	**197**	26	-17	28	3	36	-28	28	-3
167	15	9	2	40	10	28	0	42	**198**	30	-25	28	4	38	-28	24	10
168	8	25	3	44	10	31	7	34	**199**	28	-20	32	0	38	-27	27	0
169	13	18	0	49	33	-11	11	29	**200**	33	-23	34	-1	34	-18	34	-14
170	15	9	0	46	52	-43	8	31	**201**	37	-27	30	6	35	-16	52	-44
171	13	19	2	44	18	15	6	37	**202**	33	-23	30	6	34	-14	39	-24
172	10	37	2	51	28	0	7	42	**203**	40	-28	32	9	32	-8	19	17
173	12	18	0	47	35	-22	3	40	**204**	38	-17	31	19	37	-6	31	25
174	6	29	4	39	38	-25	8	33	**205**	33	-11	26	27	35	0	36	29
175	20	33	2	62	34	0	13	43	**206**	40	-15	26	30	30	10	24	33
176	15	30	6	46	39	-18	13	36	**207**	41	-6	37	20	28	18	34	15
177	4	45	0	54	32	-12	4	47	**208**	38	1	28	34	26	25	30	20
178	1	58	3	54	102	-94	3	55	**209**	41	17	17	70	29	41	22	73
179	0	62	2	58	0	0	2	58	**210**	30	-6	1	67	0	75	20	34
180	7	61	4	63	56	-15	6	60	**211**	27	3	5	59	2	72	19	31
181	12	38	6	51	33	-4	8	44	**212**	26	22	9	67	8	77	27	44
182	11	45	6	57	29	10	11	44	**213**	37	-16	16	30	14	35	19	16
183	15	39	7	53	37	-5	14	42	**214**	35	-4	18	32	18	31	15	36
184	11	42	6	52	51	-29	7	48	**215**	38	-8	18	35	17	35	15	36
185	13	44	6	55	39	-9	4	56	**216**	38	-3	22	29	21	30	21	28
186	16	45	11	45	52	-34	4	52	**217**	37	3	24	31	17	45	25	21
187	12	41	14	36	69	-58	13	37	**218**	38	5	23	38	20	42	30	20
188	10	49	8	53	67	-63	9	49	**219**	42	0	18	43	18	45	31	12
189	30	34	-1	82	44	-5	19	58	**220**	35	16	20	41	27	26	27	16
190	18	42	7	55	32	7	10	48	**221**	39	22	11	63	16	54	24	42
191	10	55	-3	78	55	-29	12	45	**222**	14	48	9	59	7	66	0	93
192	17	51	15	46	32	1	0	69	**223**	27	37	9	64	16	56	14	56
193	17	46	22	31	0	0	20	33	**224**	21	60	-1	94	11	73	15	57
194	0	89	-1	84	27	36	8	63	**225**	12	68	-2	89	10	67	26	38
195	26	-19	25	7	33	-25	35	-18	**226**	2	97	-9	108	-10	116	-24	127
196	22	-17	30	-7	34	-30	33	-25									

Table 9-21 – Values of variables m and n for ctxIdx from 227 to 275

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
227	-3	71	-6	76	-23	112	-24	115	**252**	-12	73	-6	55	-16	72	-14	75
228	-6	42	-2	44	-15	71	-22	82	**253**	-8	76	0	58	-7	69	-10	79
229	-5	50	0	45	-7	61	-9	62	**254**	-7	80	0	64	-4	69	-9	83
230	-3	54	0	52	0	53	0	53	**255**	-9	88	-3	74	-5	74	-12	92
231	-2	62	-3	64	-5	66	0	59	**256**	-17	110	-10	90	-9	86	-18	108
232	0	58	-2	59	-11	77	-14	85	**257**	-11	97	0	70	2	66	-4	79
233	1	63	-4	70	-9	80	-13	89	**258**	-20	84	-4	29	-9	34	-22	69
234	-2	72	-4	75	-9	84	-13	94	**259**	-11	79	5	31	1	32	-16	75
235	-1	74	-8	82	-10	87	-11	92	**260**	-6	73	7	42	11	31	-2	58
236	-9	91	-17	102	-34	127	-29	127	**261**	-4	74	1	59	5	52	1	58
237	-5	67	-9	77	-21	101	-21	100	**262**	-13	86	-2	58	-2	55	-13	78
238	-5	27	3	24	-3	39	-14	57	**263**	-13	96	-3	72	-2	67	-9	83
239	-3	39	0	42	-5	53	-12	67	**264**	-11	97	-3	81	0	73	-4	81
240	-2	44	0	48	-7	61	-11	71	**265**	-19	117	-11	97	-8	89	-13	99
241	0	46	0	55	-11	75	-10	77	**266**	-8	78	0	58	3	52	-13	81
242	-16	64	-6	59	-15	77	-21	85	**267**	-5	33	8	5	7	4	-6	38
243	-8	68	-7	71	-17	91	-16	88	**268**	-4	48	10	14	10	8	-13	62
244	-10	78	-12	83	-25	107	-23	104	**269**	-2	53	14	18	17	8	-6	58
245	-6	77	-11	87	-25	111	-15	98	**270**	-3	62	13	27	16	19	-2	59
246	-10	86	-30	119	-28	122	-37	127	**271**	-13	71	2	40	3	37	-16	73
247	-12	92	1	58	-11	76	-10	82	**272**	-10	79	0	58	-1	61	-10	76
248	-15	55	-3	29	-10	44	-8	48	**273**	-12	86	-3	70	-5	73	-13	86
249	-10	60	-1	36	-10	52	-8	61	**274**	-13	90	-6	79	-1	70	-9	83
250	-6	62	1	38	-10	57	-8	66	**275**	-14	97	-8	85	-4	78	-10	87
251	-4	65	2	43	-9	58	-7	70									

Table 9-22 – Values of variables m and n for ctxIdx from 277 to 337

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
277	-6	93	-13	106	-21	126	-22	127	**308**	-16	96	-1	51	-16	77	-10	67
278	-6	84	-16	106	-23	124	-25	127	**309**	-7	88	7	49	-2	64	1	68
279	-8	79	-10	87	-20	110	-25	120	**310**	-8	85	8	52	2	61	0	77
280	0	66	-21	114	-26	126	-27	127	**311**	-7	85	9	41	-6	67	2	64
281	-1	71	-18	110	-25	124	-19	114	**312**	-9	85	6	47	-3	64	0	68
282	0	62	-14	98	-17	105	-23	117	**313**	-13	88	2	55	2	57	-5	78
283	-2	60	-22	110	-27	121	-25	118	**314**	4	66	13	41	-3	65	7	55
284	-2	59	-21	106	-27	117	-26	117	**315**	-3	77	10	44	-3	66	5	59
285	-5	75	-18	103	-17	102	-24	113	**316**	-3	76	6	50	0	62	2	65
286	-3	62	-21	107	-26	117	-28	118	**317**	-6	76	5	53	9	51	14	54
287	-4	58	-23	108	-27	116	-31	120	**318**	10	58	13	49	-1	66	15	44
288	-9	66	-26	112	-33	122	-37	124	**319**	-1	76	4	63	-2	71	5	60
289	-1	79	-10	96	-10	95	-10	94	**320**	-1	83	6	64	-2	75	2	70
290	0	71	-12	95	-14	100	-15	102	**321**	-7	99	-2	69	-1	70	-2	76
291	3	68	-5	91	-8	95	-10	99	**322**	-14	95	-2	59	-9	72	-18	86
292	10	44	-9	93	-17	111	-13	106	**323**	2	95	6	70	14	60	12	70
293	-7	62	-22	94	-28	114	-50	127	**324**	0	76	10	44	16	37	5	64
294	15	36	-5	86	-6	89	-5	92	**325**	-5	74	9	31	0	47	-12	70
295	14	40	9	67	-2	80	17	57	**326**	0	70	12	43	18	35	11	55
296	16	27	-4	80	-4	82	-5	86	**327**	-11	75	3	53	11	37	5	56
297	12	29	-10	85	-9	85	-13	94	**328**	1	68	14	34	12	41	0	69
298	1	44	-1	70	-8	81	-12	91	**329**	0	65	10	38	10	41	2	65
299	20	36	7	60	-1	72	-2	77	**330**	-14	73	-3	52	2	48	-6	74
300	18	32	9	58	5	64	0	71	**331**	3	62	13	40	12	41	5	54
301	5	42	5	61	1	67	-1	73	**332**	4	62	17	32	13	41	7	54
302	1	48	12	50	9	56	4	64	**333**	-1	68	7	44	0	59	-6	76
303	10	62	15	50	0	69	-7	81	**334**	-13	75	7	38	3	50	-11	82
304	17	46	18	49	1	69	5	64	**335**	11	55	13	50	19	40	-2	77
305	9	64	17	54	7	69	15	57	**336**	5	64	10	57	3	66	-2	77
306	-12	104	10	41	-7	69	1	67	**337**	12	70	26	43	18	50	25	42
307	-11	97	7	46	-6	67	0	68									

Table 9-23 – Values of variables m and n for ctxIdx from 338 to 398

ctxIdx	I and SI slices		Value of cabac_init_idc						ctxIdx	I and SI slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
338	15	6	14	11	19	-6	17	-13	**369**	32	-26	31	-4	40	-37	37	-17
339	6	19	11	14	18	-6	16	-9	**370**	37	-30	27	6	38	-30	32	1
340	7	16	9	11	14	0	17	-12	**371**	44	-32	34	8	46	-33	34	15
341	12	14	18	11	26	-12	27	-21	**372**	34	-18	30	10	42	-30	29	15
342	18	13	21	9	31	-16	37	-30	**373**	34	-15	24	22	40	-24	24	25
343	13	11	23	-2	33	-25	41	-40	**374**	40	-15	33	19	49	-29	34	22
344	13	15	32	-15	33	-22	42	-41	**375**	33	-7	22	32	38	-12	31	16
345	15	16	32	-15	37	-28	48	-47	**376**	35	-5	26	31	40	-10	35	18
346	12	23	34	-21	39	-30	39	-32	**377**	33	0	21	41	38	-3	31	28
347	13	23	39	-23	42	-30	46	-40	**378**	38	2	26	44	46	-5	33	41
348	15	20	42	-33	47	-42	52	-51	**379**	33	13	23	47	31	20	36	28
349	14	26	41	-31	45	-36	46	-41	**380**	23	35	16	65	29	30	27	47
350	14	44	46	-28	49	-34	52	-39	**381**	13	58	14	71	25	44	21	62
351	17	40	38	-12	41	-17	43	-19	**382**	29	-3	8	60	12	48	18	31
352	17	47	21	29	32	9	32	11	**383**	26	0	6	63	11	49	19	26
353	24	17	45	-24	69	-71	61	-55	**384**	22	30	17	65	26	45	36	24
354	21	21	53	-45	63	-63	56	-46	**385**	31	-7	21	24	22	22	24	23
355	25	22	48	-26	66	-64	62	-50	**386**	35	-15	23	20	23	22	27	16
356	31	27	65	-43	77	-74	81	-67	**387**	34	-3	26	23	27	21	24	30
357	22	29	43	-19	54	-39	45	-20	**388**	34	3	27	32	33	20	31	29
358	19	35	39	-10	52	-35	35	-2	**389**	36	-1	28	23	26	28	22	41
359	14	50	30	9	41	-10	28	15	**390**	34	5	28	24	30	24	22	42
360	10	57	18	26	36	0	34	1	**391**	32	11	23	40	27	34	16	60
361	7	63	20	27	40	-1	39	1	**392**	35	5	24	32	18	42	15	52
362	-2	77	0	57	30	14	30	17	**393**	34	12	28	29	25	39	14	60
363	-4	82	-14	82	28	26	20	38	**394**	39	11	23	42	18	50	3	78
364	-3	94	-5	75	23	37	18	45	**395**	30	29	19	57	12	70	-16	123
365	9	69	-19	97	12	55	15	54	**396**	34	26	22	53	21	54	21	53
366	-12	109	-35	125	11	65	0	79	**397**	29	39	22	61	14	71	22	56
367	36	-35	27	0	37	-33	36	-16	**398**	19	66	11	86	11	83	25	61
368	36	-34	28	0	39	-36	37	-14									

Table 9-24 – Values of variables m and n for ctxIdx from 402 to 459

ctxIdx	I slices		Value of cabac_init_idc						ctxIdx	I slices		Value of cabac_init_idc					
			0		1		2					0		1		2	
	m	n	m	n	m	n	m	n		m	n	m	n	m	n	m	n
402	-17	120	-4	79	-5	85	-3	78	**431**	-2	55	-12	56	-9	57	-12	59
403	-20	112	-7	71	-6	81	-8	74	**432**	0	61	-6	60	-6	63	-8	63
404	-18	114	-5	69	-10	77	-9	72	**433**	1	64	-5	62	-4	65	-9	67
405	-11	85	-9	70	-7	81	-10	72	**434**	0	68	-8	66	-4	67	-6	68
406	-15	92	-8	66	-17	80	-18	75	**435**	-9	92	-8	76	-7	82	-10	79
407	-14	89	-10	68	-18	73	-12	71	**436**	-14	106	-5	85	-3	81	-3	78
408	-26	71	-19	73	-4	74	-11	63	**437**	-13	97	-6	81	-3	76	-8	74
409	-15	81	-12	69	-10	83	-5	70	**438**	-15	90	-10	77	-7	72	-9	72
410	-14	80	-16	70	-9	71	-17	75	**439**	-12	90	-7	81	-6	78	-10	72
411	0	68	-15	67	-9	67	-14	72	**440**	-18	88	-17	80	-12	72	-18	75
412	-14	70	-20	62	-1	61	-16	67	**441**	-10	73	-18	73	-14	68	-12	71
413	-24	56	-19	70	-8	66	-8	53	**442**	-9	79	-4	74	-3	70	-11	63
414	-23	68	-16	66	-14	66	-14	59	**443**	-14	86	-10	83	-6	76	-5	70
415	-24	50	-22	65	0	59	-9	52	**444**	-10	73	-9	71	-5	66	-17	75
416	-11	74	-20	63	2	59	-11	68	**445**	-10	70	-9	67	-5	62	-14	72
417	23	-13	9	-2	17	-10	9	-2	**446**	-10	69	-1	61	0	57	-16	67
418	26	-13	26	-9	32	-13	30	-10	**447**	-5	66	-8	66	-4	61	-8	53
419	40	-15	33	-9	42	-9	31	-4	**448**	-9	64	-14	66	-9	60	-14	59
420	49	-14	39	-7	49	-5	33	-1	**449**	-5	58	0	59	1	54	-9	52
421	44	3	41	-2	53	0	33	7	**450**	2	59	2	59	2	58	-11	68
422	45	6	45	3	64	3	31	12	**451**	21	-10	21	-13	17	-10	9	-2
423	44	34	49	9	68	10	37	23	**452**	24	-11	33	-14	32	-13	30	-10
424	33	54	45	27	66	27	31	38	**453**	28	-8	39	-7	42	-9	31	-4
425	19	82	36	59	47	57	20	64	**454**	28	-1	46	-2	49	-5	33	-1
426	-3	75	-6	66	-5	71	-9	71	**455**	29	3	51	2	53	0	33	7
427	-1	23	-7	35	0	24	-7	37	**456**	29	9	60	6	64	3	31	12
428	1	34	-7	42	-1	36	-8	44	**457**	35	20	61	17	68	10	37	23
429	1	43	-8	45	-2	42	-11	49	**458**	29	36	55	34	66	27	31	38
430	0	54	-5	48	-2	52	-10	56	**459**	14	67	42	62	47	57	20	64

9.3.1.2 Initialisation process for the arithmetic decoding engine

This process is invoked before decoding the first macroblock of a slice or after the decoding of any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data for a macroblock of type I_PCM.

Outputs of this process are the initialised decoding engine registers codIRange and codIOffset both in 16 bit register precision.

The status of the arithmetic decoding engine is represented by the variables codIRange and codIOffset. In the initialisation procedure of the arithmetic decoding process, codIRange is set equal to 0x01FE and codIOffset is set equal

to the value returned from read_bits(9) interpreted as a 9 bit binary representation of an unsigned integer with most significant bit written first.

The bitstream shall not contain data that results in a value of codIOffset being equal to 0x01FE or 0x01FF.

NOTE – The description of the arithmetic decoding engine in this Recommendation | International Standard utilizes 16 bit register precision. However, the minimum register precision for the variables codIRange and codIOffset is 9 bits.

9.3.2 Binarization process

Input to this process is a request for a syntax element.

Output of this process is the binarization of the syntax element, maxBinIdxCtx, ctxIdxOffset, and bypassFlag.

Table 9-25 specifies the type of binarization process, maxBinIdxCtx, and ctxIdxOffset associated with each syntax element.

The specification of the unary (U) binarization process, the truncated unary (TU) binarization process, the concatenated unary / k-th order Exp-Golomb (UEGk) binarization process, and the fixed-length (FL) binarization process are given in subclauses 9.3.2.1 to 9.3.2.4, respectively. Other binarizations are specified in subclauses 9.3.2.5 to 9.3.2.7.

Except for I slices, the binarizations for the syntax element mb_type as specified in subclause 9.3.2.5 consist of bin strings given by a concatenation of prefix and suffix bit strings. The UEGk binarization as specified in 9.3.2.3, which is used for the binarization of the syntax elements mvd_lX (X = 0, 1) and coeff_abs_level_minus1, and the binarization of the coded_block_pattern also consist of a concatenation of prefix and suffix bit strings. For these binarization processes, the prefix and the suffix bit string are separately indexed using the binIdx variable as specified further in subclause 9.3.3. The two sets of prefix bit strings and suffix bit strings are referred to as the binarization prefix part and the binarization suffix part, respectively.

Associated with each binarization or binarization part of a syntax element is a specific value of the context index offset (ctxIdxOffset) variable and a specific value of the maxBinIdxCtx variable as given in Table 9-25. When two values for each of these variables are specified for one syntax element in Table 9-25, the value in the upper row is related to the prefix part while the value in the lower row is related to the suffix part of the binarization of the corresponding syntax element.

The use of the DecodeBypass process and the variable bypassFlag is derived as follows.

– If no value is assigned to ctxIdxOffset for the corresponding binarization or binarization part in Table 9-25 labelled as “na”, all bins of the bit strings of the corresponding binarization or of the binarization prefix/suffix part are decoded by invoking the DecodeBypass process as specified in subclause 9.3.3.2.3. In such a case, bypassFlag is set equal to 1, where bypassFlag is used to indicate that for parsing the value of the bin from the bitstream the DecodeBypass process is applied.

– Otherwise, for each possible value of binIdx up to the specified value of maxBinIdxCtx given in Table 9-25, a specific value of the variable ctxIdx is further specified in subclause 9.3.3. bypassFlag is set equal to 0.

The possible values of the context index ctxIdx are in the range 0 to 459, inclusive. The value assigned to ctxIdxOffset specifies the lower value of the range of ctxIdx assigned to the corresponding binarization or binarization part of a syntax element.

ctxIdx = ctxIdxOffset = 276 is assigned to the syntax element end_of_slice_flag and the bin of mb_type, which specifies the I_PCM macroblock type as further specified in subclause 9.3.3.1. For parsing the value of the corresponding bin from the bitstream, the arithmetic decoding process for decisions before termination (DecodeTerminate) as specified in subclause 9.3.3.2.4 is applied.

NOTE – The bins of mb_type in I slices and the bins of the suffix for mb_type in SI slices that correspond to the same value of binIdx share the same ctxIdx. The last bin of the prefix of mb_type and the first bin of the suffix of mb_type in P, SP, and B slices may share the same ctxIdx.

Table 9-25 – Syntax elements and associated types of binarization, maxBinIdxCtx, and ctxIdxOffset

Syntax element	Type of binarization	maxBinIdxCtx	ctxIdxOffset
mb_type (SI slices only)	prefix and suffix as specified in subclause 9.3.2.5	prefix: 0 suffix: 6	prefix: 0 suffix: 3
mb_type (I slices only)	as specified in subclause 9.3.2.5	6	3
mb_skip_flag (P, SP slices only)	FL, cMax=1	0	11
mb_type (P, SP slices only)	prefix and suffix as specified in subclause 9.3.2.5	prefix: 2 suffix: 5	prefix: 14 suffix: 17
sub_mb_type (P, SP slices only)	as specified in subclause 9.3.2.5	2	21
mb_skip_flag (B slices only)	FL, cMax=1	0	24
mb_type (B slices only)	prefix and suffix as specified in subclause 9.3.2.5	prefix: 3 suffix: 5	prefix: 27 suffix: 32
sub_mb_type (B slices only)	as specified in subclause 9.3.2.5	3	36
mvd_l0[ ][ ][0], mvd_l1[ ][ ][0]	prefix and suffix as given by UEG3 with signedValFlag=1, uCoff=9	prefix: 4 suffix: na	prefix: 40 suffix: na (uses DecodeBypass)
mvd_l0[ ][ ][1], mvd_l1[ ][ ][1]		prefix: 4 suffix: na	prefix: 47 suffix: na (uses DecodeBypass)
ref_idx_l0, ref_idx_l1	U	2	54
mb_qp_delta	as specified in subclause 9.3.2.7	2	60
intra_chroma_pred_mode	TU, cMax=3	1	64
prev_intra4x4_pred_mode_flag, prev_intra8x8_pred_mode_flag	FL, cMax=1	0	68
rem_intra4x4_pred_mode, rem_intra8x8_pred_mode	FL, cMax=7	0	69
mb_field_decoding_flag	FL, cMax=1	0	70
coded_block_pattern	prefix and suffix as specified in subclause 9.3.2.6	prefix: 3 suffix: 1	prefix: 73 suffix: 77
coded_block_flag	FL, cMax=1	0	85
significant_coeff_flag (frame coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	105
last_significant_coeff_flag (frame coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	166
coeff_abs_level_minus1 (blocks with ctxBlockCat < 5)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 227 suffix: na, (uses DecodeBypass)
coeff_sign_flag	FL, cMax=1	0	na, (uses DecodeBypass)
end_of_slice_flag	FL, cMax=1	0	276
significant_coeff_flag (field coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	277

Syntax element	Type of binarization	maxBinIdxCtx	ctxIdxOffset
last_significant_coeff_flag (field coded blocks with ctxBlockCat < 5)	FL, cMax=1	0	338
transform_size_8x8_flag	FL, cMax=1	0	399
significant_coeff_flag (frame coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	402
last_significant_coeff_flag (frame coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	417
coeff_abs_level_minus1 (blocks with ctxBlockCat = = 5)	prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14	prefix: 1 suffix: na	prefix: 426 suffix: na, (uses DecodeBypass)
significant_coeff_flag (field coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	436
last_significant_coeff_flag (field coded blocks with ctxBlockCat = = 5)	FL, cMax=1	0	451

9.3.2.1 Unary (U) binarization process

Input to this process is a request for a U binarization for a syntax element.

Output of this process is the U binarization of the syntax element.

The bin string of a syntax element having (unsigned integer) value synElVal is a bit string of length synElVal + 1 indexed by BinIdx. The bins for binIdx less than synElVal are equal to 1. The bin with binIdx equal to synElVal is equal to 0.

Table 9-26 illustrates the bin strings of the unary binarization for a syntax element.

Table 9-26 – Bin string of the unary binarization (informative)

Value of syntax element	Bin string					
0 (I_NxN)	0					
1	1	0				
2	1	1	0			
3	1	1	1	0		
4	1	1	1	1	0	
5	1	1	1	1	1	0
…						
binIdx	0	1	2	3	4	5

9.3.2.2 Truncated unary (TU) binarization process

Input to this process is a request for a TU binarization for a syntax element and cMax.

Output of this process is the TU binarization of the syntax element.

For syntax element (unsigned integer) values less than cMax, the U binarization process as specified in subclause 9.3.2.1 is invoked. For the syntax element value equal to cMax the bin string is a bit string of length cMax with all bins being equal to 1.

NOTE – TU binarization is always invoked with a cMax value equal to the largest possible value of the syntax element being decoded.

9.3.2.3 Concatenated unary/ k-th order Exp-Golomb (UEGk) binarization process

Input to this process is a request for a UEGk binarization for a syntax element, signedValFlag and uCoff.

Output of this process is the UEGk binarization of the syntax element.

A UEGk bin string is a concatenation of a prefix bit string and a suffix bit string. The prefix of the binarization is specified by invoking the TU binarization process for the prefix part Min(uCoff, Abs(synElVal)) of a syntax element value synElVal as specified in subclause 9.3.2.2 with cMax = uCoff, where uCoff > 0.

The UEGk bin string is derived as follows.

- If one of the following is true, the bin string of a syntax element having value synElVal consists only of a prefix bit string,
    - signedValFlag is equal to 0 and the prefix bit string is not equal to the bit string of length uCoff with all bits equal to 1.
    - signedValFlag is equal to 1 and the prefix bit string is equal to the bit string that consists of a single bit with value equal to 0.
- Otherwise, the bin string of the UEGk suffix part of a syntax element value synElVal is specified by a process equivalent to the following pseudo-code:

```
if( Abs( synElVal ) >= uCoff ) {
    sufS = Abs( synElVal ) − uCoff
    stopLoop = 0
    do {
        if( sufS >= ( 1 << k ) ) {
            put( 1 )
            sufS = sufS − ( 1<<k )
            k++
        } else {
            put( 0 )
            while( k− − )
                put( ( sufS >> k ) & 0x01 )
            stopLoop = 1
        }
    } while( !stopLoop )
}
if( signedValFlag && synElVal != 0)
    if( synElVal > 0 )
        put( 0 )
    else
        put( 1 )
```

NOTE – The specification for the k-th order Exp-Golomb (EGk) code uses 1's and 0's in reverse meaning for the unary part of the Exp-Golomb code of 0-th order as specified in subclause 9.1.

9.3.2.4 Fixed-length (FL) binarization process

Input to this process is a request for a FL binarization for a syntax element and cMax.

Output of this process is the FL binarization of the syntax element.

FL binarization is constructed by using an fixedLength-bit unsigned integer bin string of the syntax element value, where fixedLength = Ceil(Log2(cMax + 1)). The indexing of bins for the FL binarization is such that the binIdx = 0 relates to the least significant bit with increasing values of binIdx towards the most significant bit.

9.3.2.5 Binarization process for macroblock type and sub-macroblock type

Input to this process is a request for a binarization for syntax elements mb_type or sub_mb_type.

Output of this process is the binarization of the syntax element.

The binarization scheme for decoding of macroblock type in I slices is specified in Table 9-27.

For macroblock types in SI slices, the binarization consists of bin strings specified as a concatenation of a prefix and a suffix bit string as follows.

The prefix bit string consists of a single bit, which is specified by b_0 = ((mb_type = = SI) ? 0 : 1). For the syntax element value for which b_0 is equal to 0, the bin string only consists of the prefix bit string. For the syntax element value for which b_0 is equal to 1, the binarization is given by concatenating the prefix b_0 and the suffix bit string as specified in Table 9-27 for macroblock type in I slices indexed by subtracting 1 from the value of mb_type in SI slices.

Table 9-27 – Binarization for macroblock types in I slices

Value (name) of mb_type	Bin string						
0 (I_4x4)	0						
1 (I_16x16_0_0_0)	1	0	0	0	0	0	
2 (I_16x16_1_0_0)	1	0	0	0	0	1	
3 (I_16x16_2_0_0)	1	0	0	0	1	0	
4 (I_16x16_3_0_0)	1	0	0	0	1	1	
5 (I_16x16_0_1_0)	1	0	0	1	0	0	0
6 (I_16x16_1_1_0)	1	0	0	1	0	0	1
7 (I_16x16_2_1_0)	1	0	0	1	0	1	0
8 (I_16x16_3_1_0)	1	0	0	1	0	1	1
9 (I_16x16_0_2_0)	1	0	0	1	1	0	0
10 (I_16x16_1_2_0)	1	0	0	1	1	0	1
11 (I_16x16_2_2_0)	1	0	0	1	1	1	0
12 (I_16x16_3_2_0)	1	0	0	1	1	1	1
13 (I_16x16_0_0_1)	1	0	1	0	0	0	
14 (I_16x16_1_0_1)	1	0	1	0	0	1	
15 (I_16x16_2_0_1)	1	0	1	0	1	0	
16 (I_16x16_3_0_1)	1	0	1	0	1	1	
17 (I_16x16_0_1_1)	1	0	1	1	0	0	0
18 (I_16x16_1_1_1)	1	0	1	1	0	0	1
19 (I_16x16_2_1_1)	1	0	1	1	0	1	0
20 (I_16x16_3_1_1)	1	0	1	1	0	1	1
21 (I_16x16_0_2_1)	1	0	1	1	1	0	0
22 (I_16x16_1_2_1)	1	0	1	1	1	0	1
23 (I_16x16_2_2_1)	1	0	1	1	1	1	0
24 (I_16x16_3_2_1)	1	0	1	1	1	1	1
25 (I_PCM)	1	1					
binIdx	0	1	2	3	4	5	6

The binarization schemes for P macroblock types in P and SP slices and for B macroblocks in B slices are specified in Table 9-28.

The bin string for I macroblock types in P and SP slices corresponding to mb_type values 5 to 30 consists of a concatenation of a prefix, which consists of a single bit with value equal to 1 as specified in Table 9-28 and a suffix as specified in Table 9-27, indexed by subtracting 5 from the value of mb_type.

mb_type equal to 4 (P_8x8ref0) is not allowed.

For I macroblock types in B slices (mb_type values 23 to 48) the binarization consists of bin strings specified as a concatenation of a prefix bit string as specified in Table 9-28 and suffix bit strings as specified in Table 9-27, indexed by subtracting 23 from the value of mb_type.

Table 9-28 – Binarization for macroblock types in P, SP, and B slices

Slice type	Value (name) of mb_type	Bin string						
P, SP slice	0 (P_L0_16x16)	0	0	0				
	1 (P_L0_L0_16x8)	0	1	1				
	2 (P_L0_L0_8x16)	0	1	0				
	3 (P_8x8)	0	0	1				
	4 (P_8x8ref0)	na						
	5 to 30 (Intra, prefix only)	1						
B slice	0 (B_Direct_16x16)	0						
	1 (B_L0_16x16)	1	0	0				
	2 (B_L1_16x16)	1	0	1				
	3 (B_Bi_16x16)	1	1	0	0	0	0	
	4 (B_L0_L0_16x8)	1	1	0	0	0	1	
	5 (B_L0_L0_8x16)	1	1	0	0	1	0	
	6 (B_L1_L1_16x8)	1	1	0	0	1	1	
	7 (B_L1_L1_8x16)	1	1	0	1	0	0	
	8 (B_L0_L1_16x8)	1	1	0	1	0	1	
	9 (B_L0_L1_8x16)	1	1	0	1	1	0	
	10 (B_L1_L0_16x8)	1	1	0	1	1	1	
	11 (B_L1_L0_8x16)	1	1	1	1	1	0	
	12 (B_L0_Bi_16x8)	1	1	1	0	0	0	0
	13 (B_L0_Bi_8x16)	1	1	1	0	0	0	1
	14 (B_L1_Bi_16x8)	1	1	1	0	0	1	0
	15 (B_L1_Bi_8x16)	1	1	1	0	0	1	1
	16 (B_Bi_L0_16x8)	1	1	1	0	1	0	0
	17 (B_Bi_L0_8x16)	1	1	1	0	1	0	1
	18 (B_Bi_L1_16x8)	1	1	1	0	1	1	0
	19 (B_Bi_L1_8x16)	1	1	1	0	1	1	1
	20 (B_Bi_Bi_16x8)	1	1	1	1	0	0	0
	21 (B_Bi_Bi_8x16)	1	1	1	1	0	0	1
	22 (B_8x8)	1	1	1	1	1	1	
	23 to 48 (Intra, prefix only)	1	1	1	1	0	1	
binIdx		0	1	2	3	4	5	6

For P, SP, and B slices the specification of the binarization for sub_mb_type is given in Table 9-29.

Table 9-29 – Binarization for sub-macroblock types in P, SP, and B slices

Slice type	Value (name) of sub_mb_type	Bin string					
P, SP slice	0 (P_L0_8x8)	1					
	1 (P_L0_8x4)	0	0				
	2 (P_L0_4x8)	0	1	1			
	3 (P_L0_4x4)	0	1	0			
B slice	0 (B_Direct_8x8)	0					
	1 (B_L0_8x8)	1	0	0			
	2 (B_L1_8x8)	1	0	1			
	3 (B_Bi_8x8)	1	1	0	0	0	
	4 (B_L0_8x4)	1	1	0	0	1	
	5 (B_L0_4x8)	1	1	0	1	0	
	6 (B_L1_8x4)	1	1	0	1	1	
	7 (B_L1_4x8)	1	1	1	0	0	0
	8 (B_Bi_8x4)	1	1	1	0	0	1
	9 (B_Bi_4x8)	1	1	1	0	1	0
	10 (B_L0_4x4)	1	1	1	0	1	1
	11 (B_L1_4x4)	1	1	1	1	0	
	12 (B_Bi_4x4)	1	1	1	1	1	
binIdx		0	1	2	3	4	5

9.3.2.6 Binarization process for coded block pattern

Input to this process is a request for a binarization for the syntax element coded_block_pattern.

Output of this process is the binarization of the syntax element.

The binarization of coded_block_pattern consists of a prefix part and (when present) a suffix part. The prefix part of the binarization is given by the FL binarization of CodedBlockPatternLuma with cMax = 15. When chroma_format_idc is not equal to 0 (monochrome), the suffix part is present and consists of the TU binarization of CodedBlockPatternChroma with cMax = 2. The relationship between the value of the syntax element coded_block_pattern and the values of CodedBlockPatternLuma and CodedBlockPatternChroma is given as specified in subclause 7.4.5.

9.3.2.7 Binarization process for mb_qp_delta

Input to this process is a request for a binarization for the syntax element mb_qp_delta.

Output of this process is the binarization of the syntax element.

The bin string of mb_qp_delta is derived by the U binarization of the mapped value of the syntax element mb_qp_delta, where the assignment rule between the signed value of mb_qp_delta and its mapped value is given as specified in Table 9-3.

9.3.3 Decoding process flow

Input to this process is a binarization of the requested syntax element, maxBinIdxCtx, bypassFlag and ctxIdxOffset as specified in subclause 9.3.2.

Output of this process is the value of the syntax element.

This process specifies how each bit of a bit string is parsed for each syntax element.

After parsing each bit, the resulting bit string is compared to all bin strings of the binarization of the syntax element and the following applies.

– If the bit string is equal to one of the bin strings, the corresponding value of the syntax element is the output.

– Otherwise (the bit string is not equal to one of the bin strings), the next bit is parsed.

While parsing each bin, the variable binIdx is incremented by 1 starting with binIdx being set equal to 0 for the first bin.

When the binarization of the corresponding syntax element consists of a prefix and a suffix binarization part,, the variable binIdx is set equal to 0 for the first bin of each part of the bin string (prefix part or suffix part). In this case, after parsing the prefix bit string, the parsing process of the suffix bit string related to the binarizations specified in subclauses 9.3.2.3 and 9.3.2.5 is invoked depending on the resulting prefix bit string as specified in subclauses 9.3.2.3 and 9.3.2.5. Note that for the binarization of the syntax element coded_block_pattern, the suffix bit string is present regardless of the prefix bit string of length 4 as specified in subclause 9.3.2.6.

Depending on the variable bypassFlag, the following applies.

– If bypassFlag is equal to 1, the bypass decoding process as specified in subclause 9.3.3.2.3 is applied for parsing the value of the bins from the bitstream.

– Otherwise (bypassFlag is equal to 0), the parsing of each bin is specified by the following two ordered steps:

1. Given binIdx, maxBinIdxCtx and ctxIdxOffset, ctxIdx is derived as specified in subclause 9.3.3.1.
2. Given ctxIdx, the value of the bin from the bitstream as specified in subclause 9.3.3.2 is decoded.

9.3.3.1 Derivation process for ctxIdx

Inputs to this process are binIdx, maxBinIdxCtx and ctxIdxOffset.

Output of this process is ctxIdx.

Table 9-30 shows the assignment of ctxIdx increments (ctxIdxInc) to binIdx for all ctxIdxOffset values except those related to the syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1.

The ctxIdx to be used with a specific binIdx is specified by first determining the ctxIdxOffset associated with the given bin string or part thereof. The ctxIdx is determined as follows.

– If the ctxIdxOffset is listed in Table 9-30, the ctxIdx for a binIdx is the sum of ctxIdxOffset and ctxIdxInc, which is found in Table 9-30. When more than one value is listed in Table 9-30 for a binIdx, the assignment process for ctxIdxInc for that binIdx is further specified in the subclauses given in parenthesis of the corresponding table entry.

– Otherwise (ctxIdxOffset is not listed in Table 9-30), the ctxIdx is specified to be the sum of the following terms: ctxIdxOffset and ctxIdxBlockCatOffset(ctxBlockCat) as specified in Table 9-31 and ctxIdxInc(ctxBlockCat). Subclause 9.3.3.1.3 specifies which ctxBlockCat is used. Subclause 9.3.3.1.1.9 specifies the assignment of ctxIdxInc(ctxBlockCat) for coded_block_flag, and subclause 9.3.3.1.3 specifies the assignment of ctxIdxInc(ctxBlockCat) for significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1.

All bins with binIdx greater than maxBinIdxCtx are parsed using the value of ctxIdx being assigned to binIdx equal to maxBinIdxCtx.

All entries in Table 9-30 labelled with “na” correspond to values of binIdx that do not occur for the corresponding ctxIdxOffset.

ctxIdx = 276 is assigned to the binIdx of mb_type indicating the I_PCM mode. For parsing the value of the corresponding bins from the bitstream, the arithmetic decoding process for decisions before termination as specified in subclause 9.3.3.2.4 is applied.

Table 9-30 – Assignment of ctxIdxInc to binIdx for all ctxIdxOffset values except those related to the syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1

ctxIdxOffset	binIdx						
	0	**1**	**2**	**3**	**4**	**5**	**>= 6**
0	0,1,2 (subclause 9.3.3.1.1.3)	na	na	na	na	na	na
3	0,1,2 (subclause 9.3.3.1.1.3)	ctxIdx=276	3	4	5,6 (subclause 9.3.3.1.2)	6,7 (subclause 9.3.3.1.2)	7
11	0,1,2 (subclause 9.3.3.1.1.1)	na	na	na	na	na	na
14	0	1	2,3 (subclause 9.3.3.1.2)	na	na	na	na
17	0	ctxIdx=276	1	2	2,3 (subclause 9.3.3.1.2)	3	3
21	0	1	2	na	na	na	na
24	0,1,2 (subclause 9.3.3.1.1.1)	na	na	na	na	na	na
27	0,1,2 (subclause 9.3.3.1.1.3)	3	4,5 (subclause 9.3.3.1.2)	5	5	5	5
32	0	ctxIdx=276	1	2	2,3 (subclause 9.3.3.1.2)	3	3
36	0	1	2,3 (subclause 9.3.3.1.2)	3	3	3	na
40	0,1,2 (subclause 9.3.3.1.1.7)	3	4	5	6	6	6
47	0,1,2 (subclause 9.3.3.1.1.7)	3	4	5	6	6	6
54	0,1,2,3 (subclause 9.3.3.1.1.6)	4	5	5	5	5	5
60	0,1 (subclause 9.3.3.1.1.5)	2	3	3	3	3	3
64	0,1,2 (subclause 9.3.3.1.1.8)	3	3	na	na	na	na
68	0	na	na	na	na	na	na
69	0	0	0	na	na	na	na
70	0,1,2 (subclause 9.3.3.1.1.2)	na	na	na	na	na	na
73	0,1,2,3 (subclause 9.3.3.1.1.4)	0,1,2,3 (subclause 9.3.3.1.1.4)	0,1,2,3 (subclause 9.3.3.1.1.4)	0,1,2,3 (subclause 9.3.3.1.1.4)	na	na	na
77	0,1,2,3 (subclause 9.3.3.1.1.4)	4,5,6,7 (subclause 9.3.3.1.1.4)	na	na	na	na	na
276	0	na	na	na	na	na	na
399	0,1,2 (subclause 9.3.3.1.1.10)	na	na	na	na	na	na

Table 9-31 shows the values of ctxIdxBlockCatOffset depending on ctxBlockCat for the syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1. The specification of ctxBlockCat is given in Table 9-33.

Table 9-31 – Assignment of ctxIdxBlockCatOffset to ctxBlockCat for syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1

Syntax element	ctxBlockCat (as specified in Table 9-33)					
	0	**1**	**2**	**3**	**4**	**5**
coded_block_flag	0	4	8	12	16	na
significant_coeff_flag	0	15	29	44	47	0
last_significant_coeff_flag	0	15	29	44	47	0
coeff_abs_level_minus1	0	10	20	30	39	0

9.3.3.1.1 Assignment process of ctxIdxInc using neighbouring syntax elements

Subclause 9.3.3.1.1.1 specifies the derivation process of ctxIdxInc for the syntax element mb_skip_flag.

Subclause 9.3.3.1.1.2 specifies the derivation process of ctxIdxInc for the syntax element mb_field_decoding_flag.

Subclause 9.3.3.1.1.3 specifies the derivation process of ctxIdxInc for the syntax element mb_type.

Subclause 9.3.3.1.1.4 specifies the derivation process of ctxIdxInc for the syntax element coded_block_pattern.

Subclause 9.3.3.1.1.5 specifies the derivation process of ctxIdxInc for the syntax element mb_qp_delta.

Subclause 9.3.3.1.1.6 specifies the derivation process of ctxIdxInc for the syntax elements ref_idx_l0 and ref_idx_l1.

Subclause 9.3.3.1.1.7 specifies the derivation process of ctxIdxInc for the syntax elements mvd_l0 and mvd_l1.

Subclause 9.3.3.1.1.8 specifies the derivation process of ctxIdxInc for the syntax element intra_chroma_pred_mode.

Subclause 9.3.3.1.1.9 specifies the derivation process of ctxIdxInc for the syntax element coded_block_flag.

Subclause 9.3.3.1.1.10 specifies the derivation process of ctxIdxInc for the syntax element transform_size_8x8_flag.

9.3.3.1.1.1 Derivation process of ctxIdxInc for the syntax element mb_skip_flag

Output of this process is ctxIdxInc.

When MbaffFrameFlag is equal to 1 and mb_field_decoding_flag has not been decoded (yet) for the current macroblock pair with top macroblock address 2 * (CurrMbAddr / 2), the inference rule for the syntax element mb_field_decoding_flag as specified in subclause 7.4.4 is applied.

The derivation process for neighbouring macroblocks specified in subclause 6.4.8.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If mbAddrN is not available or mb_skip_flag for the macroblock mbAddrN is equal to 1, condTermFlagN is set equal to 0.

– Otherwise (mbAddrN is available and mb_skip_flag for the macroblock mbAddrN is equal to 0), condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$ctxIdxInc = condTermFlagA + condTermFlagB \tag{9-1}$$

9.3.3.1.1.2 Derivation process of ctxIdxInc for the syntax element mb_field_decoding_flag

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblock addresses and their availability in MBAFF frames as specified in subclause 6.4.7 is invoked and the output is assigned to mbAddrA and mbAddrB.

When both macroblocks mbAddrN and mbAddrN + 1 have mb_type equal to P_Skip or B_Skip, the inference rule for the syntax element mb_field_decoding_flag as specified in subclause 7.4.4 is applied for the macroblock mbAddrN.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0,
  – mbAddrN is not available
  – the macroblock mbAddrN is a frame macroblock.
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

ctxIdxInc = condTermFlagA + condTermFlagB (9-2)

9.3.3.1.1.3 Derivation process of ctxIdxInc for the syntax element mb_type

Input to this process is ctxIdxOffset.

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblocks specified in subclause 6.4.8.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0
  – mbAddrN is not available
  – ctxIdxOffset is equal to 0 and mb_type for the macroblock mbAddrN is equal to SI
  – ctxIdxOffset is equal to 3 and mb_type for the macroblock mbAddrN is equal to I_NxN
  – ctxIdxOffset is equal to 27 and mb_type for the macroblock mbAddrN is equal to P_Skip, B_Skip, or B_Direct_16x16
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived as

ctxIdxInc = condTermFlagA + condTermFlagB (9-3)

9.3.3.1.1.4 Derivation process of ctxIdxInc for the syntax element coded_block_pattern

Inputs to this process are ctxIdxOffset and binIdx.

Output of this process is ctxIdxInc.

Depending on the value of the variable ctxIdxOffset, the following applies.

– If ctxIdxOffset is equal to 73, the following applies
  – The derivation process for neighbouring 8x8 luma blocks specified in subclause 6.4.8.2 is invoked with luma8x8BlkIdx = binIdx as input and the output is assigned to mbAddrA, mbAddrB, luma8x8BlkIdxA, and luma8x8BlkIdxB.
  – Let the variable condTermFlagN (with N being either A or B) be derived as follows.
    – If any of the following conditions are true, condTermFlagN is set equal to 0
      – mbAddrN is not available
      – mb_type for the macroblock mbAddrN is equal to I_PCM
      – the macroblock mbAddrN is not the current macroblock CurrMbAddr and the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, and ((CodedBlockPatternLuma >> luma8x8BlkIdxN) & 1) is not equal to 0 for the value of CodedBlockPatternLuma for the macroblock mbAddrN

– the macroblock mbAddrN is the current macroblock CurrMbAddr and the prior decoded bin value b_k of coded_block_pattern with k = luma8x8BlkIdxN is not equal to 0.

– Otherwise, condTermFlagN is set equal to 1.

– The variable ctxIdxInc is derived as

$$ctxIdxInc = condTermFlagA + 2 * condTermFlagB \quad (9\text{-}4)$$

– Otherwise (ctxIdxOffset is equal to 77), the following applies.

– The derivation process for neighbouring macroblocks specified in subclause 6.4.8.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

– Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If mbAddrN is available and mb_type for the macroblock mbAddrN is equal to I_PCM, condTermFlagN is set equal to 1

– Otherwise, if any of the following conditions is true, condTermFlagN is set equal to 0

– mbAddrN is not available or the macroblock mbAddrN has mb_type equal to P_Skip or B_Skip

– binIdx is equal to 0 and CodedBlockPatternChroma for the macroblock mbAddrN is equal to 0

– binIdx is equal to 1 and CodedBlockPatternChroma for the macroblock mbAddrN is not equal to 2

– Otherwise, condTermFlagN is set equal to 1.

– The variable ctxIdxInc is derived as

$$ctxIdxInc = condTermFlagA + 2 * condTermFlagB + ((binIdx == 1) ? 4 : 0) \quad (9\text{-}5)$$

NOTE – When a macroblock uses an Intra_16x16 prediction mode, the values of CodedBlockPatternLuma and CodedBlockPatternChroma for the macroblock are derived from mb_type as specified in Table 7-11.

9.3.3.1.1.5 Derivation process of ctxIdxInc for the syntax element mb_qp_delta

Output of this process is ctxIdxInc.

Let prevMbAddr be the macroblock address of the macroblock that precedes the current macroblock in decoding order. When the current macroblock is the first macroblock of a slice, prevMbAddr is marked as not available.

Let the variable ctxIdxInc be derived as follows.

– If any of the following conditions is true, ctxIdxInc is set equal to 0

– prevMbAddr is not available or the macroblock prevMbAddr has mb_type equal to P_Skip or B_Skip

– mb_type of the macroblock prevMbAddr is equal to I_PCM

– The macroblock prevMbAddr is not coded in Intra_16x16 prediction mode and both CodedBlockPatternLuma and CodedBlockPatternChroma for the macroblock prevMbAddr are equal to 0

– mb_qp_delta for the macroblock prevMbAddr is equal to 0

– Otherwise, ctxIdxInc is set equal to 1.

9.3.3.1.1.6 Derivation process of ctxIdxInc for the syntax elements ref_idx_l0 and ref_idx_l1

Input to this process is mbPartIdx.

Output of this process is ctxIdxInc.

The interpretation of ref_idx_lX and Pred_LX within this subclause is specified as follows.

– If this process is invoked for the derivation of ref_idx_l0, ref_idx_lX is interpreted as ref_idx_l0 and Pred_LX is interpreted as Pred_L0.

– Otherwise (this process is invoked for the derivation of ref_idx_l1), ref_idx_lX is interpreted as ref_idx_l1 and Pred_LX is interpreted as Pred_L1.

Let currSubMbType be set equal to sub_mb_type[mbPartIdx].

The derivation process for neighbouring partitions specified in subclause 6.4.8.5 is invoked with mbPartIdx, currSubMbType, and subMbPartIdx = 0 as input and the output is assigned to mbAddrA\mbPartIdxA and mbAddrB\mbPartIdxB.

With ref_idx_lX[mbPartIdxN] (with N being either A or B) specifying the syntax element for the macroblock mbAddrN, let the variable refIdxZeroFlagN be derived as follows.

– If MbaffFrameFlag is equal to 1, the current macroblock is a frame macroblock, and the macroblock mbAddrN is a field macroblock

$$refIdxZeroFlagN = ((ref\_idx\_lX[mbPartIdxN] > 1) ? 0 : 1) \quad (9\text{-}6)$$

– Otherwise,

$$refIdxZeroFlagN = ((ref\_idx\_lX[mbPartIdxN] > 0) ? 0 : 1) \quad (9\text{-}7)$$

Let the variable predModeEqualFlagN be specified as follows.

– If the macroblock mbAddrN has mb_type equal to P_8x8 or B_8x8, the following applies.
  – If SubMbPredMode(sub_mb_type[mbPartIdxN]) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where sub_mb_type specifies the syntax element for the macroblock mbAddrN.
  – Otherwise, predModeEqualFlagN is set equal to 1.
– Otherwise, the following applies.
  – If MbPartPredMode(mb_type, mbPartIdxN) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where mb_type specifies the syntax element for the macroblock mbAddrN.
  – Otherwise, predModeEqualFlagN is set equal to 1.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0
  – mbAddrN is not available
  – the macroblock mbAddrN has mb_type equal to P_Skip or B_Skip
  – The macroblock mbAddrN is coded in Intra prediction mode
  – predModeEqualFlagN is equal to 0
  – refIdxZeroFlagN is equal to 1
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived as

$$ctxIdxInc = condTermFlagA + 2 * condTermFlagB \quad (9\text{-}8)$$

9.3.3.1.1.7 Derivation process of ctxIdxInc for the syntax elements mvd_l0 and mvd_l1

Inputs to this process are mbPartIdx, subMbPartIdx, and ctxIdxOffset.

Output of this process is ctxIdxInc.

The interpretation of mvd_lX and Pred_LX within this subclause is specified as follows.

– If this process is invoked for the derivation of mvd_l0, mvd_lX is interpreted as mvd_l0 and Pred_LX is interpreted as Pred_L0.
– Otherwise (this process is invoked for the derivation of mvd_l1), mvd_lX is interpreted as mvd_l1 and Pred_LX is interpreted as Pred_L1.

Let currSubMbType be set equal to sub_mb_type[mbPartIdx].

The derivation process for neighbouring partitions specified in subclause 6.4.8.5 is invoked with mbPartIdx, currSubMbType, and subMbPartIdx as input and the output is assigned to mbAddrA\mbPartIdxA\subMbPartIdxA and mbAddrB\mbPartIdxB\subMbPartIdxB.

Let the variable compIdx be derived as follows.

– If ctxIdxOffset is equal to 40, compIdx is set equal to 0.

– Otherwise (ctxIdxOffset is equal to 47), compIdx is set equal to 1.

Let the variable predModeEqualFlagN be specified as follows.

– If the macroblock mbAddrN has mb_type equal to P_8x8 or B_8x8, the following applies.

  – If SubMbPredMode(sub_mb_type[mbPartIdxN]) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where sub_mb_type specifies the syntax element for the macroblock mbAddrN.

  – Otherwise, predModeEqualFlagN is set equal to 1.

– Otherwise, the following applies.

  – If MbPartPredMode(mb_type, mbPartIdxN) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where mb_type specifies the syntax element for the macroblock mbAddrN.

  – Otherwise, predModeEqualFlagN is set equal to 1.

Let the variable absMvdCompN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, absMvdCompN is set equal to 0

  – mbAddrN is not available

  – the macroblock mbAddrN has mb_type equal to P_Skip or B_Skip

  – The macroblock mbAddrN is coded in an Intra prediction mode

  – predModeEqualFlagN is equal to 0

– Otherwise, the following applies

  – If compIdx is equal to 1, MbaffFrameFlag is equal to 1, the current macroblock is a frame macroblock, and the macroblock mbAddrN is a field macroblock

    absMvdCompN = Abs(mvd_lX[mbPartIdxN][subMbPartIdxN][compIdx]) * 2 (9-9)

  – Otherwise, if compIdx is equal to 1, MbaffFrameFlag is equal to 1, the current macroblock is a field macroblock, and the macroblock mbAddrN is a frame macroblock

    absMvdCompN = Abs(mvd_lX[mbPartIdxN][subMbPartIdxN][compIdx]) / 2 (9-10)

  – Otherwise,

    absMvdCompN = Abs(mvd_lX[mbPartIdxN][subMbPartIdxN][compIdx]) (9-11)

The variable ctxIdxInc is derived as follows

– If (absMvdCompA + absMvdCompB) is less than 3, ctxIdxInc is set equal to 0.

– Otherwise, if (absMvdCompA + absMvdCompB) is greater than 32, ctxIdxInc is set equal to 2.

– Otherwise ((absMvdCompA + absMvdCompB) is in the range of 3 to 32, inclusive), ctxIdxInc is set equal to 1.

9.3.3.1.1.8 Derivation process of ctxIdxInc for the syntax element intra_chroma_pred_mode

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblocks specified in subclause 6.4.8.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being replaced by either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0
  – mbAddrN is not available
  – The macroblock mbAddrN is coded in Inter prediction mode
  – mb_type for the macroblock mbAddrN is equal to I_PCM
  – intra_chroma_pred_mode for the macroblock mbAddrN is equal to 0
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad (9\text{-}12)$$

9.3.3.1.1.9 Derivation process of ctxIdxInc for the syntax element coded_block_flag

Input to this process is ctxBlockCat and additional input is specified as follows.

- If ctxBlockCat is equal to 0, no additional input
- Otherwise, if ctxBlockCat is equal to 1 or 2, luma4x4BlkIdx
- Otherwise, if ctxBlockCat is equal to 3, the chroma component index iCbCr
- Otherwise (ctxBlockCat is equal to 4), chroma4x4BlkIdx and the chroma component index iCbCr

Output of this process is ctxIdxInc(ctxBlockCat).

Let the variable transBlockN (with N being either A or B) be derived as follows.

- If ctxBlockCat is equal to 0, the following applies.
  - The derivation process for neighbouring macroblocks specified in subclause 6.4.8.1 is invoked and the output is assigned to mbAddrN (with N being either A or B).
  - The variable transBlockN is derived as follows.
    - If mbAddrN is available and the macroblock mbAddrN is coded in Intra_16x16 prediction mode, the luma DC block of macroblock mbAddrN is assigned to transBlockN
    - Otherwise, transBlockN is marked as not available.
- Otherwise, if ctxBlockCat is equal to 1 or 2, the following applies.
  - The derivation process for neighbouring 4x4 luma blocks specified in subclause 6.4.8.3 is invoked with luma4x4BlkIdx as input and the output is assigned to mbAddrN, luma4x4BlkIdxN (with N being either A or B).
  - The variable transBlockN is derived as follows.
    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ((CodedBlockPatternLuma >> (luma4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 0 for the macroblock mbAddrN, the 4x4 luma block with index luma4x4BlkIdxN of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, if mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, ((CodedBlockPatternLuma >> (luma4x4BlkIdxN >>2)) & 1) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 luma block with index (luma4x4BlkIdxN >> 2) of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, transBlockN is marked as not available.
- Otherwise, if ctxBlockCat is equal to 3, the following applies.
  - The derivation process for neighbouring macroblocks specified in subclause 6.4.8.1 is invoked and the output is assigned to mbAddrN (with N being either A or B).
  - The variable transBlockN is derived as follows.

- If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, and CodedBlockPatternChroma is not equal to 0 for the macroblock mbAddrN, the chroma DC block of chroma component iCbCr of macroblock mbAddrN is assigned to transBlockN.
- Otherwise, transBlockN is marked as not available.

- Otherwise (ctxBlockCat is equal to 4), the following applies.
  - The derivation process for neighbouring 4x4 chroma blocks specified in subclause 6.4.8.4 is invoked with chroma4x4BlkIdx as input and the output is assigned to mbAddrN, chroma4x4BlkIdxN (with N being either A or B).
  - The variable transBlockN is derived as follows.
    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, and CodedBlockPatternChroma is equal to 2 for the macroblock mbAddrN, the 4x4 chroma block with chroma4x4BlkIdxN of the chroma component iCbCr of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, transBlockN is marked as not available.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

- If any of the following conditions is true, condTermFlagN is set equal to 0
  - mbAddrN is not available and the current macroblock is coded in Inter prediction mode
  - mbAddrN is available and transBlockN is not available and mb_type for the macroblock mbAddrN is not equal to I_PCM
  - The current macroblock is coded in Intra prediction mode, constrained_intra_pred_flag is equal to 1, the macroblock mbAddrN is available and coded in Inter prediction mode, and slice data partitioning is in use (nal_unit_type is in the range of 2 through 4, inclusive).
- Otherwise, if any of the following conditions is true, condTermFlagN is set equal to 1
  - mbAddrN is not available and the current macroblock is coded in Intra prediction mode
  - mb_type for the macroblock mbAddrN is equal to I_PCM
- Otherwise, condTermFlagN is set equal to the value of the coded_block_flag of the transform block transBlockN that was decoded for the macroblock mbAddrN.

The variable ctxIdxInc(ctxBlockCat) is derived by

$$ctxIdxInc(ctxBlockCat) = condTermFlagA + 2 * condTermFlagB \quad (9\text{-}13)$$

9.3.3.1.1.10 Derivation process of ctxIdxInc for the syntax element transform_size_8x8_flag

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblocks specified in subclause 6.4.8.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0.
  – mbAddrN is not available
  – transform_size_8x8_flag for the macroblock mbAddrN is equal to 0
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad (9\text{-}14)$$

9.3.3.1.2 Assignment process of ctxIdxInc using prior decoded bin values

Inputs to this process are ctxIdxOffset and binIdx.

Output of this process is ctxIdxInc.

Table 9-32 contains the specification of ctxIdxInc for the given values of ctxIdxOffset and binIdx.

For each value of ctxIdxOffset and binIdx, ctxIdxInc is derived by using some of the values of prior decoded bin values (b_0, b_1, b_2,…, b_k), where the value of the index k is less than the value of binIdx.

Table 9-32 – Specification of ctxIdxInc for specific values of ctxIdxOffset and binIdx

Value (name) of ctxIdxOffset	binIdx	ctxIdxInc
3	4	(b_3 != 0) ? 5: 6
	5	(b_3 != 0) ? 6: 7
14	2	(b_1 != 1) ? 2: 3
17	4	(b_3 != 0) ? 2: 3
27	2	(b_1 != 0) ? 4: 5
32	4	(b_3 != 0) ? 2: 3
36	2	(b_1 != 0) ? 2: 3

9.3.3.1.3 Assignment process of ctxIdxInc for syntax elements significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1

Inputs to this process are ctxIdxOffset and binIdx.

Output of this process is ctxIdxInc.

The assignment process of ctxIdxInc for syntax elements significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1 as well as for coded_block_flag depends on categories of different blocks denoted by the variable ctxBlockCat. The specification of these block categories is given in Table 9-33.

Table 9-33 – Specification of ctxBlockCat for the different blocks

Block description	maxNumCoeff	ctxBlockCat
block of luma DC transform coefficient levels (i.e., list Intra16x16DCLevel as described in subclause 7.4.5.3)	16	0
block of luma AC transform coefficient levels (i.e., list Intra16x16ACLevel[i] as described in subclause 7.4.5.3)	15	1
block of 16 luma transform coefficient levels (i.e., list LumaLevel[i] as described in subclause 7.4.5.3)	16	2
block of chroma DC transform coefficient levels	4 * NumC8x8	3
block of chroma AC transform coefficient levels	15	4
block of 64 luma transform coefficient levels (i.e., list LumaLevel8x8[i] as described in subclause 7.4.5.3)	64	5

Let the variable levelListIdx be set equal to the index of the list of transform coefficient levels as specified in subclause 7.4.5.3.

For the syntax elements significant_coeff_flag and last_significant_coeff_flag in blocks with ctxBlockCat < 5 and ctxBlockCat != 3, the variable ctxIdxInc is derived by

ctxIdxInc = levelListIdx (9-15)

where levelListIdx ranges from 0 to maxNumCoeff – 2, inclusive.

For the syntax elements significant_coeff_flag and last_significant_coeff_flag in blocks with ctxBlockCat = = 3, the variable ctxIdxInc is derived by

ctxIdxInc = Min(levelListIdx / NumC8x8, 2) (9-16)

where levelListIdx ranges from 0 to 4 * NumC8x8 – 2, inclusive.

For the syntax elements significant_coeff_flag and last_significant_coeff_flag in 8x8 luma blocks with ctxBlockCat = = 5, Table 9-34 contains the specification of ctxIdxInc for the given values of levelListIdx, where levelListIdx ranges from 0 to 62, inclusive.

Table 9-34 – Mapping of scanning position to ctxIdxInc for ctxBlockCat = = 5

levelListIdx	ctxIdxInc for significant_coeff_flag (frame coded macroblocks)	ctxIdxInc for significant_coeff_flag (field coded macroblocks)	ctxIdxInc for last_significant_coeff_flag	levelListIdx	ctxIdxInc for significant_coeff_flag (frame coded macroblocks)	ctxIdxInc for significant_coeff_flag (field coded macroblocks)	ctxIdxInc for last_significant_coeff_flag
0	0	0	0	**32**	7	9	3
1	1	1	1	**33**	6	9	3
2	2	1	1	**34**	11	10	3
3	3	2	1	**35**	12	10	3
4	4	2	1	**36**	13	8	3
5	5	3	1	**37**	11	11	3
6	5	3	1	**38**	6	12	3
7	4	4	1	**39**	7	11	3
8	4	5	1	**40**	8	9	4
9	3	6	1	**41**	9	9	4
10	3	7	1	**42**	14	10	4
11	4	7	1	**43**	10	10	4
12	4	7	1	**44**	9	8	4
13	4	8	1	**45**	8	13	4
14	5	4	1	**46**	6	13	4
15	5	5	1	**47**	11	9	4
16	4	6	2	**48**	12	9	5
17	4	9	2	**49**	13	10	5
18	4	10	2	**50**	11	10	5
19	4	10	2	**51**	6	8	5
20	3	8	2	**52**	9	13	6
21	3	11	2	**53**	14	13	6
22	6	12	2	**54**	10	9	6
23	7	11	2	**55**	9	9	6
24	7	9	2	**56**	11	10	7

levelListIdx	ctxIdxInc for significant_coeff_flag (frame coded macroblocks)	ctxIdxInc for significant_coeff_flag (field coded macroblocks)	ctxIdxInc for last_significant_coeff_flag	levelListIdx	ctxIdxInc for significant_coeff_flag (frame coded macroblocks)	ctxIdxInc for significant_coeff_flag (field coded macroblocks)	ctxIdxInc for last_significant_coeff_flag
25	7	9	2	**57**	12	10	7
26	8	10	2	**58**	13	14	7
27	9	10	2	**59**	11	14	7
28	10	8	2	**60**	14	14	8
29	9	11	2	**61**	10	14	8
30	8	12	2	**62**	12	14	8
31	7	11	2				

Let numDecodAbsLevelEq1 denotes the accumulated number of decoded transform coefficient levels with absolute value equal to 1, and let numDecodAbsLevelGt1 denotes the accumulated number of decoded transform coefficient levels with absolute value greater than 1. Both numbers are related to the same transform coefficient block, where the current decoding process takes place. Then, for decoding of coeff_abs_level_minus1, ctxIdxInc for coeff_abs_level_minus1 is specified depending on binIdx as follows.

– If binIdx is equal to 0, ctxIdxInc is derived by

ctxIdxInc = ((numDecodAbsLevelGt1 != 0) ? 0: Min(4, 1 + numDecodAbsLevelEq1)) (9-17)

– Otherwise (binIdx is greater than 0), ctxIdxInc is derived by

ctxIdxInc = 5 + Min(4 – (ctxBlockCat == 3), numDecodAbsLevelGt1) (9-18)

9.3.3.2 Arithmetic decoding process

Inputs to this process are the bypassFlag, ctxIdx as derived in subclause 9.3.3.1, and the state variables codIRange and codIOffset of the arithmetic decoding engine.

Output of this process is the value of the bin.

Figure 9-2 illustrates the whole arithmetic decoding process for a single bin. For decoding the value of a bin, the context index ctxIdx is passed to the arithmetic decoding process DecodeBin(ctxIdx), which is specified as follows.

– If bypassFlag is equal to 1, DecodeBypass( ) as specified in subclause 9.3.3.2.3 is invoked.

– Otherwise, if bypassFlag is equal to 0 and ctxIdx is equal to 276, DecodeTerminate( ) as specified in subclause 9.3.3.2.4 is invoked.

– Otherwise (bypassFlag is equal to 0 and ctxIdx is not equal to 276), DecodeDecision( ) as specified in subclause 9.3.3.2.1 is applied.

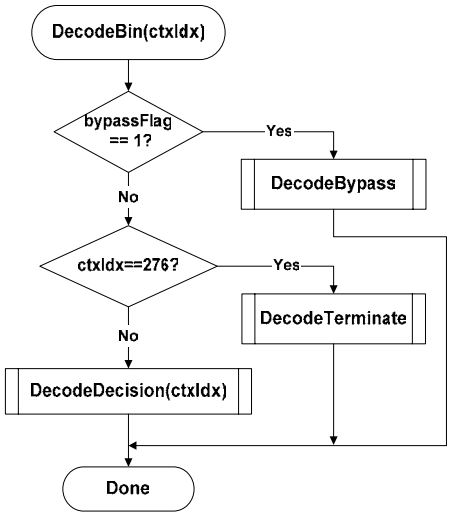


Figure 9-2 – Overview of the arithmetic decoding process for a single bin (informative)

NOTE – Arithmetic coding is based on the principle of recursive interval subdivision. Given a probability estimation p(0) and p(1) = 1 – p(0) of a binary decision (0, 1), an initially given code sub-interval with the range codIRange will be subdivided into two sub-intervals having range p(0) * codIRange and codIRange – p(0) * codIRange, respectively. Depending on the decision, which has been observed, the corresponding sub-interval will be chosen as the new code interval, and a binary code string pointing into that interval will represent the sequence of observed binary decisions. It is useful to distinguish between the most probable symbol (MPS) and the least probable symbol (LPS), so that binary decisions have to be identified as either MPS or LPS, rather than 0 or 1. Given this terminology, each context is specified by the probability p_{LPS} of the LPS and the value of MPS (valMPS), which is either 0 or 1.

The arithmetic core engine in this Recommendation | International Standard has three distinct properties:

– The probability estimation is performed by means of a finite-state machine with a table-based transition process between 64 different representative probability states { p_{LPS}(pStateIdx) | 0 <= pStateIdx < 64 } for the LPS probability p_{LPS}. The numbering of the states is arranged in such a way that the probability state with index pStateIdx = 0 corresponds to an LPS probability value of 0.5, with decreasing LPS probability towards higher state indices.

– The range codIRange representing the state of the coding engine is quantised to a small set $\{Q_1,\ldots,Q_4\}$ of pre-set quantisation values prior to the calculation of the new interval range. Storing a table containing all 64x4 pre-computed product values of $Q_i * p_{LPS}$(pStateIdx) allows a multiplication-free approximation of the product codIRange * p_{LPS}(pStateIdx).

– For syntax elements or parts thereof for which an approximately uniform probability distribution is assumed to be given a separate simplified encoding and decoding bypass process is used.

9.3.3.2.1 Arithmetic decoding process for a binary decision

Inputs to this process are ctxIdx, codIRange, and codIOffset.

Outputs of this process are the decoded value binVal, and the updated variables codIRange and codIOffset.

Figure 9-3 shows the flowchart for decoding a single decision (DecodeDecision).

1. The value of the variable codIRangeLPS is derived as follows.

– Given the current value of codIRange, the variable qCodIRangeIdx is derived by

qCodIRangeIdx =(codIRange >> 6) & 0x03 (9-19)

– Given qCodIRangeIdx and pStateIdx associated with ctxIdx, the value of the variable rangeTabLPS as specified in Table 9-35 is assigned to codIRangeLPS:

codIRangeLPS = rangeTabLPS[pStateIdx][qCodIRangeIdx] (9-20)

2. The variable codIRange is set equal to codIRange – codIRangeLPS and the following applies.

– If codIOffset is greater than or equal to codIRange, the variable binVal is set equal to 1 - valMPS, codIOffset is decremented by codIRange, and codIRange is set equal to codIRangeLPS.

– Otherwise, the variable binVal is set equal to valMPS.

Given the value of binVal, the state transition is performed as specified in subclause 9.3.3.2.1.1. Depending on the current value of codIRange, renormalization is performed as specified in subclause 9.3.3.2.2.

9.3.3.2.1.1 State transition process

Inputs to this process are the current pStateIdx, the decoded value binVal and valMPS values of the context variable associated with ctxIdx.

Outputs of this process are the updated pStateIdx and valMPS of the context variable associated with ctxIdx.

Depending on the decoded value binVal, the update of the two variables pStateIdx and valMPS associated with ctxIdx is derived as follows:

```
if( binVal  = =  valMPS )
    pStateIdx = transIdxMPS( pStateIdx )
else {                                                    (9-21)
    if( pStateIdx  = =  0 )
        valMPS = 1 – valMPS
    pStateIdx = transIdxLPS( pStateIdx )
}
```

Table 9-36 specifies the transition rules transIdxMPS( ) and transIdxLPS( ) after decoding the value of valMPS and 1 – valMPS, respectively.

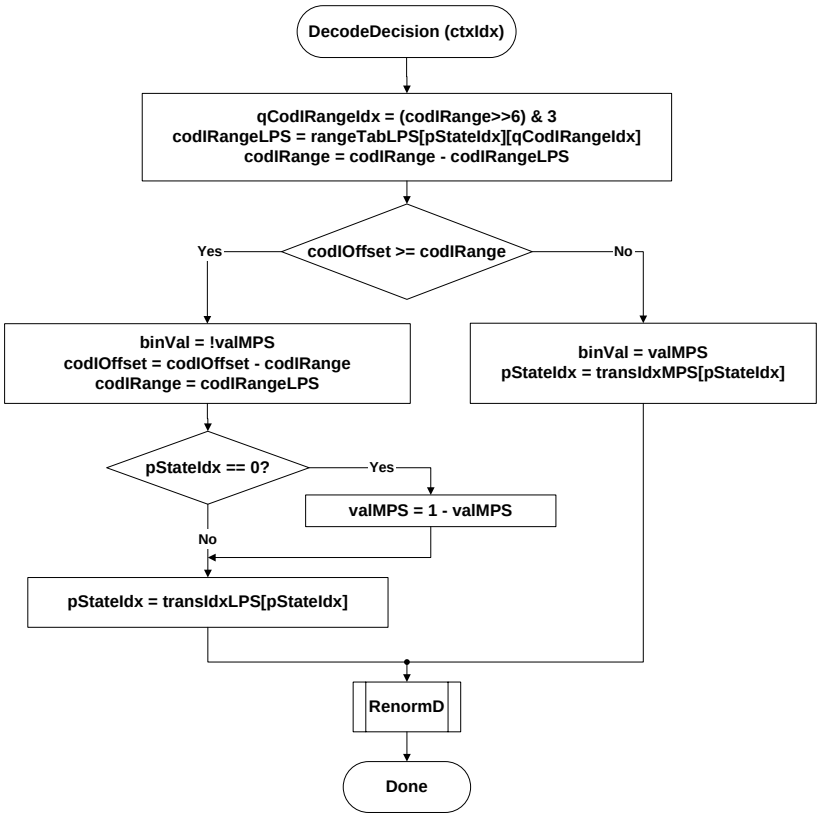


Figure 9-3 – Flowchart for decoding a decision

Table 9-35 – Specification of rangeTabLPS depending on pStateIdx and qCodIRangeIdx

pStateIdx	qCodIRangeIdx				pStateIdx	qCodIRangeIdx			
	0	1	2	3		0	1	2	3
0	128	176	208	240	**32**	27	33	39	45
1	128	167	197	227	**33**	26	31	37	43
2	128	158	187	216	**34**	24	30	35	41
3	123	150	178	205	**35**	23	28	33	39
4	116	142	169	195	**36**	22	27	32	37
5	111	135	160	185	**37**	21	26	30	35
6	105	128	152	175	**38**	20	24	29	33
7	100	122	144	166	**39**	19	23	27	31
8	95	116	137	158	**40**	18	22	26	30
9	90	110	130	150	**41**	17	21	25	28
10	85	104	123	142	**42**	16	20	23	27
11	81	99	117	135	**43**	15	19	22	25
12	77	94	111	128	**44**	14	18	21	24
13	73	89	105	122	**45**	14	17	20	23
14	69	85	100	116	**46**	13	16	19	22
15	66	80	95	110	**47**	12	15	18	21
16	62	76	90	104	**48**	12	14	17	20
17	59	72	86	99	**49**	11	14	16	19
18	56	69	81	94	**50**	11	13	15	18
19	53	65	77	89	**51**	10	12	15	17
20	51	62	73	85	**52**	10	12	14	16
21	48	59	69	80	**53**	9	11	13	15
22	46	56	66	76	**54**	9	11	12	14
23	43	53	63	72	**55**	8	10	12	14
24	41	50	59	69	**56**	8	9	11	13
25	39	48	56	65	**57**	7	9	11	12
26	37	45	54	62	**58**	7	9	10	12
27	35	43	51	59	**59**	7	8	10	11
28	33	41	48	56	**60**	6	8	9	11
29	32	39	46	53	**61**	6	7	9	10
30	30	37	43	50	**62**	6	7	8	9
31	29	35	41	48	**63**	2	2	2	2

Table 9-36 – State transition table

pStateIdx	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
transIdxLPS	0	0	1	2	2	4	4	5	6	7	8	9	9	11	11	12
transIdxMPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
pStateIdx	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
transIdxLPS	13	13	15	15	16	16	18	18	19	19	21	21	22	22	23	24
transIdxMPS	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
pStateIdx	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**
transIdxLPS	24	25	26	26	27	27	28	29	29	30	30	30	31	32	32	33
transIdxMPS	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
pStateIdx	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**
transIdxLPS	33	33	34	34	35	35	35	36	36	36	37	37	37	38	38	63
transIdxMPS	49	50	51	52	53	54	55	56	57	58	59	60	61	62	62	63

9.3.3.2.2 Renormalization process in the arithmetic decoding engine

Inputs to this process are bits from slice data and the variables codIRange and codIOffset.

Outputs of this process are the updated variables codIRange and codIOffset.

A flowchart of the renormalization is shown in Figure 9-4. The current value of codIRange is first compared to 0x0100 and further steps are specified as follows.

– If codIRange is greater than or equal to 0x0100, no renormalization is needed and the RenormD process is finished;

– Otherwise (codIRange is less than 0x0100), the renormalization loop is entered. Within this loop, the value of codIRange is doubled, i.e., left-shifted by 1 and a single bit is shifted into codIOffset by using read_bits(1).

The bitstream shall not contain data that results in a value of codIOffset being greater than or equal to codIRange upon completion of this process.

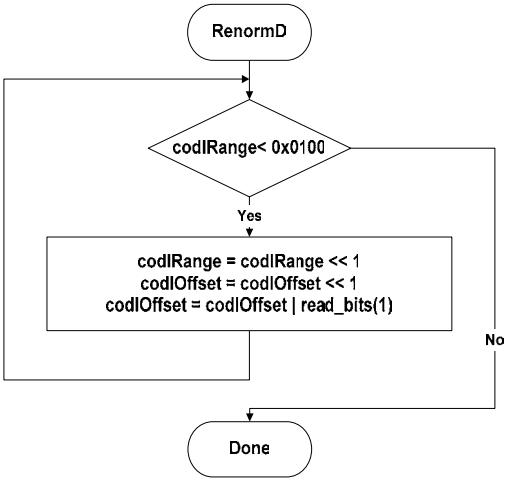


Figure 9-4 – Flowchart of renormalization

9.3.3.2.3 Bypass decoding process for binary decisions

Inputs to this process are bits from slice data and the variables codIRange and codIOffset.

Outputs of this process are the updated variable codIOffset and the decoded value binVal.

The bypass decoding process is invoked when bypassFlag is equal to 1. Figure 9-5 shows a flowchart of the corresponding process.

First, the value of codIOffset is doubled, i.e., left-shifted by 1 and a single bit is shifted into codIOffset by using read_bits(1). Then, the value of codIOffset is compared to the value of codIRange and further steps are specified as follows.

– If codIOffset is greater than or equal to codIRange, the variable binVal is set equal to 1 and codIOffset is decremented by codIRange.

– Otherwise (codIOffset is less than codIRange), the variable binVal is set equal to 0.

The bitstream shall not contain data that results in a value of codIOffset being greater than or equal to codIRange upon completion of this process.

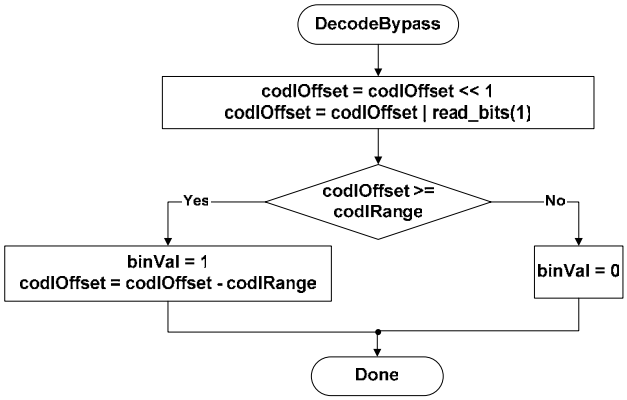


Figure 9-5 – Flowchart of bypass decoding process

9.3.3.2.4 Decoding process for binary decisions before termination

Inputs to this process are bits from slice data and the variables codIRange and codIOffset.

Outputs of this process are the updated variables codIRange and codIOffset, and the decoded value binVal.

This special decoding routine applies to decoding of end_of_slice_flag and of the bin indicating the I_PCM mode corresponding to ctxIdx equal to 276. Figure 9-6 shows the flowchart of the corresponding decoding process, which is specified as follows.

First, the value of codIRange is decremented by 2. Then, the value of codIOffset is compared to the value of codIRange and further steps are specified as follows.

– If codIOffset is greater than or equal to codIRange, the variable binVal is set equal to 1, no renormalization is carried out, and CABAC decoding is terminated. The last bit inserted in register codIOffset is equal to 1. When decoding end_of_slice_flag, this last bit inserted in register codIOffset is interpreted as rbsp_stop_one_bit.

– Otherwise (codIOffset is less than codIRange), the variable binVal is set equal to 0 and renormalization is performed as specified in subclause 9.3.3.2.2.

NOTE – This procedure may also be implemented using DecodeDecision(ctxIdx) with ctxIdx = 276. In the case where the decoded value is equal to 1, seven more bits would be read by DecodeDecision(ctxIdx) and a decoding process would have to adjust its bitstream pointer accordingly to properly decode following syntax elements.

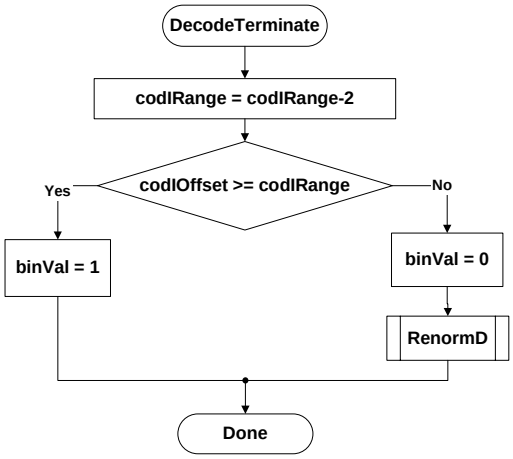


Figure 9-6 – Flowchart of decoding a decision before termination

9.3.4 Arithmetic encoding process (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Inputs to this process are decisions that are to be encoded and written.

Outputs of this process are bits that are written to the RBSP.

This informative subclause describes an arithmetic encoding engine that matches the arithmetic decoding engine described in subclause 9.3.3.2. The encoding engine is essentially symmetric with the decoding engine, i.e., procedures are called in the same order. The following procedures are described in this section: InitEncoder, EncodeDecision, EncodeBypass, EncodeTerminate, which correspond to InitDecoder, DecodeDecision, DecodeBypass, and DecodeTerminate, respectively. The state of the arithmetic encoding engine is represented by a value of the variable codILow pointing to the lower end of a sub-interval and a value of the variable codIRange specifying the corresponding range of that sub-interval.

9.3.4.1 Initialisation process for the arithmetic encoding engine (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

This process is invoked before encoding the first macroblock of a slice, and after encoding any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data for a macroblock of type I_PCM.

Outputs of this process are the values codILow, codIRange, firstBitFlag, bitsOutstanding, and symCnt of the arithmetic encoding engine.

In the initialisation procedure of the encoder, codILow is set equal to 0, and codIRange is set equal to 0x01FE. Furthermore, a firstBitFlag is set equal to 1, and bitsOutstanding and symCnt counters are set equal to 0.

NOTE – The minimum register precision required for codILow is 10 bits and for CodIRange is 9 bits. The precision required for the counters bitsOutstanding and symCnt should be sufficiently large to prevent overflow of the related registers. When MaxBinCountInSlice denotes the maximum total number of binary decisions to encode in one slice, the minimum register precision required for the variables bitsOutstanding and symCnt is given by Ceil(Log2(MaxBinCountInSlice + 1)).

9.3.4.2 Encoding process for a binary decision (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Inputs to this process are the context index ctxIdx, the value of binVal to be encoded, and the variables codIRange, codILow and symCnt.

Outputs of this process are the variables codIRange, codILow, and symCnt.

Figure 9-7 shows the flowchart for encoding a single decision. In a first step, the variable codIRangeLPS is derived as follows.

Given the current value of codIRange, codIRange is mapped to the index qCodIRangeIdx of a quantised value of codIRange by using Equation 9-19. The value of qCodIRangeIdx and the value of pStateIdx associated with ctxIdx are

used to determine the value of the variable rangeTabLPS as specified in Table 9-35, which is assigned to codIRangeLPS. The value of codIRange – codIRangeLPS is assigned to codIRange.

In a second step, the value of binVal is compared to valMPS associated with ctxIdx. When binVal is different from valMPS, codIRange is added to codILow and codIRange is set equal to the value codIRangeLPS. Given the encoded decision, the state transition is performed as specified in subclause 9.3.3.2.1.1. Depending on the current value of codIRange, renormalization is performed as specified in subclause 9.3.4.3. Finally, the variable symCnt is incremented by 1.

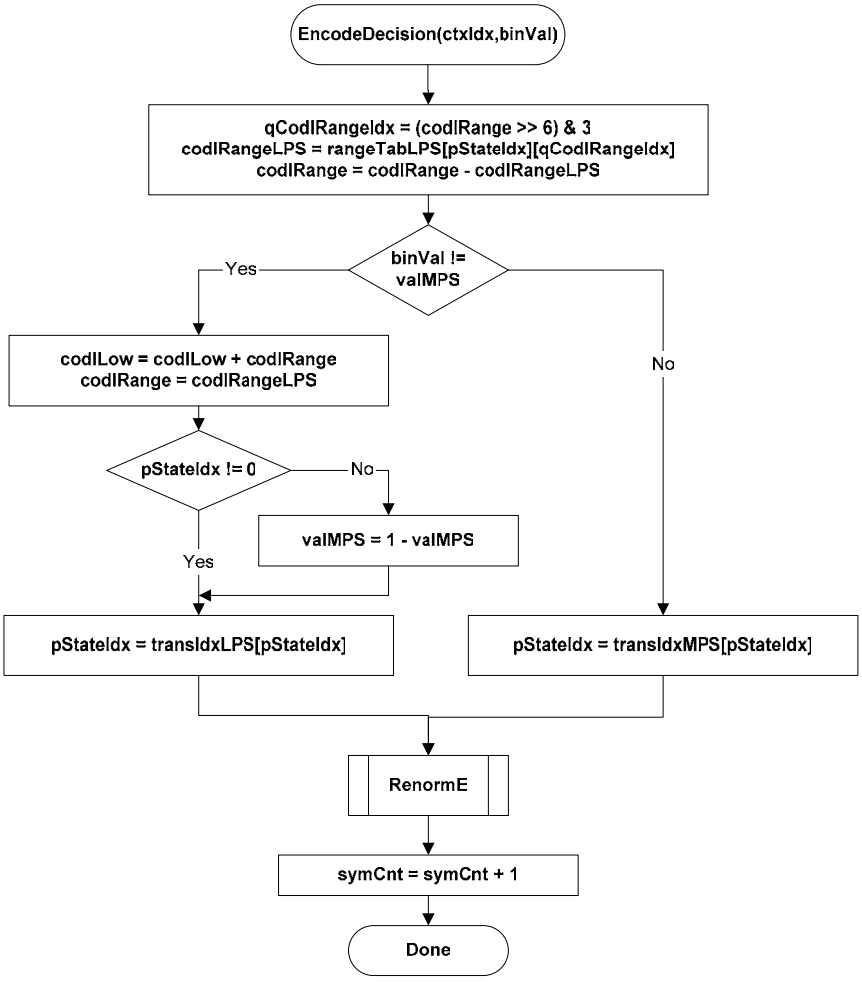


Figure 9-7 – Flowchart for encoding a decision

9.3.4.3 Renormalization process in the arithmetic encoding engine (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Inputs to this process are the variables codIRange, codILow, firstBitFlag, and bitsOutstanding.

Outputs of this process are zero or more bits written to the RBSP and the updated variables codIRange, codILow, firstBitFlag, and bitsOutstanding.

Renormalization is illustrated in Figure 9-8.

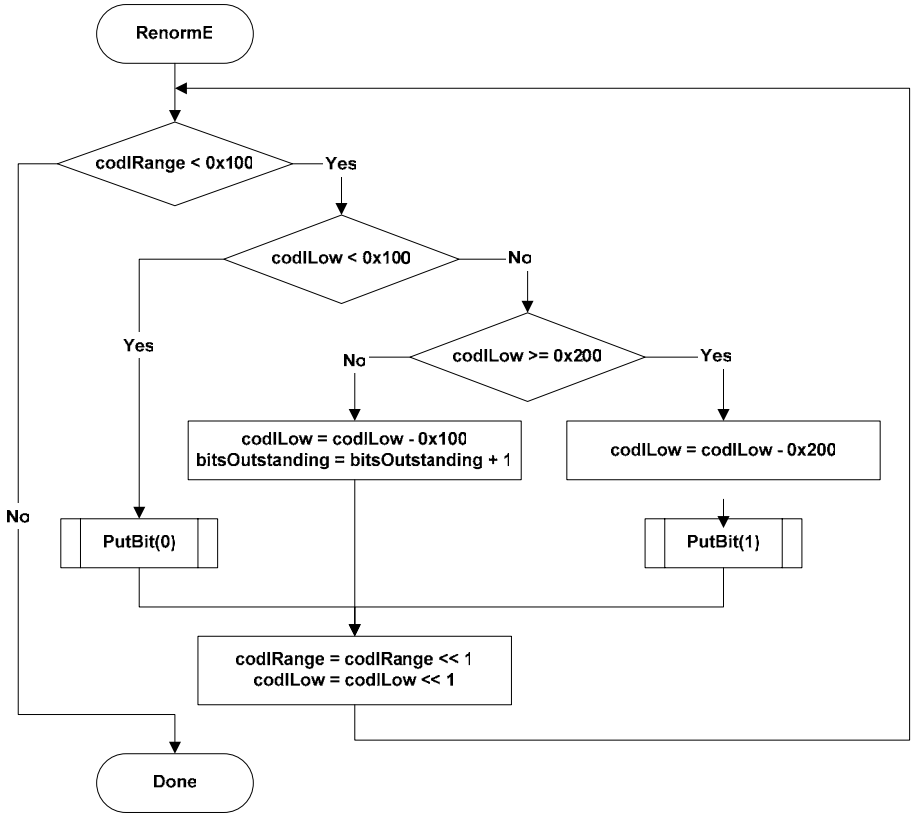


Figure 9-8 – Flowchart of renormalization in the encoder

The PutBit( ) procedure described in Figure 9-9 provides carry over control. It uses the function WriteBits(B, N) that writes N bits with value B to the bitstream and advances the bitstream pointer by N bit positions. This function assumes the existence of a bitstream pointer with an indication of the position of the next bit to be written to the bitstream by the encoding process.

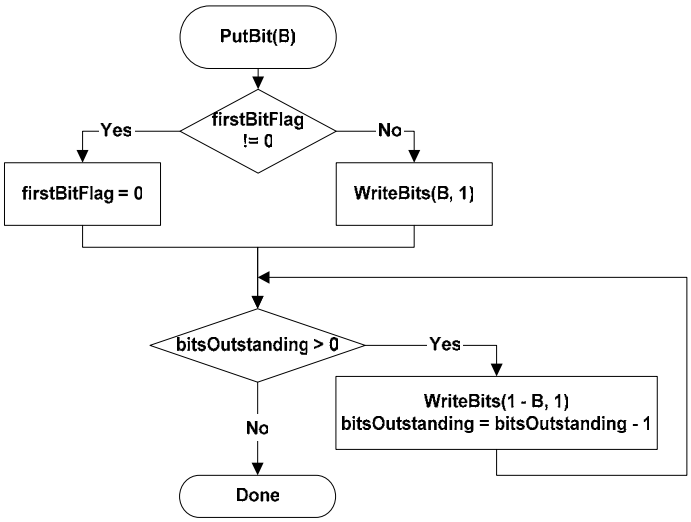


Figure 9-9 – Flowchart of PutBit(B)

9.3.4.4 Bypass encoding process for binary decisions (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Inputs to this process are the variables binVal, codILow, codIRange, bitsOutstanding, and symCnt.

Output of this process is a bit written to the RBSP and the updated variables codILow, bitsOutstanding, and symCnt.

This encoding process applies to all binary decisions with bypassFlag equal to 1. Renormalization is included in the specification of this process as given in Figure 9-10.

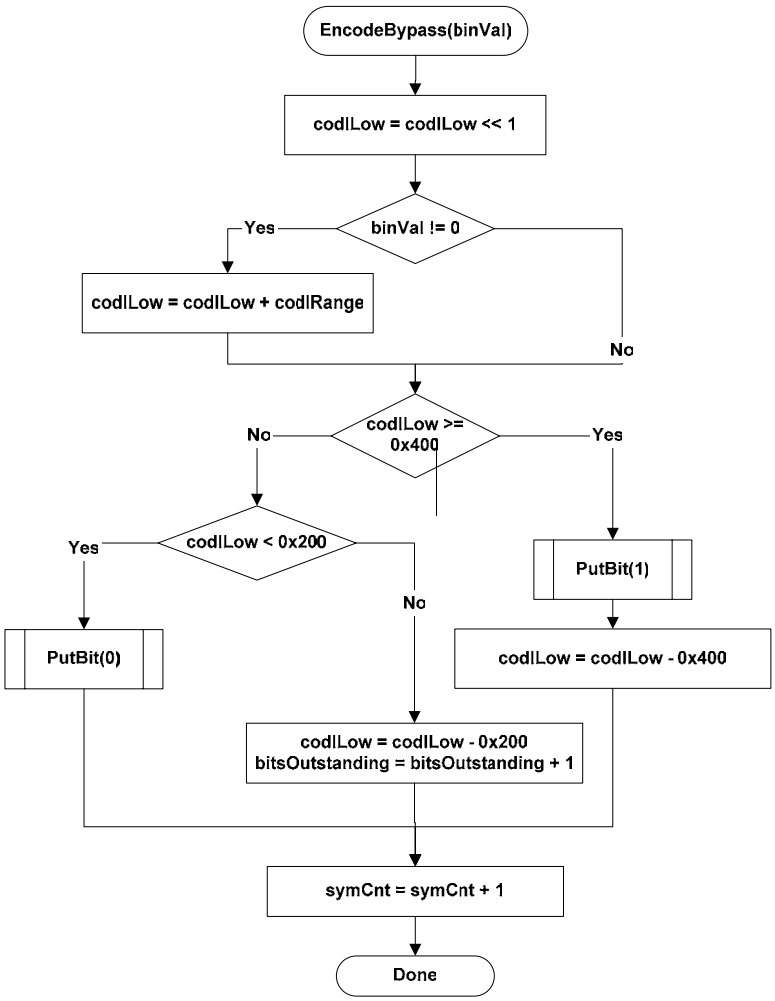


Figure 9-10 – Flowchart of encoding bypass

9.3.4.5 Encoding process for a binary decision before termination (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Inputs to this process are the variables binVal, codIRange, codILow, bitsOutstanding, and symCnt.

Outputs of this process are zero or more bits written to the RBSP and the updated variables codILow, codIRange, bitsOutstanding, and symCnt.

This encoding routine shown in Figure 9-11 applies to encoding of the end_of_slice_flag and of the bin indicating the I_PCM mb_type both associated with ctxIdx equal to 276.

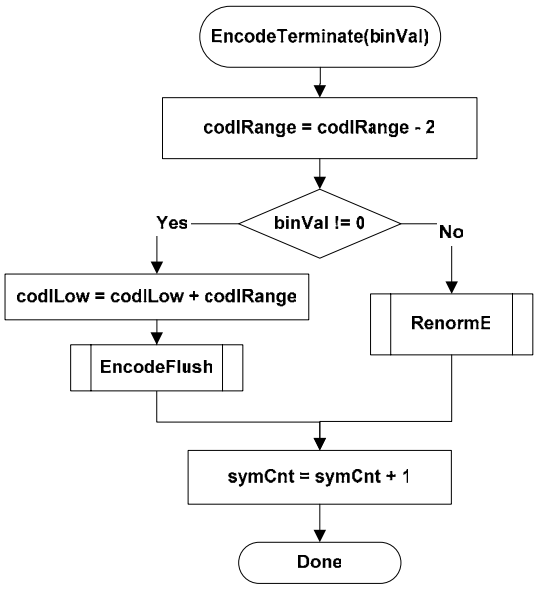


Figure 9-11 – Flowchart of encoding a decision before termination

When the value of binVal to encode is equal to 1, CABAC encoding is terminated and the flushing procedure shown in Figure 9-12 is applied. In this flushing procedure, the last bit written by WriteBits(B, N) is equal to 1. When encoding end_of_slice_flag, this last bit is interpreted as the rbsp_stop_one_bit.

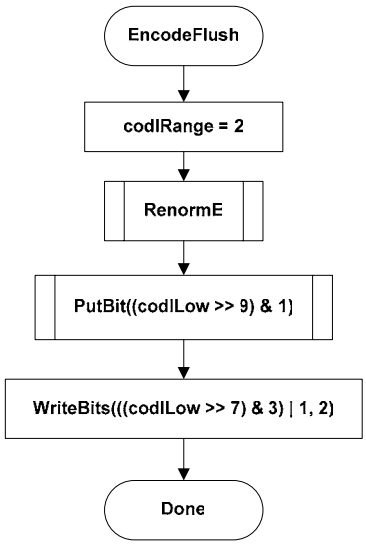


Figure 9-12 – Flowchart of flushing at termination

9.3.4.6 Byte stuffing process (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

This process is invoked after encoding the last macroblock of the last slice of a picture and after encapsulation.

Inputs to this process are the number of bytes NumBytesInVclNALunits of all VCL NAL units of a picture, the number of macroblocks PicSizeInMbs in the picture, and the number of binary symbols BinCountsInNALunits resulting from encoding the contents of all VCL NAL units of the picture.

Outputs of this process are zero or more bytes appended to the NAL unit.

Let the variable k be set equal to Ceil((Ceil(3 * (32 * BinCountsInNALunits – RawMbBits * PicSizeInMbs) ÷ 1024) – NumBytesInVclNALunits) ÷ 3). Depending on the variable k the following applies.

– If k is less than or equal to 0, no cabac_zero_word is appended to the NAL unit.

– Otherwise (k is greater than 0), the 3-byte sequence 0x000003 is appended k times to the NAL unit after encapsulation, where the first two bytes 0x0000 represent a cabac_zero_word and the third byte 0x03 represents an emulation_prevention_three_byte.

Annex A
Profiles and levels

(This annex forms an integral part of this Recommendation | International Standard)

Profiles and levels specify restrictions on bitstreams and hence limits on the capabilities needed to decode the bitstreams. Profiles and levels may also be used to indicate interoperability points between individual decoder implementations.

NOTE 1 – This Recommendation | International Standard does not include individually selectable "options" at the decoder, as this would increase interoperability difficulties.

Each profile specifies a subset of algorithmic features and limits that shall be supported by all decoders conforming to that profile.

NOTE 2 – Encoders are not required to make use of any particular subset of features supported in a profile.

Each level specifies a set of limits on the values that may be taken by the syntax elements of this Recommendation | International Standard. The same set of level definitions is used with all profiles, but individual implementations may support a different level for each supported profile. For any given profile, levels generally correspond to decoder processing load and memory capability.

A.1 Requirements on video decoder capability

Capabilities of video decoders conforming to this Recommendation | International Standard are specified in terms of the ability to decode video streams conforming to the constraints of profiles and levels specified in this Annex. For each such profile, the level supported for that profile shall also be expressed.

Specific values are specified in this annex for the syntax elements profile_idc and level_idc. All other values of profile_idc and level_idc are reserved for future use by ITU-T | ISO/IEC.

NOTE – Decoders should not infer that when a reserved value of profile_idc or level_idc falls between the values specified in this Recommendation | International Standard that this indicates intermediate capabilities between the specified profiles or levels, as there are no restrictions on the method to be chosen by ITU-T | ISO/IEC for the use of such future reserved values.

A.2 Profiles

A.2.1 Baseline profile

Bitstreams conforming to the Baseline profile shall obey the following constraints:

– Only I and P slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Sequence parameter sets shall have frame_mbs_only_flag equal to 1.

– The syntax elements chroma_format_idc, bit_depth_luma_minus8, bit_depth_chroma_minus8, qpprime_y_zero_transform_bypass_flag, and seq_scaling_matrix_present_flag shall not be present in sequence parameter sets.

– Picture parameter sets shall have weighted_pred_flag and weighted_bipred_idc both equal to 0.

– Picture parameter sets shall have entropy_coding_mode_flag equal to 0.

– Picture parameter sets shall have num_slice_groups_minus1 in the range of 0 to 7, inclusive.

– The syntax elements transform_8x8_mode_flag, pic_scaling_matrix_present_flag, and second_chroma_qp_index_offset shall not be present in picture parameter sets.

– The syntax element level_prefix shall not be greater than 15.

– The level constraints specified for the Baseline profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the Baseline profile is specified by profile_idc being equal to 66.

Decoders conforming to the Baseline profile at a specific level shall be capable of decoding all bitstreams in which profile_idc is equal to 66 or constraint_set0_flag is equal to 1 and in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

A.2.2 Main profile

Bitstreams conforming to the Main profile shall obey the following constraints:

– Only I, P, and B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– The syntax elements chroma_format_idc, bit_depth_luma_minus8, bit_depth_chroma_minus8, qpprime_y_zero_transform_bypass_flag, and seq_scaling_matrix_present_flag shall not be present in sequence parameter sets.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– The syntax elements transform_8x8_mode_flag, pic_scaling_matrix_present_flag, and second_chroma_qp_index_offset shall not be present in picture parameter sets.

– The syntax element level_prefix shall not be greater than 15 (when present).

– The level constraints specified for the Main profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the Main profile is specified by profile_idc being equal to 77.

Decoders conforming to the Main profile at a specified level shall be capable of decoding all bitstreams in which profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

A.2.3 Extended profile

Bitstreams conforming to the Extended profile shall obey the following constraints:

– Sequence parameter sets shall have direct_8x8_inference_flag equal to 1.

– The syntax elements chroma_format_idc, bit_depth_luma_minus8, bit_depth_chroma_minus8, qpprime_y_zero_transform_bypass_flag, and seq_scaling_matrix_present_flag shall not be present in sequence parameter sets.

– Picture parameter sets shall have entropy_coding_mode_flag equal to 0.

– Picture parameter sets shall have num_slice_groups_minus1 in the range of 0 to 7, inclusive.

– The syntax elements transform_8x8_mode_flag, pic_scaling_matrix_present_flag, and second_chroma_qp_index_offset shall not be present in picture parameter sets.

– The syntax element level_prefix shall not be greater than 15 (when present).

– The level constraints specified for the Extended profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the Extended profile is specified by profile_idc being equal to 88.

Decoders conforming to the Extended profile at a specified level shall be capable of decoding all bitstreams in which profile_idc is equal to 88 or constraint_set2_flag is equal to 1 and in which level_idc represents a level less than or equal to specified level.

Decoders conforming to the Extended profile at a specified level shall also be capable of decoding all bitstreams in which profile_idc is equal to 66 or constraint_set0_flag is equal to 1, in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

A.2.4 High profile

Bitstreams conforming to the High profile shall obey the following constraints:

– Only I, P, and B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– Sequence parameter sets shall have chroma_format_idc in the range of 0 to 1 inclusive.

– Sequence parameter sets shall have bit_depth_luma_minus8 equal to 0 only.

– Sequence parameter sets shall have bit_depth_chroma_minus8 equal to 0 only.

– Sequence parameter sets shall have qpprime_y_zero_transform_bypass_flag equal to 0 only.

– The level constraints specified for the High profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High profile is specified by profile_idc being equal to 100. Decoders conforming to the High profile at a specific level shall be capable of decoding all bitstreams in which level_idc and constraint_set3_flag represents a level less than or equal to the specified level and either or both of the following conditions are true:

– profile_idc is equal to 77 or 100, or

– constraint_set1_flag is equal to 1.

A.2.5 High 10 profile

Bitstreams conforming to the High 10 profile shall obey the following constraints:

– Only I, P, and B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– Sequence parameter sets shall have chroma_format_idc in the range of 0 to 1 inclusive.

– Sequence parameter sets shall have bit_depth_luma_minus8 in the range of 0 to 2 inclusive.

– Sequence parameter sets shall have bit_depth_chroma_minus8 in the range of 0 to 2 inclusive.

– Sequence parameter sets shall have qpprime_y_zero_transform_bypass_flag equal to 0 only.

– The level constraints specified for the High 10 profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 10 profile is specified by profile_idc being equal to 110. Decoders conforming to the High 10 profile at a specific level shall be capable of decoding all bitstreams in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level and either or both of the following conditions are true:

– profile_idc is equal to 77, 100, or 110, or

– constraint_set1_flag is equal to 1.

A.2.6 High 4:2:2 profile

Bitstreams conforming to the High 4:2:2 profile shall obey the following constraints:

– Only I, P, and B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– Sequence parameter sets shall have chroma_format_idc in the range of 0 to 2 inclusive

– Sequence parameter sets shall have bit_depth_luma_minus8 in the range of 0 to 2 inclusive.

– Sequence parameter sets shall have bit_depth_chroma_minus8 in the range of 0 to 2 inclusive.

– Sequence parameter sets shall have qpprime_y_zero_transform_bypass_flag equal to 0 only.

– The level constraints specified for the High 4:2:2 profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 4:2:2 profile is specified by profile_idc being equal to 122. Decoders conforming to the High 4:2:2 profile at a specific level shall be capable of decoding all bitstreams in which level_idc and constraint_set3_flag represents a level less than or equal to the specified level and either or both of the following conditions are true:

– profile_idc is equal to 77, 100, 110, or 122, or

– constraint_set1_flag is equal to 1.

A.2.7 High 4:4:4 profile

Bitstreams conforming to the High 4:4:4 profile shall obey the following constraints:

– Only I, P, and B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– Sequence parameter sets shall have bit_depth_luma_minus8 in the range of 0 to 4 inclusive.

– Sequence parameter sets shall have bit_depth_chroma_minus8 in the range of 0 to 4 inclusive.

– The level constraints specified for the High 4:4:4 profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 4:4:4 profile is specified by profile_idc being equal to 144. Decoders conforming to the High 4:4:4 profile at a specific level shall be capable of decoding all bitstreams in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level and either or both of the following conditions are true:

– profile_idc is equal to 77, 100, 110, 122, or 144, or

– constraint_set1_flag is equal to 1.

A.3 Levels

The following is specified for expressing the constraints in this Annex.

– Let access unit n be the n-th access unit in decoding order with the first access unit being access unit 0.

– Let picture n be the primary coded picture or the corresponding decoded picture of access unit n.

A.3.1 Level limits common to the Baseline, Main, and Extended profiles

Let the variable fR be derived as follows.

– If picture n is a frame, fR is set equal to 1 ÷ 172.

– Otherwise (picture n is a field), fR is set equal to 1 ÷ (172 * 2).

Bitstreams conforming to the Baseline, Main, or Extended profiles at a specified level shall obey the following constraints:

a) The nominal removal time of access unit n (with n > 0) from the CPB as specified in subclause C.1.2, satisfies the constraint that $t_{r,n}(n) - t_r(n - 1)$ is greater than or equal to Max(PicSizeInMbs ÷ MaxMBPS, fR), where MaxMBPS is the value specified in Table A-1 that applies to picture n – 1, and PicSizeInMbs is the number of macroblocks in picture n – 1.

b) The difference between consecutive output times of pictures from the DPB as specified in subclause C.2.2, satisfies the constraint that $\Delta t_{o,dpb}(n)$ >= Max(PicSizeInMbs ÷ MaxMBPS, fR), where MaxMBPS is the value specified in Table A-1 for picture n, and PicSizeInMbs is the number of macroblocks of picture n, provided that picture n is a picture that is output and is not the last picture of the bitstream that is output.

c) The sum of the NumBytesInNALunit variables for access unit 0 is less than or equal to 384 * (PicSizeInMbs + MaxMBPS * ($t_r(0) - t_{r,n}(0)$)) ÷ MinCR, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture 0 and PicSizeInMbs is the number of macroblocks in picture 0.

d) The sum of the NumBytesInNALunit variables for access unit n (with n > 0) is less than or equal to 384 * MaxMBPS * ($t_r(n) - t_r(n – 1)$) ÷ MinCR, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture n.

e) PicWidthInMbs * FrameHeightInMbs <= MaxFS, where MaxFS is specified in Table A-1

f) PicWidthInMbs <= Sqrt(MaxFS * 8)

g) FrameHeightInMbs <= Sqrt(MaxFS * 8)

h) max_dec_frame_buffering <= MaxDpbSize, where MaxDpbSize is equal to Min(1024 * MaxDPB / (PicWidthInMbs * FrameHeightInMbs * 384), 16) and MaxDPB is given in Table A-1 in units of 1024 bytes.

i) For the VCL HRD parameters, BitRate[SchedSelIdx] <= 1000 * MaxBR and CpbSize[SchedSelIdx] <= 1000 * MaxCPB for at least one value of SchedSelIdx, where BitRate[SchedSelIdx] is given by Equation E-37 and CpbSize[SchedSelIdx] is given by Equation E-38 when vcl_hrd_parameters_present_flag is equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of 1000 bits/s and 1000 bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1, inclusive.

j) For the NAL HRD parameters, BitRate[SchedSelIdx] <= 1200 * MaxBR and CpbSize[SchedSelIdx] <= 1200 * MaxCPB for at least one value of SchedSelIdx, where BitRate[SchedSelIdx] is given by Equation E-37 and CpbSize[SchedSelIdx] is given by Equation E-38 when nal_hrd_parameters_present_flag equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of 1200 bits/s and 1200 bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1.

k) Vertical motion vector component range luma motion vectors does not exceed MaxVmvR in units of luma frame samples, where MaxVmvR is specified in Table A-1

NOTE 1 – When chroma_format_idc is equal to 1 and the current macroblock is a field macroblock, the motion vector component range for chroma motion vectors may exceed MaxVmvR in units of luma frame samples, due to the method of deriving chroma motion vectors as specified in subclause 8.4.1.4.

l) Horizontal motion vector range does not exceed the range of -2048 to 2047.75, inclusive, in units of luma samples

m) Number of motion vectors per two consecutive macroblocks in decoding order (also applying to the total from the last macroblock of a slice and the first macroblock of the next slice in decoding order, and in particular also applying to the total from the last macroblock of the last slice of a picture and the first macroblock of the first slice of the next picture in decoding order) does not exceed MaxMvsPer2Mb, where MaxMvsPer2Mb is specified in Table A-1. The number of motion vectors for each macroblock is the value of the variable MvCnt after the completion of the intra or inter prediction process for the macroblock.

n) Number of bits of macroblock_layer( ) data for any macroblock is not greater than 3200. Depending on entropy_coding_mode_flag, the bits of macroblock_layer( ) data are counted as follows.

– If entropy_coding_mode_flag is equal to 0, the number of bits of macroblock_layer( ) data is given by the number of bits in the macroblock_layer( ) syntax structure for a macroblock.

– Otherwise (entropy_coding_mode_flag is equal to 1), the number of bits of macroblock_layer( ) data for a macroblock is given by the number of times read_bits(1) is called in subclauses 9.3.3.2.2 and 9.3.3.2.3 when parsing the macroblock_layer( ) associated with the macroblock.

Table A-1 specifies the limits for each level. Entries marked "-" in Table A-1 denote the absence of a corresponding limit. For purposes of comparison of level capabilities, a level shall be considered to be a lower (higher) level than some other level if the level appears nearer to the top (bottom) row of Table A-1 than the other level.

A level to which the bitstream conforms shall be indicated by the syntax elements level_idc and constraint_set3_flag as follows.

– If level_idc is equal to 11 and constraint_set3_flag is equal to 1, the indicated level is level 1b.

– Otherwise (level_idc is not equal to 11 or constraint_set3_flag is not equal to 1), level_idc shall be set equal to a value of ten times the level number specified in Table A-1 and constraint_set3_flag shall be set equal to 0.

Table A-1 – Level limits

Level number	Max macroblock processing rate MaxMBPS (MB/s)	Max frame size MaxFS (MBs)	Max decoded picture buffer size MaxDPB (1024 bytes for 4:2:0)	Max video bit rate MaxBR (1000 bits/s, 1200 bits/s, cpbBrVclFactor bits/s, or cpbBrNalFactor bits/s)	Max CPB size MaxCPB (1000 bits, 1200 bits, cpbBrVclFactor bits, or cpbBrNalFactor bits)	Vertical MV component range MaxVmvR (luma frame samples)	Min compression ratio MinCR	Max number of motion vectors per two consecutive MBs MaxMvsPer2Mb
1	1 485	99	148.5	64	175	[-64,+63.75]	2	-
1b	1 485	99	148.5	128	350	[-64,+63.75]	2	-
1.1	3 000	396	337.5	192	500	[-128,+127.75]	2	-
1.2	6 000	396	891.0	384	1 000	[-128,+127.75]	2	-
1.3	11 880	396	891.0	768	2 000	[-128,+127.75]	2	-
2	11 880	396	891.0	2 000	2 000	[-128,+127.75]	2	-
2.1	19 800	792	1 782.0	4 000	4 000	[-256,+255.75]	2	-
2.2	20 250	1 620	3 037.5	4 000	4 000	[-256,+255.75]	2	-
3	40 500	1 620	3 037.5	10 000	10 000	[-256,+255.75]	2	32
3.1	108 000	3 600	6 750.0	14 000	14 000	[-512,+511.75]	4	16
3.2	216 000	5 120	7 680.0	20 000	20 000	[-512,+511.75]	4	16
4	245 760	8 192	12 288.0	20 000	25 000	[-512,+511.75]	4	16
4.1	245 760	8 192	12 288.0	50 000	62 500	[-512,+511.75]	2	16
4.2	522 240	8 704	13 056.0	50 000	62 500	[-512,+511.75]	2	16
5	589 824	22 080	41 400.0	135 000	135 000	[-512,+511.75]	2	16
5.1	983 040	36 864	69 120.0	240 000	240 000	[-512,+511.75]	2	16

Levels with non-integer level numbers in Table A-1 are referred to as “intermediate levels”.

NOTE 2 – All levels have the same status, but some applications may choose to use only the integer-numbered levels.

Informative subclause A.3.4 shows the effect of these limits on frame rates for several example picture formats.

A.3.2 Level limits common to the High, High 10, High 4:2:2, and High 4:4:4 profiles

Let the variable fR be derived as follows.

– If picture n is a frame, fR is set equal to 1 ÷ 172.

– Otherwise (picture n is a field), fR is set equal to 1 ÷ (172 * 2).

Bitstreams conforming to the High, High 10, High 4:2:2, or High 4:4:4 profiles at a specified level shall obey the following constraints:

a) The nominal removal time of access unit n (with n > 0) from the CPB as specified in subclause C.1.2, satisfies the constraint that $t_{r,n}(n) - t_r(n - 1)$ is greater than or equal to Max(PicSizeInMbs ÷ MaxMBPS, fR), where MaxMBPS is the value specified in Table A-1 that applies to picture n – 1, and PicSizeInMbs is the number of macroblocks in picture n – 1.

b) The difference between consecutive output times of pictures from the DPB as specified in subclause C.2.2, satisfies the constraint that $\Delta t_{o,dpb}(n)$ >= Max(PicSizeInMbs ÷ MaxMBPS, fR), where MaxMBPS is the value specified in Table A-1 for picture n, and PicSizeInMbs is the number of macroblocks of picture n, provided that picture n is a picture that is output and is not the last picture of the bitstream that is output.

c) PicWidthInMbs * FrameHeightInMbs <= MaxFS, where MaxFS is specified in Table A-1

d) PicWidthInMbs <= Sqrt(MaxFS * 8)

e) FrameHeightInMbs <= Sqrt(MaxFS * 8)

f) max_dec_frame_buffering <= MaxDpbSize, where MaxDpbSize is equal to Min(1024 * MaxDPB / (PicWidthInMbs * FrameHeightInMbs * 384), 16) and MaxDPB is specified in Table A-1.

g) Vertical motion vector component range does not exceed MaxVmvR in units of luma frame samples, where MaxVmvR is specified in Table A-1.

h) Horizontal motion vector range does not exceed the range of -2048 to 2047.75, inclusive, in units of luma samples.

i) Number of motion vectors per two consecutive macroblocks in decoding order (also applying to the total from the last macroblock of a slice and the first macroblock of the next slice in decoding order) does not exceed MaxMvsPer2Mb, where MaxMvsPer2Mb is specified in Table A-1. The number of motion vectors for each macroblock is value of the variable MvCnt after the completion of the intra or inter prediction process for the macroblock.

j) Number of bits of macroblock_layer( ) data for any macroblock is not greater than 128 + RawMbBits. Depending on entropy_coding_mode_flag, the bits of macroblock_layer( ) data are counted as follows.

   – If entropy_coding_mode_flag is equal to 0, the number of bits of macroblock_layer( ) data is given by the number of bits in the macroblock_layer( ) syntax structure for a macroblock.

   – Otherwise (entropy_coding_mode_flag is equal to 1), the number of bits of macroblock_layer( ) data for a macroblock is given by the number of times read_bits(1) is called in subclauses 9.3.3.2.2 and 9.3.3.2.3 when parsing the macroblock_layer( ) associated with the macroblock.

Table A-1 specifies the limits for each level. Entries marked "-" in Table A-1 denote the absence of a corresponding limit.

A level to which the bitstream conforms shall be indicated by the syntax element level_idc as follows.

– If level_idc is equal to 9, the indicated level is level 1b.

– Otherwise (level_idc is not equal to 9), level_idc shall be set equal to a value of ten times the level number specified in Table A-1.

A.3.3 Profile-specific level limits

a) In bitstreams conforming to the Main, High, High 10, High 4:2:2, or High 4:4:4 profiles, the removal time of access unit 0 shall satisfy the constraint that the number of slices in picture 0 is less than or equal to (PicSizeInMbs + MaxMBPS * (t_r(0) - $t_{r,n}$(0))) ÷ SliceRate, where SliceRate is the value specified in Table A-4 that applies to picture 0.

b) In bitstreams conforming to the Main, High, High 10, High 4:2:2, or High 4:4:4 profiles, the difference between consecutive removal time of access units n and n - 1 (with n > 0) shall satisfy the constraint that the number of slices in picture n is less than or equal to MaxMBPS * (t_r(n) - t_r(n - 1)) ÷ SliceRate, where SliceRate is the value specified in Table A-4 that applies to picture n.

c) In bitstreams conforming to the Main, High, High 10, High 4:2:2, or High 4:4:4 profiles, sequence parameter sets shall have direct_8x8_inference_flag equal to 1 for the levels specified in Table A-4.

   NOTE 1 – direct_8x8_inference_flag is not relevant to the Baseline profile as it does not allow B slice types (specified in subclause A.2.1), and direct_8x8_inference_flag is equal to 1 for all levels of the Extended profile (specified in subclause A.2.3).

d) In bitstreams conforming to the Main, High, High 10, High 4:2:2, or High 4:4:4 or Extended profiles, sequence parameter sets shall have frame_mbs_only_flag equal to 1 for the levels specified in Table A-4 for the Main, High, High 10, High 4:2:2, and High 4:4:4 profiles and in Table A-5 for the Extended profile.

   NOTE 2 – frame_mbs_only_flag is equal to 1 for all levels of the Baseline profile (specified in subclause A.2.1).

e) In bitstreams conforming to the Main, High, High 10, High 4:2:2, or High 4:4:4 or Extended profiles, the value of sub_mb_type in B macroblocks shall not be equal to B_Bi_8x4, B_Bi_4x8, or B_Bi_4x4 for the levels in which MinLumaBiPredSize is shown as 8x8 in Table A-4 for the Main, High, High 10, High 4:2:2, and High 4:4:4 profiles and in Table A-5 for the Extended profile.

f) In bitstreams conforming to the Baseline and Extended profiles, ($xInt_{max}$ – $xInt_{min}$ + 6) * ($yInt_{max}$ – $yInt_{min}$ + 6) <= MaxSubMbRectSize in macroblocks coded with mb_type equal to P_8x8, P_8x8ref0 or B_8x8 for all

invocations of the process specified in subclause 8.4.2.2.1 used to generate the predicted luma sample array for a single reference picture list (reference picture list 0 or reference picture list 1) for each 8x8 sub-macroblock, where NumSubMbPart(sub_mb_type) > 1, where MaxSubMbRectSize is specified in Table A-3 for the Baseline profile and in Table A-5 for the Extended profile and

- $xInt_{min}$ is the minimum value of $xInt_L$ among all luma sample predictions for the sub-macroblock
- $xInt_{max}$ is the maximum value of $xInt_L$ among all luma sample predictions for the sub-macroblock
- $yInt_{min}$ is the minimum value of $yInt_L$ among all luma sample predictions for the sub-macroblock
- $yInt_{max}$ is the maximum value of $yInt_L$ among all luma sample predictions for the sub-macroblock

g) In bitstreams conforming to the High, High 10, High 4:2:2, or High 4:4:4 profile, for the VCL HRD parameters, BitRate[SchedSelIdx] <= cpbBrVclFactor * MaxBR and CpbSize[SchedSelIdx] <= cpbBrVclFactor * MaxCPB for at least one value of SchedSelIdx, where cpbBrVclFactor is specified in Table A-2, BitRate[SchedSelIdx] is specified by Equation E-37 and CpbSize[SchedSelIdx] is specified by Equation E-38 when vcl_hrd_parameters_present_flag is equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of cpbBrVclFactor bits/s and cpbBrVclFactor bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1, inclusive.

h) In bitstreams conforming to the High, High 10, High 4:2:2, or High 4:4:4 profile, for the NAL HRD parameters, BitRate[SchedSelIdx] <= cpbBrNalFactor * MaxBR and CpbSize[SchedSelIdx] <= cpbBrNalFactor * MaxCPB for at least one value of SchedSelIdx, where cpbBrNalFactor is specified in Table A-2, BitRate[SchedSelIdx] is specified by Equation E-37 and CpbSize[SchedSelIdx] is specified by Equation E-38 when nal_hrd_parameters_present_flag equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of cpbBrNalFactor bits/s and cpbBrNalFactor bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1.

Table A-2 – Specification of cpbBrVclFactor and cpbBrNalFactor

Profile	cpbBrVclFactor	cpbBrNalFactor
High	1 250	1 500
High 10	3 000	3 600
High 4:2:2	4 000	4 800
High 4:4:4	4 000	4 800

A.3.3.1 Baseline profile limits

Table A-3 specifies limits for each level that are specific to bitstreams conforming to the Baseline profile. Entries marked "-" in Table A-3 denote the absence of a corresponding limit.

Table A-3 – Baseline profile level limits

Level number	MaxSubMbRectSize
1	576
1b	576
1.1	576
1.2	576
1.3	576
2	576
2.1	576
2.2	576
3	576
3.1	-
3.2	-
4	-
4.1	-
4.2	-
5	-
5.1	-

A.3.3.2 Main, High, High 10, High 4:2:2, or High 4:4:4 profile limits

Table A-4 specifies limits for each level that are specific to bitstreams conforming to the Main, High, High 10, High 4:2:2, or High 4:4:4 profiles. Entries marked "-" in Table A-4 denote the absence of a corresponding limit.

Table A-4 – Main, High, High 10, High 4:2:2, or High 4:4:4 profile level limits

Level number	SliceRate	MinLumaBiPredSize	direct_8x8_inference_flag	frame_mbs_only_flag
1	-	-	-	1
1b	-	-	-	1
1.1	-	-	-	1
1.2	-	-	-	1
1.3	-	-	-	1
2	-	-	-	1
2.1	-	-	-	-
2.2	-	-	-	-
3	22	-	1	-
3.1	60	8x8	1	-
3.2	60	8x8	1	-
4	60	8x8	1	-
4.1	24	8x8	1	-
4.2	24	8x8	1	1
5	24	8x8	1	1
5.1	24	8x8	1	1

A.3.3.3 Extended Profile Limits

Table A-5 specifies limits for each level that are specific to bitstreams conforming to the Extended profile. Entries marked "-" in Table A-5 denote the absence of a corresponding limit.

Table A-5 – Extended profile level limits

Level number	MaxSubMbRectSize	MinLumaBiPredSize	frame_mbs_only_flag
1	576	-	1
1b	576	-	1
1.1	576	-	1
1.2	576	-	1
1.3	576	-	1
2	576	-	1
2.1	576	-	-
2.2	576	-	-
3	576	-	-
3.1	-	8x8	-
3.2	-	8x8	-
4	-	8x8	-
4.1	-	8x8	-
4.2	-	8x8	1
5	-	8x8	1
5.1	-	8x8	1

A.3.4 Effect of level limits on frame rate (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Table A-6 – Maximum frame rates (frames per second) for some example frame sizes

Level:					**1**	**1b**	**1.1**	**1.2**	**1.3**	**2**	**2.1**
Max frame size (macroblocks):					**99**	**99**	**396**	**396**	**396**	**396**	**792**
Max macroblocks/second:					**1 485**	**1 485**	**3 000**	**6 000**	**11 880**	**11 880**	**19 800**
Max frame size (samples):					25 344	25 344	101 376	101 376	101 376	101 376	202 752
Max samples/second:					380 160	380 160	768 000	1 536 000	3 041 280	3 041 280	5 068 800
Format	**Luma Width**	**Luma Height**	**MBs Total**	**Luma Samples**							
SQCIF	**128**	**96**	48	12 288	30.9	30.9	62.5	125.0	172.0	172.0	172.0
QCIF	**176**	**144**	99	25 344	15.0	15.0	30.3	60.6	120.0	120.0	172.0
QVGA	**320**	**240**	300	76 800	-	-	10.0	20.0	39.6	39.6	66.0
525 SIF	**352**	**240**	330	84 480	-	-	9.1	18.2	36.0	36.0	60.0
CIF	**352**	**288**	396	101 376	-	-	7.6	15.2	30.0	30.0	50.0
525 HHR	**352**	**480**	660	168 960	-	-	-	-	-	-	30.0
625 HHR	**352**	**576**	792	202 752	-	-	-	-	-	-	25.0
VGA	**640**	**480**	1 200	307 200	-	-	-	-	-	-	-
525 4SIF	**704**	**480**	1 320	337 920	-	-	-	-	-	-	-
525 SD	**720**	**480**	1 350	345 600	-	-	-	-	-	-	-
4CIF	**704**	**576**	1 584	405 504	-	-	-	-	-	-	-
625 SD	**720**	**576**	1 620	414 720	-	-	-	-	-	-	-
SVGA	**800**	**600**	1 900	486 400	-	-	-	-	-	-	-
XGA	**1024**	**768**	3 072	786 432	-	-	-	-	-	-	-
720p HD	**1280**	**720**	3 600	921 600	-	-	-	-	-	-	-
4VGA	**1280**	**960**	4 800	1 228 800	-	-	-	-	-	-	-
SXGA	**1280**	**1024**	5 120	1 310 720	-	-	-	-	-	-	-
525 16SIF	**1408**	**960**	5 280	1 351 680	-	-	-	-	-	-	-
16CIF	**1408**	**1152**	6 336	1 622 016	-	-	-	-	-	-	-
4SVGA	**1600**	**1200**	7 500	1 920 000	-	-	-	-	-	-	-
1080 HD	**1920**	**1088**	8 160	2 088 960	-	-	-	-	-	-	-
2Kx1K	**2048**	**1024**	8 192	2 097 152	-	-	-	-	-	-	-
2Kx1080	**2048**	**1088**	8 704	2 228 224	-	-	-	-	-	-	-
4XGA	**2048**	**1536**	12 288	3 145 728	-	-	-	-	-	-	-
16VGA	**2560**	**1920**	19 200	4 915 200	-	-	-	-	-	-	-
3616x1536 (2.35:1)	**3616**	**1536**	21 696	5 554 176	-	-	-	-	-	-	-
3672x1536 (2.39:1)	**3680**	**1536**	22 080	5 652 480	-	-	-	-	-	-	-
4Kx2K	**4096**	**2048**	32 768	8 388 608	-	-	-	-	-	-	-
4096x2304 (16:9)	**4096**	**2304**	36 864	9 437 184	-	-	-	-	-	-	-

Table A-6 (continued) – Maximum frame rates (frames per second) for some example frame sizes

Level:					**2.2**	**3**	**3.1**	**3.2**	**4**	**4.1**	**4.2**
Max frame size (macroblocks):					**1 620**	**1 620**	**3 600**	**5 120**	**8 192**	**8 192**	**8 704**
Max macroblocks/second:					**20 250**	**40 500**	**108 000**	**216 000**	**245 760**	**245 760**	**522 240**
Max frame size (samples):					414 720	414 720	921 600	1 310 720	2 097 152	2 097 152	2 228 224
Max samples/second:					5 184 000	10 368 000	27 648 000	55 296 000	62 914 560	62 914 560	133 693 440
Format	**Luma Width**	**Luma Height**	**MBs Total**	**Luma Samples**							
SQCIF	**128**	**96**	48	12 288	172.0	172.0	172.0	172.0	172.0	172.0	172.0
QCIF	**176**	**144**	99	25 344	172.0	172.0	172.0	172.0	172.0	172.0	172.0
QVGA	**320**	**240**	300	76 800	67.5	135.0	172.0	172.0	172.0	172.0	172.0
525 SIF	**352**	**240**	330	84 480	61.4	122.7	172.0	172.0	172.0	172.0	172.0
CIF	**352**	**288**	396	101 376	51.1	102.3	172.0	172.0	172.0	172.0	172.0
525 HHR	**352**	**480**	660	168 960	30.7	61.4	163.6	172.0	172.0	172.0	172.0
625 HHR	**352**	**576**	792	202 752	25.6	51.1	136.4	172.0	172.0	172.0	172.0
VGA	**640**	**480**	1 200	307 200	16.9	33.8	90.0	172.0	172.0	172.0	172.0
525 4SIF	**704**	**480**	1 320	337 920	15.3	30.7	81.8	163.6	172.0	172.0	172.0
525 SD	**720**	**480**	1 350	345 600	15.0	30.0	80.0	160.0	172.0	172.0	172.0
4CIF	**704**	**576**	1 584	405 504	12.8	25.6	68.2	136.4	155.2	155.2	172.0
625 SD	**720**	**576**	1 620	414 720	12.5	25.0	66.7	133.3	151.7	151.7	172.0
SVGA	**800**	**600**	1 900	486 400	-	-	56.8	113.7	129.3	129.3	172.0
XGA	**1024**	**768**	3 072	786 432	-	-	35.2	70.3	80.0	80.0	172.0
720p HD	**1280**	**720**	3 600	921 600	-	-	30.0	60.0	68.3	68.3	145.1
4VGA	**1280**	**960**	4 800	1 228 800	-	-	-	45.0	51.2	51.2	108.8
SXGA	**1280**	**1024**	5 120	1 310 720	-	-	-	42.2	48.0	48.0	102.0
525 16SIF	**1408**	**960**	5 280	1 351 680	-	-	-	-	46.5	46.5	98.9
16CIF	**1408**	**1152**	6 336	1 622 016	-	-	-	-	38.8	38.8	82.4
4SVGA	**1600**	**1200**	7 500	1 920 000	-	-	-	-	32.8	32.8	69.6
1080 HD	**1920**	**1088**	8 160	2 088 960	-	-	-	-	30.1	30.1	64.0
2Kx1K	**2048**	**1024**	8 192	2 097 152	-	-	-	-	30.0	30.0	63.8
2Kx1080	**2048**	**1088**	8 704	2 228 224	-	-	-	-	-	-	60.0
4XGA	**2048**	**1536**	12 288	3 145 728	-	-	-	-	-	-	-
16VGA	**2560**	**1920**	19 200	4 915 200	-	-	-	-	-	-	-
3616x1536 (2.35:1)	**3616**	**1536**	21 696	5 554 176	-	-	-	-	-	-	-
3672x1536 (2.39:1)	**3680**	**1536**	22 080	5 652 480	-	-	-	-	-	-	-
4Kx2K	**4096**	**2048**	32 768	8 388 608	-	-	-	-	-	-	-
4096x2304 (16:9)	**4096**	**2304**	36 864	9 437 184	-	-	-	-	-	-	-

Table A-6 (concluded) – Maximum frame rates (frames per second) for some example frame sizes

Level:					**5**	**5.1**
Max frame size (macroblocks):					**22 080**	**36 864**
Max macroblocks/second:					**589 824**	**983 040**
Max frame size (samples):					5 652 480	9 437 184
Max samples/second:					150 994 944	251 658 240
Format	**Luma Width**	**Luma Height**	**MBs Total**	**Luma Samples**		
SQCIF	**128**	**96**	48	12 288	172.0	172.0
QCIF	**176**	**144**	99	25 344	172.0	172.0
QVGA	**320**	**240**	300	76 800	172.0	172.0
525 SIF	**352**	**240**	330	84 480	172.0	172.0
CIF	**352**	**288**	396	101 376	172.0	172.0
525 HHR	**352**	**480**	660	168 960	172.0	172.0
625 HHR	**352**	**576**	792	202 752	172.0	172.0
VGA	**640**	**480**	1 200	307 200	172.0	172.0
525 4SIF	**704**	**480**	1 320	337 920	172.0	172.0
525 SD	**720**	**480**	1 350	345 600	172.0	172.0
4CIF	**704**	**576**	1 584	405 504	172.0	172.0
625 SD	**720**	**576**	1 620	414 720	172.0	172.0
SVGA	**800**	**600**	1 900	486 400	172.0	172.0
XGA	**1024**	**768**	3 072	786 432	172.0	172.0
720p HD	**1280**	**720**	3 600	921 600	163.8	172.0
4VGA	**1280**	**960**	4 800	1 228 800	122.9	172.0
SXGA	**1280**	**1024**	5 120	1 310 720	115.2	172.0
525 16SIF	**1408**	**960**	5 280	1 351 680	111.7	172.0
16CIF	**1408**	**1152**	6 336	1 622 016	93.1	155.2
4SVGA	**1600**	**1200**	7 500	1 920 000	78.6	131.1
1080 HD	**1920**	**1088**	8 160	2 088 960	72.3	120.5
2Kx1K	**2048**	**1024**	8 192	2 097 152	72.0	120.0
2Kx1080	**2048**	**1088**	8 704	2 228 224	67.8	112.9
4XGA	**2048**	**1536**	12 288	3 145 728	48.0	80.0
16VGA	**2560**	**1920**	19 200	4 915 200	30.7	51.2
3616x1536 (2.35:1)	**3616**	**1536**	21 696	5 554 176	27.2	45.3
3672x1536 (2.39:1)	**3680**	**1536**	22 080	5 652 480	26.7	44.5
4Kx2K	**4096**	**2048**	32 768	8 388 608	-	30.0
4096x2304 (16:9)	**4096**	**2304**	36 864	9 437 184	-	26.7

The following should be noted.

– This Recommendation | International Standard is a variable-frame-size specification. The specific frame sizes in Table A-6 are illustrative examples only.

– As used in Table A-6, "525" refers to typical use for environments using 525 analogue scan lines (of which approximately 480 lines contain the visible picture region), and "625" refers to environments using 625 analogue scan lines (of which approximately 576 lines contain the visible picture region).

– XGA is also known as (aka) XVGA, 4SVGA aka UXGA, 16XGA aka 4Kx3K, CIF aka 625 SIF, 625 HHR aka 2CIF aka half 625 D-1, aka half 625 ITU-R BT.601, 525 SD aka 525 D-1 aka 525 ITU-R BT.601, 625 SD aka 625 D-1 aka 625 ITU-R BT.601.

– Frame rates given are correct for progressive scan modes. The frame rates are also correct for interlaced video coding for the cases of frame height divisible by 32.

Annex B
Byte stream format

(This annex forms an integral part of this Recommendation | International Standard)

This annex specifies syntax and semantics of a byte stream format specified for use by applications that deliver some or all of the NAL unit stream as an ordered stream of bytes or bits within which the locations of NAL unit boundaries need to be identifiable from patterns in the data, such as ITU-T Rec. H.222.0 | ISO/IEC 13818-1 systems or ITU-T Rec. H.320 systems. For bit-oriented delivery, the bit order for the byte stream format is specified to start with the MSB of the first byte, proceed to the LSB of the first byte, followed by the MSB of the second byte, etc.

The byte stream format consists of a sequence of byte stream NAL unit syntax structures. Each byte stream NAL unit syntax structure contains one start code prefix followed by one nal_unit(NumBytesInNALunit) syntax structure. It may (and under some circumstances, it shall) also contain an additional zero_byte syntax element. It may also contain one or more additional trailing_zero_8bits syntax elements. When it is the first byte stream NAL unit in the bitstream, it may also contain one or more additional leading_zero_8bits syntax elements.

B.1 Byte stream NAL unit syntax and semantics

B.1.1 Byte stream NAL unit syntax

byte_stream_nal_unit(NumBytesInNALunit) {	C	Descriptor
while(next_bits(24) != 0x000001 && next_bits(32) != 0x00000001)		
leading_zero_8bits /* equal to 0x00 */		f(8)
if(next_bits(24) != 0x000001)		
zero_byte /* equal to 0x00 */		f(8)
start_code_prefix_one_3bytes /* equal to 0x000001 */		f(24)
nal_unit(NumBytesInNALunit)		
while(more_data_in_byte_stream( ) && next_bits(24) != 0x000001 && next_bits(32) != 0x00000001)		
trailing_zero_8bits /* equal to 0x00 */		f(8)
}		

B.1.2 Byte stream NAL unit semantics

The order of byte stream NAL units in the byte stream shall follow the decoding order of the NAL units contained in the byte stream NAL units (see subclause 7.4.1.2). The content of each byte stream NAL unit is associated with the same access unit as the NAL unit contained in the byte stream NAL unit (see subclause 7.4.1.2.3).

leading_zero_8bits is a byte equal to 0x00.

NOTE – The leading_zero_8bits syntax element can only be present in the first byte stream NAL unit of the bitstream, because (as shown in the syntax diagram of subclause B.1.1) any bytes equal to 0x00 that follow a NAL unit syntax structure and precede the four-byte sequence 0x00000001 (which is to be interpreted as a zero_byte followed by a start_code_prefix_one_3bytes) will be considered to be trailing_zero_8bits syntax elements that are part of the preceding byte stream NAL unit.

zero_byte is a single byte equal to 0x00.

When any of the following conditions are fulfilled, the zero_byte syntax element shall be present.

– the nal_unit_type within the nal_unit( ) is equal to 7 (sequence parameter set) or 8 (picture parameter set)

– the byte stream NAL unit syntax structure contains the first NAL unit of an access unit in decoding order, as specified by subclause 7.4.1.2.3.

start_code_prefix_one_3bytes is a fixed-value sequence of 3 bytes equal to 0x000001. This syntax element is called a start code prefix.

trailing_zero_8bits is a byte equal to 0x00.

B.2 Byte stream NAL unit decoding process

Input to this process consists of an ordered stream of bytes consisting of a sequence of byte stream NAL unit syntax structures.

Output of this process consists of a sequence of NAL unit syntax structures.

At the beginning of the decoding process, the decoder initialises its current position in the byte stream to the beginning of the byte stream. It then extracts and discards each leading_zero_8bits syntax element (if present), moving the current position in the byte stream forward one byte at a time, until the current position in the byte stream is such that the next four bytes in the bitstream form the four-byte sequence 0x00000001.

The decoder then performs the following step-wise process repeatedly to extract and decode each NAL unit syntax structure in the byte stream until the end of the byte stream has been encountered (as determined by unspecified means) and the last NAL unit in the byte stream has been decoded:

1. When the next four bytes in the bitstream form the four-byte sequence 0x00000001, the next byte in the byte stream (which is a zero_byte syntax element) is extracted and discarded and the current position in the byte stream is set equal to the position of the byte following this discarded byte.
2. The next three-byte sequence in the byte stream (which is a start_code_prefix_one_3bytes) is extracted and discarded and the current position in the byte stream is set equal to the position of the byte following this three-byte sequence.
3. NumBytesInNALunit is set equal to the number of bytes starting with the byte at the current position in the byte stream up to and including the last byte that precedes the location of any of the following conditions:
    a. A subsequent byte-aligned three-byte sequence equal to 0x000000, or
    b. A subsequent byte-aligned three-byte sequence equal to 0x000001, or
    c. The end of the byte stream, as determined by unspecified means.
4. NumBytesInNALunit bytes are removed from the bitstream and the current position in the byte stream is advanced by NumBytesInNALunit bytes. This sequence of bytes is nal_unit(NumBytesInNALunit) and is decoded using the NAL unit decoding process.
5. When the current position in the byte stream is not at the end of the byte stream (as determined by unspecified means) and the next bytes in the byte stream do not start with a three-byte sequence equal to 0x000001 and the next bytes in the byte stream do not start with a four byte sequence equal to 0x00000001, the decoder extracts and discards each trailing_zero_8bits syntax element, moving the current position in the byte stream forward one byte at a time, until the current position in the byte stream is such that the next bytes in the byte stream form the four-byte sequence 0x00000001 or the end of the byte stream has been encountered (as determined by unspecified means).

B.3 Decoder byte-alignment recovery (informative)

This subclause does not form an integral part of this Recommendation | International Standard.

Many applications provide data to a decoder in a manner that is inherently byte aligned, and thus have no need for the bit-oriented byte alignment detection procedure described in this subclause.

A decoder is said to have byte-alignment with a bitstream when the decoder is able to determine whether or not the positions of data in the bitstream are byte-aligned. When a decoder does not have byte alignment with the encoder's byte stream, the decoder may examine the incoming bitstream for the binary pattern '00000000 00000000 00000000 00000001' (31 consecutive bits equal to 0 followed by a bit equal to 1). The bit immediately following this pattern is the first bit of an aligned byte following a start code prefix. Upon detecting this pattern, the decoder will be byte aligned with the encoder and positioned at the start of a NAL unit in the byte stream.

Once byte aligned with the encoder, the decoder can examine the incoming byte stream for subsequent three-byte sequences 0x000001 and 0x000003.

When the three-byte sequence 0x000001 is detected, this is a start code prefix.

When the three-byte sequence 0x000003 is detected, the third byte (0x03) is an emulation_prevention_three_byte to be discarded as specified in subclause 7.4.1.

When an error in the bitstream syntax is detected (e.g., a non-zero value of the forbidden_zero_bit or one of the three-byte or four-byte sequences that are prohibited in subclause 7.4.1), the decoder may consider the detected condition as an indication that byte alignment may have been lost and may discard all bitstream data until the detection of byte alignment at a later position in the bitstream as described in this subclause.

Annex C
Hypothetical reference decoder

(This annex forms an integral part of this Recommendation | International Standard)

This annex specifies the hypothetical reference decoder (HRD) and its use to check bitstream and decoder conformance.

Two types of bitstreams are subject to HRD conformance checking for this Recommendation | International Standard. The first such type of bitstream, called Type I bitstream, is a NAL unit stream containing only the VCL NAL units and filler data NAL units for all access units in the bitstream. The second type of bitstream, called a Type II bitstream, contains, in addition to the VCL NAL units and filler data NAL units for all access units in the bitstream, at least one of the following.

– additional non-VCL NAL units other than filler data NAL units
– all leading_zero_8bits, zero_byte, start_code_prefix_one_3bytes, and trailing_zero_8bits syntax elements that form a byte stream from the NAL unit stream (as specified in Annex B)

Figure C-1 shows the types of bitstream conformance points checked by the HRD.

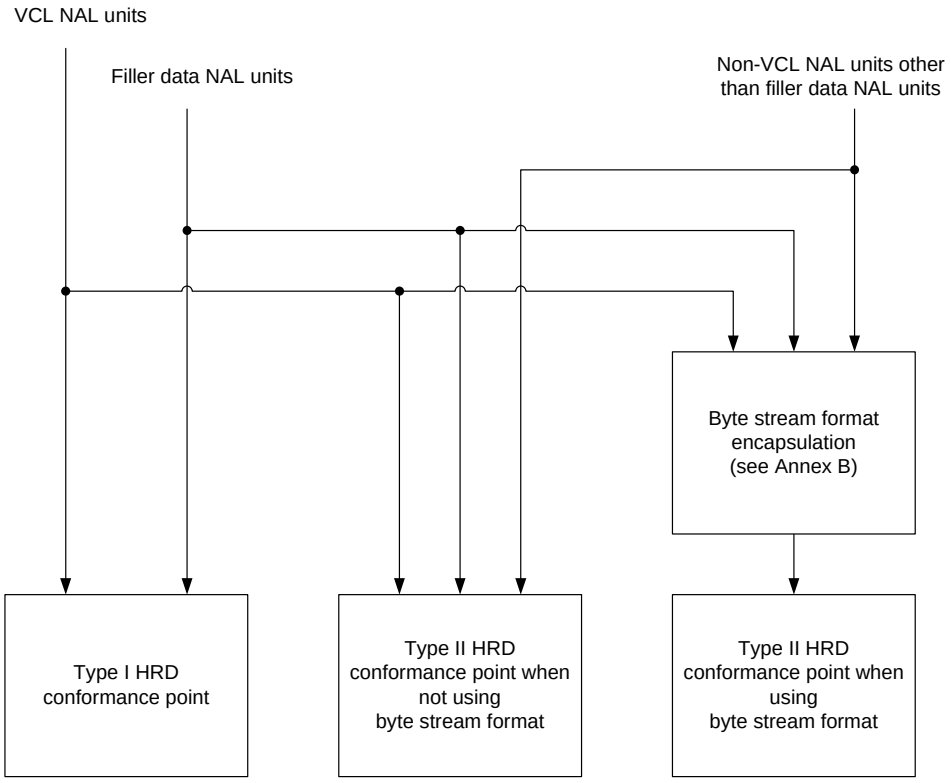


Figure C-1 – Structure of byte streams and NAL unit streams for HRD conformance checks

The syntax elements of non-VCL NAL units (or their default values for some of the syntax elements), required for the HRD, are specified in the semantic subclauses of clause 7 and Annexes D and E.

Two types of HRD parameter sets are used. The HRD parameter sets are signalled through video usability information as specified in subclauses E.1 and E.2, which is part of the sequence parameters set syntax structure.

In order to check conformance of a bitstream using the HRD, all sequence parameter sets and picture parameters sets referred to in the VCL NAL units, and corresponding buffering period and picture timing SEI messages shall be conveyed to the HRD, in a timely manner, either in the bitstream (by non-VCL NAL units), or by other means not specified in this Recommendation | International Standard.

In Annexes C, D and E, the specification for "presence" of non-VCL NAL units is also satisfied when those NAL units (or just some of them) are conveyed to decoders (or to the HRD) by other means not specified by this

Recommendation | International Standard. For the purpose of counting bits, only the appropriate bits that are actually present in the bitstream are counted.

NOTE 1 – As an example, synchronization of a non-VCL NAL unit, conveyed by means other than presence in the bitstream, with the NAL units that are present in the bitstream, can be achieved by indicating two points in the bitstream, between which the non-VCL NAL unit would have been present in the bitstream, had the encoder decided to convey it in the bitstream.

When the content of a non-VCL NAL unit is conveyed for the application by some means other than presence within the bitstream, the representation of the content of the non-VCL NAL unit is not required to use the same syntax specified in this annex.

NOTE 2 – When HRD information is contained within the bitstream, it is possible to verify the conformance of a bitstream to the requirements of this subclause based solely on information contained in the bitstream. When the HRD information is not present in the bitstream, as is the case for all "stand-alone" Type I bitstreams, conformance can only be verified when the HRD data is supplied by some other means not specified in this Recommendation | International Standard.

The HRD contains a coded picture buffer (CPB), an instantaneous decoding process, a decoded picture buffer (DPB), and output cropping as shown in Figure C-2.

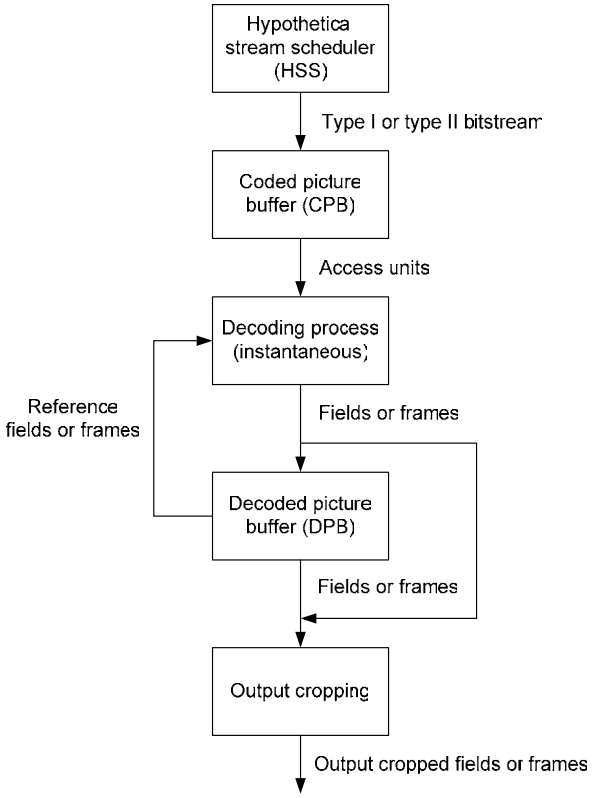


Figure C-2 – HRD buffer model

The CPB size (number of bits) is CpbSize[SchedSelIdx]. The DPB size (number of frame buffers) is Max(1, max_dec_frame_buffering).

The HRD operates as follows. Data associated with access units that flow into the CPB according to a specified arrival schedule are delivered by the HSS. The data associated with each access unit are removed and decoded instantaneously by the instantaneous decoding process at CPB removal times. Each decoded picture is placed in the DPB at its CPB removal time unless it is output at its CPB removal time and is a non-reference picture. When a picture is placed in the DPB it is removed from the DPB at the later of the DPB output time or the time that it is marked as "unused for reference".

The operation of the CPB is specified in subclause C.1. The instantaneous decoder operation is specified in clauses 8 and 9. The operation of the DPB is specified in subclause C.2. The output cropping is specified in subclause C.2.2.

HSS and HRD information concerning the number of enumerated delivery schedules and their associated bit rates and buffer sizes is specified in subclauses E.1.1, E.1.2, E.2.1 and E.2.2. The HRD is initialised as specified by the buffering period SEI message as specified in subclauses D.1.1 and D.2.1. The removal timing of access units from the CPB and output timing from the DPB are specified in the picture timing SEI message as specified in subclauses D.1.2 and D.2.2. All timing information relating to a specific access unit shall arrive prior to the CPB removal time of the access unit.

The HRD is used to check conformance of bitstreams and decoders as specified in subclauses C.3 and C.4, respectively.

NOTE 3 – While conformance is guaranteed under the assumption that all frame-rates and clocks used to generate the bitstream match exactly the values signalled in the bitstream, in a real system each of these may vary from the signalled or specified value.

All the arithmetic in this annex is done with real values, so that no rounding errors can propagate. For example, the number of bits in a CPB just prior to or after removal of an access unit is not necessarily an integer.

The variable t_c is derived as follows and is called a clock tick.

$$t_c = num\_units\_in\_tick \div time\_scale \quad (C\text{-}1)$$

The following is specified for expressing the constraints in this Annex.

– Let access unit n be the n-th access unit in decoding order with the first access unit being access unit 0.

– Let picture n be the primary coded picture or the decoded primary picture of access unit n.

C.1 Operation of coded picture buffer (CPB)

The specifications in this subclause apply independently to each set of CPB parameters that is present and to both the Type I and Type II conformance points shown in Figure C-1.

C.1.1 Timing of bitstream arrival

The HRD may be initialised at any one of the buffering period SEI messages. Prior to initialisation, the CPB is empty.

NOTE – After initialisation, the HRD is not initialised again by subsequent buffering period SEI messages.

Each access unit is referred to as access unit n, where the number n identifies the particular access unit. The access unit that is associated with the buffering period SEI message that initializes the CPB is referred to as access unit 0. The value of n is incremented by 1 for each subsequent access unit in decoding order.

The time at which the first bit of access unit n begins to enter the CPB is referred to as the initial arrival time $t_{ai}(n)$.

The initial arrival time of access units is derived as follows.

– If the access unit is access unit 0, $t_{ai}(0) = 0$,

– Otherwise (the access unit is access unit n with $n > 0$), the following applies.

  – If cbr_flag[SchedSelIdx] is equal to 1, the initial arrival time for access unit n, is equal to the final arrival time (which is derived below) of access unit n - 1, i.e.

$$t_{ai}(n) = t_{af}(n - 1) \quad (C\text{-}2)$$

  – Otherwise (cbr_flag[SchedSelIdx] is equal to 0), the initial arrival time for access unit n is derived by

$$t_{ai}(n) = Max(t_{af}(n - 1), t_{ai,earliest}(n)) \quad (C\text{-}3)$$

  where $t_{ai,earliest}(n)$ is derived as follows

  – If access unit n is not the first access unit of a subsequent buffering period, $t_{ai,earliest}(n)$ is derived as

$$t_{ai,earliest}(n) = t_{r,n}(n) - (initial\_cpb\_removal\_delay[SchedSelIdx] + initial\_cpb\_removal\_delay\_offset[SchedSelIdx]) \div 90000 \quad (C\text{-}4)$$

  with $t_{r,n}(n)$ being the nominal removal time of access unit n from the CPB as specified in subclause C.1.2 and initial_cpb_removal_delay[SchedSelIdx] and initial_cpb_removal_delay_offset[SchedSelIdx] being specified in the previous buffering period SEI message.

– Otherwise (access unit n is the first access unit of a subsequent buffering period), $t_{ai,earliest}(n)$ is derived as

$$t_{ai,earliest}(n) = t_{r,n}(n) – (initial\_cpb\_removal\_delay[SchedSelIdx] ÷ 90000) \quad (C-5)$$

with initial_cpb_removal_delay[SchedSelIdx] being specified in the buffering period SEI message associated with access unit n.

The final arrival time for access unit n is derived by

$$t_{af}(n) = t_{ai}(n) + b(n) ÷ BitRate[SchedSelIdx] \quad (C-6)$$

where b(n) is the size in bits of access unit n, counting the bits of the VCL NAL units and the filler data NAL units for the Type I conformance point or all bits of the Type II bitstream for the Type II conformance point, where the Type I and Type II conformance points are as shown in Figure C-1.

The values of SchedSelIdx, BitRate[SchedSelIdx], and CpbSize[SchedSelIdx] are constrained as follows.

– If access unit n and access unit n - 1 are part of different coded video sequences and the content of the active sequence parameter sets of the two coded video sequences differ, the HSS selects a value SchedSelIdx1 of SchedSelIdx from among the values of SchedSelIdx provided for the coded video sequence containing access unit n that results in a BitRate[SchedSelIdx1] or CpbSize[SchedSelIdx1] for the second of the two coded video sequences (which contains access unit n). The value of BitRate[SchedSelIdx1] or CpbSize[SchedSelIdx1] may differ from the value of BitRate[SchedSelIdx0] or CpbSize[SchedSelIdx0] for the value SchedSelIdx0 of SchedSelIdx that was in use for the coded video sequence containing access unit n - 1.
– Otherwise, the HSS continues to operate with the previous values of SchedSelIdx, BitRate[SchedSelIdx] and CpbSize[SchedSelIdx].

When the HSS selects values of BitRate[SchedSelIdx] or CpbSize[SchedSelIdx] that differ from those of the previous access unit, the following applies.

– the variable BitRate[SchedSelIdx] comes into effect at time $t_{ai}(n)$
– the variable CpbSize[SchedSelIdx] comes into effect as follows.
  – If the new value of CpbSize[SchedSelIdx] exceeds the old CPB size, it comes into effect at time $t_{ai}(n)$,
  – Otherwise, the new value of CpbSize[SchedSelIdx] comes into effect at the time $t_r(n)$.

C.1.2 Timing of coded picture removal

For access unit 0, the nominal removal time of the access unit from the CPB is specified by

$$t_{r,n}(0) = initial\_cpb\_removal\_delay[SchedSelIdx] ÷ 90000 \quad (C-7)$$

For the first access unit of a buffering period that does not initialise the HRD, the nominal removal time of the access unit from the CPB is specified by

$$t_{r,n}(n) = t_{r,n}(n_b) + t_c * cpb\_removal\_delay(n) \quad (C-8)$$

where $t_{r,n}(n_b)$ is the nominal removal time of the first access unit of the previous buffering period and cpb_removal_delay(n) is the value of cpb_removal_delay specified in the picture timing SEI message associated with access unit n.

When an access unit n is the first access unit of a buffering period, n_b is set equal to n at the removal time of access unit n.

The nominal removal time $t_{r,n}(n)$ of an access unit n that is not the first access unit of a buffering period is given by

$$t_{r,n}(n) = t_{r,n}(n_b) + t_c * cpb\_removal\_delay(n) \quad (C-9)$$

where $t_{r,n}(n_b)$ is the nominal removal time of the first access unit of the current buffering period and cpb_removal_delay(n) is the value of cpb_removal_delay specified in the picture timing SEI message associated with access unit n.

The removal time of access unit n is specified as follows.

– If low_delay_hrd_flag is equal to 0 or $t_{r,n}(n) >= t_{af}(n)$, the removal time of access unit n is specified by

$$t_r(n) = t_{r,n}(n) \quad \text{(C-10)}$$

– Otherwise (low_delay_hrd_flag is equal to 1 and $t_{r,n}(n) < t_{af}(n)$), the removal time of access unit n is specified by

$$t_r(n) = t_{r,n}(n) + t_c * \text{Ceil}((t_{af}(n) - t_{r,n}(n)) \div t_c) \quad \text{(C-11)}$$

NOTE – The latter case indicates that the size of access unit n, b(n), is so large that it prevents removal at the nominal removal time.

C.2 Operation of the decoded picture buffer (DPB)

The decoded picture buffer contains frame buffers. Each of the frame buffers may contain a decoded frame, a decoded complementary field pair or a single (non-paired) decoded field that are marked as "used for reference" (reference pictures) or are held for future output (reordered or delayed pictures). Prior to initialisation, the DPB is empty (the DPB fullness is set to zero). The following steps of the subclauses of this subclause all happen instantaneously at $t_r(n)$ and in the sequence listed.

C.2.1 Decoding of gaps in frame_num and storage of "non-existing" frames

If applicable, gaps in frame_num are detected by the decoding process and the generated frames are marked and inserted into the DPB as specified below.

Gaps in frame_num are detected by the decoding process and the generated frames are marked as specified in subclause 8.2.5.2.

After the marking of each generated frame, each picture m marked by the “sliding window” process as “unused for reference” is removed from the DPB when it is also marked as "non-existing" or its DPB output time is less than or equal to the CPB removal time of the current picture n; i.e., $t_{o,dpb}(m) <= t_r(n)$. When a frame or the last field in a frame buffer is removed from the DPB, the DPB fullness is decremented by one. The “non-existing” generated frame is inserted into the DPB and the DPB fullness is incremented by one.

C.2.2 Picture decoding and output

Picture n is decoded and its DPB output time $t_{o,dpb}(n)$ is derived by

$$t_{o,dpb}(n) = t_r(n) + t_c * \text{dpb\_output\_delay}(n) \quad \text{(C-12)}$$

The output of the current picture is specified as follows.

– If $t_{o,dpb}(n) = t_r(n)$, the current picture is output.
NOTE – When the current picture is a reference picture it will be stored in the DPB.

– Otherwise ($t_{o,dpb}(n) > t_r(n)$), the current picture is output later and will be stored in the DPB (as specified in subclause C.2.4) and is output at time $t_{o,dpb}(n)$ unless indicated not to be output by the decoding or inference of no_output_of_prior_pics_flag equal to 1 at a time that precedes $t_{o,dpb}(n)$.

The output picture shall be cropped, using the cropping rectangle specified in the sequence parameter set for the sequence.

When picture n is a picture that is output and is not the last picture of the bitstream that is output, the value of $\Delta t_{o,dpb}(n)$ is defined as:

$$\Delta t_{o,dpb}(n) = t_{o,dpb}(n_n) - t_{o,dpb}(n) \quad \text{(C-13)}$$

where n_n indicates the picture that follows after picture n in output order.

The decoded picture is temporarily stored (not in the DPB).

C.2.3 Removal of pictures from the DPB before possible insertion of the current picture

The removal of pictures from the DPB before possible insertion of the current picture proceeds as follows.

– If the decoded picture is an IDR picture the following applies.

– All reference pictures in the DPB are marked as "unused for reference" as specified in subclause 8.2.5.1.

– When the IDR picture is not the first IDR picture decoded and the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the active sequence parameter set is different from the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the sequence parameter set that was active for the preceding sequence, respectively, no_output_of_prior_pics_flag is inferred to be equal to 1 by the HRD, regardless of the actual value of no_output_of_prior_pics_flag.

NOTE – Decoder implementations should try to handle frame or DPB size changes more gracefully than the HRD in regard to changes in PicWidthInMbs or FrameHeightInMbs.

– When no_output_of_prior_pics_flag is equal to 1 or is inferred to be equal to 1, all frame buffers in the DPB are emptied without output of the pictures they contain, and DPB fullness is set to 0.

– Otherwise (the decoded picture is not an IDR picture), the following applies.

– If the slice header of the current picture includes memory_management_control_operation equal to 5, all reference pictures in the DPB are marked as "unused for reference".

– Otherwise (the slice header of the current picture does not include memory_management_control_operation equal to 5), the decoded reference picture marking process specified in subclause 8.2.5 is invoked.

All pictures m in the DPB, for which all of the following conditions are true, are removed from the DPB.

– picture m is marked as “unused for reference” or picture m is a non-reference picture. When a picture is a reference frame, it is considered to be marked as "unused for reference" only when both of its fields have been marked as "unused for reference".

– picture m is marked as "non-existing" or its DPB output time is less than or equal to the CPB removal time of the current picture n; i.e., $t_{o,dpb}(m) <= t_r(n)$

When a frame or the last field in a frame buffer is removed from the DPB, the DPB fullness is decremented by one.

C.2.4 Current decoded picture marking and storage

C.2.4.1 Marking and storage of a reference decoded picture into the DPB

When the current picture is a reference picture it is stored in the DPB as follows.

– If the current decoded picture is a second field (in decoding order) of a complementary reference field pair, and the first field of the pair is still in the DPB, the current decoded picture is stored in the same frame buffer as the first field of the pair.

– Otherwise, the current decoded picture is stored in an empty frame buffer, and the DPB fullness is incremented by one.

C.2.4.2 Storage of a non-reference picture into the DPB

When the current picture is a non-reference picture and current picture n has $t_{o,dpb}(n) > t_r(n)$, it is stored in the DPB as follows.

– If the current decoded picture is a second field (in decoding order) of a complementary non-reference field pair, and the first field of the pair is still in the DPB, the current decoded picture is stored in the same frame buffer as the first field of the pair.

– Otherwise, the current decoded picture is stored in an empty frame buffer, and the DPB fullness is incremented by one.

C.3 Bitstream conformance

A bitstream of coded data conforming to this Recommendation | International Standard fulfils the following requirements.

The bitstream is constructed according to the syntax, semantics, and constraints specified in this Recommendation | International Standard outside of this Annex.

The bitstream is tested by the HRD as specified below:

For Type I bitstreams, the number of tests carried out is equal to cpb_cnt_minus1 + 1 where cpb_cnt_minus1 is either the syntax element of hrd_parameters( ) following the vcl_hrd_parameters_present_flag or is determined by the application by other means not specified in this Recommendation | International Standard. One test is carried out for

each bit rate and CPB size combination specified by hrd_parameters( ) following the vcl_hrd_parameters_present_flag. Each of these tests is conducted at the Type I conformance point shown in Figure C-1.

For Type II bitstreams there are two sets of tests. The number of tests of the first set is equal to cpb_cnt_minus1 + 1 where cpb_cnt_minus1 is either the syntax element of hrd_parameters( ) following the vcl_hrd_parameters_present_flag or is determined by the application by other means not specified in this Recommendation | International Standard. One test is carried out for each bit rate and CPB size combination. Each of these tests is conducted at the Type I conformance point shown in Figure C-1. For these tests, only VCL and filler data NAL units are counted for the input bit rate and CPB storage.

The number of tests of the second set, for Type II bitstreams, is equal to cpb_cnt_minus1 + 1 where cpb_cnt_minus1 is either the syntax element of hrd_parameters( ) following the nal_hrd_parameters_present_flag or is determined by the application by other means not specified in this Recommendation | International Standard. One test is carried out for each bit rate and CPB size combination specified by hrd_parameters( ) following the nal_hrd_parameters_present_flag. Each of these tests is conducted at the Type II conformance point shown in Figure C-1. For these tests, all NAL units (of a Type II NAL unit stream) or all bytes (of a byte stream) are counted for the input bit rate and CPB storage.

NOTE 1 – NAL HRD parameters established by a value of SchedSelIdx for the Type II conformance point shown in Figure C-1 are sufficient to also establish VCL HRD conformance for the Type I conformance point shown in Figure C-1 for the same values of initial_cpb_removal_delay[SchedSelIdx], BitRate[SchedSelIdx], and CpbSize[SchedSelIdx] for the VBR case (cbr_flag[SchedSelIdx] equal to 0). This is because the data flow into the Type I conformance point is a subset of the data flow into the Type II conformance point and because, for the VBR case, the CPB is allowed to become empty and stay empty until the time a next picture is scheduled to begin to arrive. For example, when NAL HRD parameters are provided for the Type II conformance point that not only fall within the bounds set for NAL HRD parameters for profile conformance in item j of subclause A.3.1 or item i of subclause A.3.3 (depending on the profile in use) but also fall within the bounds set for VCL HRD parameters for profile conformance in item i of subclause A.3.1 or item h of subclause A.3.3 (depending on the profile in use), conformance of the VCL HRD for the Type I conformance point is also assured to fall within the bounds of item i of subclause A.3.1.

For conforming bitstreams, all of the following conditions shall be fulfilled for each of the tests.

– For each access unit n, with n>0, associated with a buffering period SEI message, with $\Delta t_{g,90}(n)$ specified by

$$\Delta t_{g,90}(n) = 90000 * (t_{r,n}(n) - t_{af}(n - 1)) \quad \text{(C-14)}$$

The value of initial_cpb_removal_delay[SchedSelIdx] shall be constrained as follows.

– If cbr_flag[SchedSelIdx] is equal to 0,

$$\text{initial\_cpb\_removal\_delay[SchedSelIdx]} <= \text{Ceil}(\Delta t_{g,90}(n)) \quad \text{(C-15)}$$

– Otherwise (cbr_flag[SchedSelIdx] is equal to 1),

$$\text{Floor}(\Delta t_{g,90}(n)) <= \text{initial\_cpb\_removal\_delay[SchedSelIdx]} <= \text{Ceil}(\Delta t_{g,90}(n)) \quad \text{(C-16)}$$

NOTE 2 – The exact number of bits in the CPB at the removal time of each picture may depend on which buffering period SEI message is selected to initialize the HRD. Encoders must take this into account to ensure that all specified constraints must be obeyed regardless of which buffering period SEI message is selected to initialize the HRD, as the HRD may be initialised at any one of the buffering period SEI messages.

– A CPB overflow is specified as the condition in which the total number of bits in the CPB is larger than the CPB size. The CPB shall never overflow.

– A CPB underflow is specified as the condition in which tr,n(n) is less than taf(n). When low_delay_hrd_flag is equal to 0, the CPB shall never underflow.

– The nominal removal times of pictures from the CPB (starting from the second picture in decoding order), shall satisfy the constraints on tr,n(n) and tr(n) expressed in subclauses A.3.1 through A.3.3 for the profile and level specified in the bitstream.

– Immediately after any decoded picture is added to the DPB, the fullness of the DPB shall be less than or equal to the DPB size as constrained by Annexes A, D, and E for the profile and level specified in the bitstream.

– All reference pictures shall be present in the DPB when needed for prediction. Each picture shall be present in the DPB at its DPB output time unless it is not stored in the DPB at all, or is removed from the DPB before its output time by one of the processes specified in subclause C.2.

– The value of $\Delta_{to,dpb}(n)$ as given by Equation C-13, which is the difference between the output time of a picture and that of the picture immediately following it in output order, shall satisfy the constraint expressed in subclause A.3.1 for the profile and level specified in the bitstream.

C.4 Decoder conformance

A decoder conforming to this Recommendation | International Standard fulfils the following requirements.

A decoder claiming conformance to a specific profile and level shall be able to decode successfully all conforming bitstreams specified for decoder conformance in subclause C.3, provided that all sequence parameter sets and picture parameters sets referred to in the VCL NAL units, and appropriate buffering period and picture timing SEI messages are conveyed to the decoder, in a timely manner, either in the bitstream (by non-VCL NAL units), or by external means not specified by this Recommendation | International Standard.

There are two types of conformance that can be claimed by a decoder: output timing conformance and output order conformance.

To check conformance of a decoder, test bitstreams conforming to the claimed profile and level, as specified by subclause C.3 are delivered by a hypothetical stream scheduler (HSS) both to the HRD and to the decoder under test (DUT). All pictures output by the HRD shall also be output by the DUT and, for each picture output by the HRD, the values of all samples that are output by the DUT for the corresponding picture shall be equal to the values of the samples output by the HRD.

For output timing decoder conformance, the HSS operates as described above, with delivery schedules selected only from the subset of values of SchedSelIdx for which the bit rate and CPB size are restricted as specified in Annex A for the specified profile and level, or with "interpolated" delivery schedules as specified below for which the bit rate and CPB size are restricted as specified in Annex A. The same delivery schedule is used for both the HRD and DUT.

When the HRD parameters and the buffering period SEI messages are present with cpb_cnt_minus1 greater than 0, the decoder shall be capable of decoding the bitstream as delivered from the HSS operating using an "interpolated" delivery schedule specified as having peak bit rate r, CPB size c(r), and initial CPB removal delay (f(r) ÷ r) as follows

$$\alpha = (r - BitRate[SchedSelIdx - 1]) \div (BitRate[SchedSelIdx] - BitRate[SchedSelIdx - 1]), \quad \text{(C-17)}$$

$$c(r) = \alpha * CpbSize[SchedSelIdx] + (1 - \alpha) * CpbSize[SchedSelIdx-1], \quad \text{(C-18)}$$

$$f(r) = \alpha * initial\_cpb\_removal\_delay[SchedSelIdx] * BitRate[SchedSelIdx] + (1 - \alpha) * initial\_cpb\_removal\_delay[SchedSelIdx - 1] * BitRate[SchedSelIdx - 1] \quad \text{(C-19)}$$

for any SchedSelIdx > 0 and r such that BitRate[SchedSelIdx - 1] <= r <= BitRate[SchedSelIdx] such that r and c(r) are within the limits as specified in Annex A for the maximum bit rate and buffer size for the specified profile and level.

NOTE 1 – initial_cpb_removal_delay[SchedSelIdx] can be different from one buffering period to another and have to be re-calculated.

For output timing decoder conformance, an HRD as described above is used and the timing (relative to the delivery time of the first bit) of picture output is the same for both HRD and the DUT up to a fixed delay.

For output order decoder conformance, the HSS delivers the bitstream to the DUT "by demand" from the DUT, meaning that the HSS delivers bits (in decoding order) only when the DUT requires more bits to proceed with its processing.

NOTE 2 – This means that for this test, the coded picture buffer of the DUT could be as small as the size of the largest access unit.

A modified HRD as described below is used, and the HSS delivers the bitstream to the HRD by one of the schedules specified in the bitstream such that the bit rate and CPB size are restricted as specified in Annex A. The order of pictures output shall be the same for both HRD and the DUT.

For output order decoder conformance, the HRD CPB size is equal to CpbSize[SchedSelIdx] for the selected schedule and the DPB size is equal to MaxDpbSize. Removal time from the CPB for the HRD is equal to final bit arrival time and decoding is immediate. The operation of the DPB of this HRD is described below.

C.4.1 Operation of the output order DPB

The decoded picture buffer contains frame buffers. Each of the frame buffers may contain a decoded frame, a decoded complementary field pair or a single (non-paired) decoded field that is marked as "used for reference" or is held for future output (reordered pictures). At HRD initialization, the DPB fullness, measured in frames, is set to 0. The following steps all happen instantaneously when an access unit is removed from the CPB, and in the order listed.

C.4.2 Decoding of gaps in frame_num and storage of "non-existing" pictures

When applicable, gaps in frame_num are detected by the decoding process and the necessary number of "non-existing" frames are inferred in the order specified by the generation of values of UnusedShortTermFrameNum in Equation 7-21 and are marked as specified in subclause 8.2.5.2. Frame buffers containing a frame or a complementary field pair or a non-paired field which are marked as "not needed for output" and "unused for reference" are emptied (without output), and the DPB fullness is decremented by the number of frame buffers emptied. Each "non-existing" frame is stored in the DPB as follows.

- When there is no empty frame buffer (i.e., DPB fullness is equal to DPB size), the "bumping" process specified in subclause C.4.5.3 is invoked repeatedly until there is an empty frame buffer in which to store the "non-existing" frame.
- The "non-existing" frame is stored in an empty frame buffer and is marked as "not needed for output", and the DPB fullness is incremented by one.

C.4.3 Picture decoding

Primary coded picture n is decoded and is temporarily stored (not in the DPB).

C.4.4 Removal of pictures from the DPB before possible insertion of the current picture

The removal of pictures from the DPB before possible insertion of the current picture proceeds as follows.

- If the decoded picture is an IDR picture the following applies.
  - All reference pictures in the DPB are marked as "unused for reference" as specified in subclause 8.2.5.
  - When the IDR picture is not the first IDR picture decoded and the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the active sequence parameter set is different from the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the sequence parameter set that was active for the preceding sequence, respectively, no_output_of_prior_pics_flag is inferred to be equal to 1 by the HRD, regardless of the actual value of no_output_of_prior_pics_flag.

    NOTE – Decoder implementations should try to handle changes in the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering more gracefully than the HRD.
  - When no_output_of_prior_pics_flag is equal to 1 or is inferred to be equal to 1, all frame buffers in the DPB are emptied without output of the pictures they contain, and DPB fullness is set to 0.
- Otherwise (the decoded picture is not an IDR picture), the decoded reference picture marking process is invoked as specified in subclause 8.2.5. Frame buffers containing a frame or a complementary field pair or a non-paired field which are marked as "not needed for output" and "unused for reference" are emptied (without output), and the DPB fullness is decremented by the number of frame buffers emptied.

When the current picture has a memory_management_control_operation equal to 5 or is an IDR picture for which no_output_of_prior_pics_flag is not equal to 1 and is not inferred to be equal to 1, the following two steps are performed.

1. Frame buffers containing a frame or a complementary field pair or a non-paired field which are marked as "not needed for output" and "unused for reference" are emptied (without output), and the DPB fullness is decremented by the number of frame buffers emptied.
2. All non-empty frame buffers in the DPB are emptied by repeatedly invoking the “bumping” process specified in subclause C.4.5.3, and the DPB fullness is set to 0.

C.4.5 Current decoded picture marking and storage

C.4.5.1 Storage and marking of a reference decoded picture into the DPB

When the current picture is a reference picture, it is stored in the DPB as follows.

- If the current decoded picture is the second field (in decoding order) of a complementary reference field pair, and the first field of the pair is still in the DPB, the current picture is stored in the same frame buffer as the first field of the pair and is marked as "needed for output".

– Otherwise, the following operations are performed:
  – When there is no empty frame buffer (i.e., DPB fullness is equal to DPB size), the "bumping" process specified in subclause C.4.5.3 is invoked repeatedly until there is an empty frame buffer in which to store the current decoded picture.
  – The current decoded picture is stored in an empty frame buffer and is marked as "needed for output", and the DPB fullness is incremented by one.

C.4.5.2 Storage and marking of a non-reference decoded picture into the DPB

When the current picture is a non-reference picture, the following operations are performed.

– If the current decoded picture is the second field (in decoding order) of a complementary non-reference field pair and the first field of the pair is still in the DPB, the current picture is stored in the same frame buffer as the first field of the pair and is marked as "needed for output".
– Otherwise, the following operations are performed repeatedly until the current decoded picture has been cropped and output or has been stored in the DPB:
  – If there is no empty frame buffer (i.e., DPB fullness is equal to DPB size), the following applies.
    – If the current picture does not have a lower value of PicOrderCnt( ) than all pictures in the DPB that are marked as "needed for output", the "bumping" process described in subclause C.4.5.3 is performed.
    – Otherwise (the current picture has a lower value of PicOrderCnt( ) than all pictures in the DPB that are marked as "needed for output"), the current picture is cropped, using the cropping rectangle specified in the sequence parameter set for the sequence and the cropped picture is output.
  – Otherwise (there is an empty frame buffer, i.e., DPB fullness is less than DPB size) the current decoded picture is stored in an empty frame buffer and is marked as "needed for output", and the DPB fullness is incremented by one.

C.4.5.3 "Bumping" process

The "bumping" process is invoked in the following cases.

– There is no empty frame buffer (i.e., DPB fullness is equal to DPB size) and a empty frame buffer is needed for storage of an inferred "non-existing" frame, as specified in subclause C.4.2.
– The current picture is an IDR picture and no_output_of_prior_pics_flag is not equal to 1 and is not inferred to be equal to 1, as specified in subclause C.4.4.
– The current picture has memory_management_control_operation equal to 5, as specified in subclause C.4.4.
– There is no empty frame buffer (i.e., DPB fullness is equal to DPB size) and an empty frame buffer is needed for storage of a decoded (non-IDR) reference picture, as specified in subclause C.4.5.1.
– There is no empty frame buffer (i.e., DPB fullness is equal to DPB size) and the current picture is a non-reference picture that is not the second field of a complementary non-reference field pair and there are pictures in the DPB that are marked as "needed for output" that precede the current non-reference picture in output order, as specified in subclause C.4.5.2, so an empty buffer is needed for storage of the current picture.

The "bumping" process consists of the following:

– The picture or complementary reference field pair that is first for output is selected as follows.
  – The frame buffer is selected that contains the picture having the smallest value of PicOrderCnt( ) of all pictures in the DPB marked as "needed for output".
  – If this frame buffer contains a complementary non-reference field pair with both fields marked as "needed for output" and both fields have the same PicOrderCnt( ), the first of these two fields in decoding order is considered first for output.
  – Otherwise, if this frame buffer contains a complementary reference field pair with both fields marked as "needed for output" and both fields have the same PicOrderCnt( ), the entire complementary reference field pair is considered first for output.
  – Otherwise, the picture in this frame buffer that has the smallest value of PicOrderCnt( ) is considered first for output.
– If a single picture is considered first for output, this picture is cropped, using the cropping rectangle specified in the sequence parameter set for the sequence, the cropped picture is output, and the picture is marked as "not needed for output".

– Otherwise (a complementary reference field pair is considered first for output), the two fields of the complementary reference field pair are both cropped, using the cropping rectangle specified in the sequence parameter set for the sequence, the two fields of the complementary reference field pair are output together, and both fields of the complementary reference field pair are marked as "not needed for output".
– The frame buffer that included the picture or complementary reference field pair that was cropped and output is checked, and when any of the following conditions is satisfied, the frame buffer is emptied and the DPB fullness is decremented by 1.
  – The frame buffer contains a non-reference non-paired field.
  – The frame buffer contains a non-reference frame.
  – The frame buffer contains a complementary non-reference field pair with both fields marked as "not needed for output".
  – The frame buffer contains a non-paired reference field marked as "unused for reference".
  – The frame buffer contains a reference frame with both fields marked as "unused for reference".
  – The frame buffer contains a complementary reference field pair with both fields marked as "unused for reference" and "not needed for output".

Annex D
Supplemental enhancement information

(This annex forms an integral part of this Recommendation | International Standard)

This annex specifies syntax and semantics for SEI message payloads.

SEI messages assist in processes related to decoding, display or other purposes. However, SEI messages are not required for constructing the luma or chroma samples by the decoding process. Conforming decoders are not required to process this information for output order conformance to this Recommendation | International Standard (see Annex C for the specification of conformance). Some SEI message information is required to check bitstream conformance and for output timing decoder conformance.

In Annex D, specification for presence of SEI messages are also satisfied when those messages (or some subset of them) are conveyed to decoders (or to the HRD) by other means not specified by this Recommendation | International Standard. When present in the bitstream, SEI messages shall obey the syntax and semantics specified in subclauses 7.3.2.3 and 7.4.2.3 and this annex. When the content of an SEI message is conveyed for the application by some means other than presence within the bitstream, the representation of the content of the SEI message is not required to use the same syntax specified in this annex. For the purpose of counting bits, only the appropriate bits that are actually present in the bitstream are counted.

D.1 SEI payload syntax

sei_payload(payloadType, payloadSize) {	C	Descriptor
if(payloadType = = 0)		
buffering_period(payloadSize)	5	
else if(payloadType = = 1)		
pic_timing(payloadSize)	5	
else if(payloadType = = 2)		
pan_scan_rect(payloadSize)	5	
else if(payloadType = = 3)		
filler_payload(payloadSize)	5	
else if(payloadType = = 4)		
user_data_registered_itu_t_t35(payloadSize)	5	
else if(payloadType = = 5)		
user_data_unregistered(payloadSize)	5	
else if(payloadType = = 6)		
recovery_point(payloadSize)	5	
else if(payloadType = = 7)		
dec_ref_pic_marking_repetition(payloadSize)	5	
else if(payloadType = = 8)		
spare_pic(payloadSize)	5	
else if(payloadType = = 9)		
scene_info(payloadSize)	5	
else if(payloadType = = 10)		
sub_seq_info(payloadSize)	5	
else if(payloadType = = 11)		
sub_seq_layer_characteristics(payloadSize)	5	
else if(payloadType = = 12)		
sub_seq_characteristics(payloadSize)	5	
else if(payloadType = = 13)		
full_frame_freeze(payloadSize)	5	
else if(payloadType = = 14)		
full_frame_freeze_release(payloadSize)	5	
else if(payloadType = = 15)		
full_frame_snapshot(payloadSize)	5	
else if(payloadType = = 16)		
progressive_refinement_segment_start(payloadSize)	5	
else if(payloadType = = 17)		
progressive_refinement_segment_end(payloadSize)	5	
else if(payloadType = = 18)		
motion_constrained_slice_group_set(payloadSize)	5	
else if(payloadType = = 19)		
film_grain_characteristics(payloadSize)	5	
else if(payloadType = = 20)		
deblocking_filter_display_preference(payloadSize)	5	
else if(payloadType = = 21)		
stereo_video_info(payloadSize)	5	
else		
reserved_sei_message(payloadSize)	5	

if(!byte_aligned( )) {		
bit_equal_to_one /* equal to 1 */	5	f(1)
while(!byte_aligned( ))		
bit_equal_to_zero /* equal to 0 */	5	f(1)
}		
}		

D.1.1 Buffering period SEI message syntax

buffering_period(payloadSize) {	C	Descriptor
seq_parameter_set_id	5	ue(v)
if(NalHrdBpPresentFlag) {		
for(SchedSelIdx = 0; SchedSelIdx <= cpb_cnt_minus1; SchedSelIdx++) {		
initial_cpb_removal_delay[SchedSelIdx **]**	5	u(v)
initial_cpb_removal_delay_offset[SchedSelIdx **]**	5	u(v)
}		
}		
if(VclHrdBpPresentFlag) {		
for(SchedSelIdx = 0; SchedSelIdx <= cpb_cnt_minus1; SchedSelIdx++) {		
initial_cpb_removal_delay[SchedSelIdx **]**	5	u(v)
initial_cpb_removal_delay_offset[SchedSelIdx **]**	5	u(v)
}		
}		
}		

D.1.2 Picture timing SEI message syntax

pic_timing(payloadSize) {	C	Descriptor
if(CpbDpbDelaysPresentFlag) {		
cpb_removal_delay	5	u(v)
dpb_output_delay	5	u(v)
}		
if(pic_struct_present_flag) {		
pic_struct	5	u(4)
for(i = 0; i < NumClockTS ; i++) {		
clock_timestamp_flag[i]	5	u(1)
if(clock_timestamp_flag[i]) {		
ct_type	5	u(2)
nuit_field_based_flag	5	u(1)
counting_type	5	u(5)
full_timestamp_flag	5	u(1)
discontinuity_flag	5	u(1)
cnt_dropped_flag	5	u(1)
n_frames	5	u(8)
if(full_timestamp_flag) {		
seconds_value /* 0..59 */	5	u(6)

minutes_value /* 0..59 */	5	u(6)
hours_value /* 0..23 */	5	u(5)
} else {		
seconds_flag	5	u(1)
if(seconds_flag) {		
seconds_value /* range 0..59 */	5	u(6)
minutes_flag	5	u(1)
if(minutes_flag) {		
minutes_value /* 0..59 */	5	u(6)
hours_flag	5	u(1)
if(hours_flag)		
hours_value /* 0..23 */	5	u(5)
}		
}		
}		
if(time_offset_length > 0)		
time_offset	5	i(v)
}		
}		
}		
}		

D.1.3 Pan-scan rectangle SEI message syntax

pan_scan_rect(payloadSize) {	C	Descriptor
pan_scan_rect_id	5	ue(v)
pan_scan_rect_cancel_flag	5	u(1)
if(!pan_scan_rect_cancel_flag) {		
pan_scan_cnt_minus1	5	ue(v)
for(i = 0; i <= pan_scan_cnt_minus1; i++) {		
pan_scan_rect_left_offset[i **]**	5	se(v)
pan_scan_rect_right_offset[i **]**	5	se(v)
pan_scan_rect_top_offset[i **]**	5	se(v)
pan_scan_rect_bottom_offset[i **]**	5	se(v)
}		
pan_scan_rect_repetition_period	5	ue(v)
}		
}		

D.1.4 Filler payload SEI message syntax

filler_payload(payloadSize) {	C	Descriptor
for(k = 0; k < payloadSize; k++)		
ff_byte /* equal to 0xFF */	5	f(8)
}		

D.1.5 User data registered by ITU-T Rec. T.35 SEI message syntax

user_data_registered_itu_t_t35(payloadSize) {	C	Descriptor
itu_t_t35_country_code	5	b(8)
if(itu_t_t35_country_code != 0xFF)		
i = 1		
else {		
itu_t_t35_country_code_extension_byte	5	b(8)
i = 2		
}		
do {		
itu_t_t35_payload_byte	5	b(8)
i++		
} while(i < payloadSize)		
}		

D.1.6 User data unregistered SEI message syntax

user_data_unregistered(payloadSize) {	C	Descriptor
uuid_iso_iec_11578	**5**	u(128)
for(i = 16; i < payloadSize; i++)		
user_data_payload_byte	5	b(8)
}		

D.1.7 Recovery point SEI message syntax

recovery_point(payloadSize) {	C	Descriptor
recovery_frame_cnt	5	ue(v)
exact_match_flag	5	u(1)
broken_link_flag	5	u(1)
changing_slice_group_idc	5	u(2)
}		

D.1.8 Decoded reference picture marking repetition SEI message syntax

dec_ref_pic_marking_repetition(payloadSize) {	C	Descriptor
original_idr_flag	5	u(1)
original_frame_num	5	ue(v)
if(!frame_mbs_only_flag) {		
original_field_pic_flag	5	u(1)
if(original_field_pic_flag)		
original_bottom_field_flag	5	u(1)
}		
dec_ref_pic_marking( )	5	
}		

D.1.9 Spare picture SEI message syntax

spare_pic(payloadSize) {	C	Descriptor
target_frame_num	5	ue(v)
spare_field_flag	5	u(1)
if(spare_field_flag)		
target_bottom_field_flag	5	u(1)
num_spare_pics_minus1	5	ue(v)
for(i = 0; i < num_spare_pics_minus1 + 1; i++) {		
delta_spare_frame_num[i **]**	5	ue(v)
if(spare_field_flag)		
spare_bottom_field_flag[i **]**	5	u(1)
spare_area_idc[i **]**	5	ue(v)
if(spare_area_idc[i] = = 1)		
for(j = 0; j < PicSizeInMapUnits; j++)		
spare_unit_flag[i **][** j **]**	5	u(1)
else if(spare_area_idc[i] = = 2) {		
mapUnitCnt = 0		
for(j=0; mapUnitCnt < PicSizeInMapUnits; j++) {		
zero_run_length[i **][** j **]**	5	ue(v)
mapUnitCnt += zero_run_length[i][j] + 1		
}		
}		
}		
}		

D.1.10 Scene information SEI message syntax

scene_info(payloadSize) {	C	Descriptor
scene_info_present_flag	5	u(1)
if(scene_info_present_flag) {		
scene_id	5	ue(v)
scene_transition_type	5	ue(v)
if(scene_transition_type > 3)		
second_scene_id	5	ue(v)
}		
}		

D.1.11 Sub-sequence information SEI message syntax

sub_seq_info(payloadSize) {	C	Descriptor
sub_seq_layer_num	5	ue(v)
sub_seq_id	5	ue(v)
first_ref_pic_flag	5	u(1)
leading_non_ref_pic_flag	5	u(1)
last_pic_flag	5	u(1)
sub_seq_frame_num_flag	5	u(1)
if(sub_seq_frame_num_flag)		
sub_seq_frame_num	5	ue(v)
}		

D.1.12 Sub-sequence layer characteristics SEI message syntax

sub_seq_layer_characteristics(payloadSize) {	C	Descriptor
num_sub_seq_layers_minus1	5	ue(v)
for(layer = 0; layer <= num_sub_seq_layers_minus1; layer++) {		
accurate_statistics_flag	5	u(1)
average_bit_rate	5	u(16)
average_frame_rate	5	u(16)
}		
}		

D.1.13 Sub-sequence characteristics SEI message syntax

sub_seq_characteristics(payloadSize) {	C	Descriptor
sub_seq_layer_num	5	ue(v)
sub_seq_id	5	ue(v)
duration_flag	5	u(1)
if(duration_flag)		
sub_seq_duration	5	u(32)
average_rate_flag	5	u(1)
if(average_rate_flag) {		
accurate_statistics_flag	5	u(1)
average_bit_rate	5	u(16)
average_frame_rate	5	u(16)
}		
num_referenced_subseqs	5	ue(v)
for(n = 0; n < num_referenced_subseqs; n++) {		
ref_sub_seq_layer_num	5	ue(v)
ref_sub_seq_id	5	ue(v)
ref_sub_seq_direction	5	u(1)
}		
}		

D.1.14 Full-frame freeze SEI message syntax

full_frame_freeze(payloadSize) {	C	Descriptor
full_frame_freeze_repetition_period	5	ue(v)
}		

D.1.15 Full-frame freeze release SEI message syntax

full_frame_freeze_release(payloadSize) {	C	Descriptor
}		

D.1.16 Full-frame snapshot SEI message syntax

full_frame_snapshot(payloadSize) {	C	Descriptor
snapshot_id	5	ue(v)
}		

D.1.17 Progressive refinement segment start SEI message syntax

progressive_refinement_segment_start(payloadSize) {	C	Descriptor
progressive_refinement_id	5	ue(v)
num_refinement_steps_minus1	5	ue(v)
}		

D.1.18 Progressive refinement segment end SEI message syntax

progressive_refinement_segment_end(payloadSize) {	C	Descriptor
progressive_refinement_id	5	ue(v)
}		

D.1.19 Motion-constrained slice group set SEI message syntax

motion_constrained_slice_group_set(payloadSize) {	C	Descriptor
num_slice_groups_in_set_minus1	5	ue(v)
for(i = 0; i <= num_slice_groups_in_set_minus1; i++)		
slice_group_id[i **]**	5	u(v)
exact_sample_value_match_flag	5	u(1)
pan_scan_rect_flag	5	u(1)
if(pan_scan_rect_flag)		
pan_scan_rect_id	5	ue(v)
}		

D.1.20 Film grain characteristics SEI message syntax

film_grain_characteristics(payloadSize) {	C	Descriptor
film_grain_characteristics_cancel_flag	5	u(1)
if(!film_grain_**characteristics**_cancel_flag) {		
model_id	5	u(2)
separate_colour_description_present_flag	5	u(1)
if(separate_colour_description_present_flag) {		
film_grain_bit_depth_luma_minus8	5	u(3)
film_grain_bit_depth_chroma_minus8	5	u(3)
film_grain_full_range_flag	5	u(1)
film_grain_colour_primaries	5	u(8)
film_grain_transfer_characteristics	5	u(8)
film_grain_matrix_coefficients	5	u(8)
}		
blending_mode_id	5	u(2)
log2_scale_factor	5	u(4)
for(c = 0; c < 3; c++)		
comp_model_present_flag[c]	5	u(1)
for(c = 0; c < 3; c++)		
if(comp_model_present_flag[c]) {		
num_intensity_intervals_minus1[c **]**	5	u(8)
num_model_values_minus1[c **]**	5	u(3)
for(i = 0; i <= num_intensity_intervals_minus1[c]; i++) {		
intensity_interval_lower_bound[c **][** i **]**	5	u(8)
intensity_interval_upper_bound[c **][** i **]**	5	u(8)
for(j = 0; j <= num_model_values_minus1[c]; j++)		
comp_model_value[c **][** i **][** j **]**	5	se(v)
}		
}		
film_grain_characteristics_repetition_period	5	ue(v)
}		
}		

D.1.21 Deblocking filter display preference SEI message syntax

deblocking_filter_display_preference(payloadSize) {	C	Descriptor
deblocking_display_preference_cancel_flag	5	u(1)
if(!deblocking_display_preference_cancel_flag) {		
display_prior_to_deblocking_preferred_flag	5	u(1)
dec_frame_buffering_constraint_flag	5	u(1)
deblocking_display_preference_repetition_period	5	ue(v)
}		
}		

D.1.22 Stereo video information SEI message syntax

stereo_video_info(payloadSize) {	C	Descriptor
field_views_flag	5	u(1)
if(field_views_flag)		
top_field_is_left_view_flag	5	u(1)
else {		
current_frame_is_left_view_flag	5	u(1)
next_frame_is_second_view_flag	5	u(1)
}		
left_view_self_contained_flag	5	u(1)
right_view_self_contained_flag	5	u(1)
}		

D.1.23 Reserved SEI message syntax

reserved_sei_message(payloadSize) {	C	Descriptor
for(i = 0; i < payloadSize; i++)		
reserved_sei_message_payload_byte	5	b(8)
}		

D.2 SEI payload semantics

D.2.1 Buffering period SEI message semantics

When NalHrdBpPresentFlag or VclHrdBpPresentFlag are equal to 1, a buffering period SEI message can be associated with any access unit in the bitstream, and a buffering period SEI message shall be associated with each IDR access unit and with each access unit associated with a recovery point SEI message.

NOTE – For some applications, the frequent presence of a buffering period SEI message may be desirable.

A buffering period is specified as the set of access units between two instances of the buffering period SEI message in decoding order.

seq_parameter_set_id specifies the sequence parameter set that contains the sequence HRD attributes. The value of seq_parameter_set_id shall be equal to the value of seq_parameter_set_id in the picture parameter set referenced by the primary coded picture associated with the buffering period SEI message. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

initial_cpb_removal_delay[SchedSelIdx] specifies the delay for the SchedSelIdx-th CPB between the time of arrival in the CPB of the first bit of the coded data associated with the access unit associated with the buffering period SEI message and the time of removal from the CPB of the coded data associated with the same access unit, for the first buffering period after HRD initialisation. The syntax element has a length in bits given by initial_cpb_removal_delay_length_minus1 + 1. It is in units of a 90 kHz clock. initial_cpb_removal_delay[SchedSelIdx] shall not be equal to 0 and shall not exceed 90000 * (CpbSize[SchedSelIdx] ÷ BitRate[SchedSelIdx]), the time-equivalent of the CPB size in 90 kHz clock units.

initial_cpb_removal_delay_offset[SchedSelIdx] is used for the SchedSelIdx-th CPB in combination with the cpb_removal_delay to specify the initial delivery time of coded access units to the CPB. initial_cpb_removal_delay_offset[SchedSelIdx] is in units of a 90 kHz clock. The initial_cpb_removal_delay_offset[SchedSelIdx] syntax element is a fixed length code whose length in bits is given by initial_cpb_removal_delay_length_minus1 + 1. This syntax element is not used by decoders and is needed only for the delivery scheduler (HSS) specified in Annex C.

Over the entire coded video sequence, the sum of initial_cpb_removal_delay[SchedSelIdx] and initial_cpb_removal_delay_offset[SchedSelIdx] shall be constant for each value of SchedSelIdx.

D.2.2 Picture timing SEI message semantics

The presence of picture timing SEI message in the bitstream is specified as follows.

– If CpbDpbDelaysPresentFlag is equal to 1 or pic_struct_present_flag is equal to 1, one picture timing SEI message shall be present in every access unit of the coded video sequence.

– Otherwise (CpbDpbDelaysPresentFlag is equal to 0 and pic_struct_present_flag is equal to 0), no picture timing SEI messages shall be present in any access unit of the coded video sequence.

cpb_removal_delay specifies how many clock ticks (see subclause E.2.1) to wait after removal from the CPB of the access unit associated with the most recent buffering period SEI message before removing from the buffer the access unit data associated with the picture timing SEI message. This value is also used to calculate an earliest possible time of arrival of access unit data into the CPB for the HSS, as specified in Annex C. The syntax element is a fixed length code whose length in bits is given by cpb_removal_delay_length_minus1 + 1. The cpb_removal_delay is the remainder of a $2^{(\text{cpb\_removal\_delay\_length\_minus1} + 1)}$ counter.

The value of cpb_removal_delay for the first picture in the bitstream shall be equal to 0.

dpb_output_delay is used to compute the DPB output time of the picture. It specifies how many clock ticks to wait after removal of an access unit from the CPB before the decoded picture can be output from the DPB (see subclause C.2).

NOTE 1 – A picture is not removed from the DPB at its output time when it is still marked as "used for short-term reference" or "used for long-term reference".

NOTE 2 – Only one dpb_output_delay is specified for a decoded picture.

The size of the syntax element dpb_output_delay is given in bits by dpb_output_delay_length_minus1 + 1. When max_dec_frame_buffering is equal to 0, dpb_output_delay shall be equal to 0.

The output time derived from the dpb_output_delay of any picture that is output from an output timing conforming decoder as specified in subclause C.2 shall precede the output time derived from the dpb_output_delay of all pictures in any subsequent coded video sequence in decoding order.

The output time derived from the dpb_output_delay of the second field, in decoding order, of a complementary non-reference field pair shall exceed the output time derived from the dpb_output_delay of the first field of the same complementary non-reference field pair.

The picture output order established by the values of this syntax element shall be the same order as established by the values of PicOrderCnt( ) as specified by subclauses C.4.1 to C.4.5, except that when the two fields of a complementary reference field pair have the same value of PicOrderCnt( ), the two fields have different output times.

For pictures that are not output by the "bumping" process of subclause C.4.5 because they precede, in decoding order, an IDR picture with no_output_of_prior_pics_flag equal to 1 or inferred to be equal to 1, the output times derived from dpb_output_delay shall be increasing with increasing value of PicOrderCnt( ) relative to all pictures within the same coded video sequence subsequent to any picture having a memory_management_control_operation equal to 5.

pic_struct indicates whether a picture should be displayed as a frame or one or more fields, according to Table D-1. Frame doubling (pic_struct equal to 7) indicates that the frame should be displayed two times consecutively, and frame tripling (pic_struct equal to 8) indicates that the frame should be displayed three times consecutively.

NOTE 3 – Frame doubling can facilitate the display, for example, of 25p video on a 50p display and 29.97p video on a 59.94p display. Using frame doubling and frame tripling in combination on every other frame can facilitate the display of 23.98p video on a 59.94p display.

Table D-1 – Interpretation of pic_struct

Value	Indicated display of picture	Restrictions	NumClockTS
0	frame	field_pic_flag shall be 0	1
1	top field	field_pic_flag shall be 1, bottom_field_flag shall be 0	1
2	bottom field	field_pic_flag shall be 1, bottom_field_flag shall be 1	1
3	top field, bottom field, in that order	field_pic_flag shall be 0	2
4	bottom field, top field, in that order	field_pic_flag shall be 0	2
5	top field, bottom field, top field repeated, in that order	field_pic_flag shall be 0	3
6	bottom field, top field, bottom field repeated, in that order	field_pic_flag shall be 0	3
7	frame doubling	field_pic_flag shall be 0 fixed_frame_rate_flag shall be 1	2
8	frame tripling	field_pic_flag shall be 0 fixed_frame_rate_flag shall be 1	3
9..15	reserved		

NumClockTS is determined by pic_struct as specified in Table D-1. There are up to NumClockTS sets of clock timestamp information for a picture, as specified by clock_timestamp_flag[i] for each set. The sets of clock timestamp information apply to the field(s) or the frame(s) associated with the picture by pic_struct.

The contents of the clock timestamp syntax elements indicate a time of origin, capture, or alternative ideal display. This indicated time is computed as

$$\begin{aligned} \text{clockTimestamp} = {} & ((\text{hH} * 60 + \text{mM}) * 60 + \text{sS}) * \text{time\_scale} + \\ & \text{nFrames} * (\text{num\_units\_in\_tick} * (1 + \text{nuit\_field\_based\_flag})) + \text{tOffset}, \end{aligned} \tag{D-1}$$

in units of clock ticks of a clock with clock frequency equal to time_scale Hz, relative to some unspecified point in time for which clockTimestamp is equal to 0. Output order and DPB output timing are not affected by the value of clockTimestamp. When two or more frames with pic_struct equal to 0 are consecutive in output order and have equal values of clockTimestamp, the indication is that the frames represent the same content and that the last such frame in output order is the preferred representation.

NOTE 4 – clockTimestamp time indications may aid display on devices with refresh rates other than those well-matched to DPB output times.

clock_timestamp_flag[i **]** equal to 1 indicates that a number of clock timestamp syntax elements are present and follow immediately. clock_timestamp_flag[i] equal to 0 indicates that the associated clock timestamp syntax elements are not present. When NumClockTS is greater than 1 and clock_timestamp_flag[i] is equal to 1 for more than one value of i, the value of clockTimestamp shall be non-decreasing with increasing value of i.

ct_type indicates the scan type (interlaced or progressive) of the source material as specified in Table D-2.

Two fields of a coded frame may have different values of ct_type.

When clockTimestamp is equal for two fields of opposite parity that are consecutive in output order, both with ct_type equal to 0 (progressive) or ct_type equal to 2 (unknown), the two fields are indicated to have come from the same original progressive frame. Two consecutive fields in output order shall have different values of clockTimestamp when the value of ct_type for either field is 1 (interlaced).

Table D-2 – Mapping of ct_type to source picture scan

Value	Original picture scan
0	progressive
1	interlaced
2	unknown
3	reserved

nuit_field_based_flag is used in calculating clockTimestamp, as specified in Equation D-1.

counting_type specifies the method of dropping values of the n_frames as specified in Table D-3.

Table D-3 – Definition of counting_type values

Value	Interpretation
0	no dropping of n_frames count values and no use of time_offset
1	no dropping of n_frames count values
2	dropping of individual zero values of n_frames count
3	dropping of individual MaxFPS-1 values of n_frames count
4	dropping of the two lowest (value 0 and 1) n_frames counts when seconds_value is equal to 0 and minutes_value is not an integer multiple of 10
5	dropping of unspecified individual n_frames count values
6	dropping of unspecified numbers of unspecified n_frames count values
7..31	reserved

full_timestamp_flag equal to 1 specifies that the n_frames syntax element is followed by seconds_value, minutes_value, and hours_value. full_timestamp_flag equal to 0 specifies that the n_frames syntax element is followed by seconds_flag.

discontinuity_flag equal to 0 indicates that the difference between the current value of clockTimestamp and the value of clockTimestamp computed from the previous clock timestamp in output order can be interpreted as the time difference between the times of origin or capture of the associated frames or fields. discontinuity_flag equal to 1 indicates that the difference between the current value of clockTimestamp and the value of clockTimestamp computed from the previous clock timestamp in output order should not be interpreted as the time difference between the times of origin or capture of the associated frames or fields. When discontinuity_flag is equal to 0, the value of clockTimestamp shall be greater than or equal to all values of clockTimestamp present for the preceding picture in DPB output order.

cnt_dropped_flag specifies the skipping of one or more values of n_frames using the counting method specified by counting_type.

n_frames specifies the value of nFrames used to compute clockTimestamp. n_frames shall be less than

$$MaxFPS = Ceil(time\_scale \div num\_units\_in\_tick) \quad (D\text{-}2)$$

NOTE 5 – n_frames is a frame-based counter. For field-specific timing indications, time_offset should be used to indicate a distinct clockTimestamp for each field.

When counting_type is equal to 2 and cnt_dropped_flag is equal to 1, n_frames shall be equal to 1 and the value of n_frames for the previous picture in output order shall not be equal to 0 unless discontinuity_flag is equal to 1.

NOTE 6 – When counting_type is equal to 2, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates (e.g., 12.5 frames per second with time_scale equal to 25 and num_units_in_tick equal to 2 and nuit_field_based_flag equal to 0) can be avoided by occasionally skipping over the value n_frames equal to 0 when counting (e.g., counting n_frames from 0 to 12, then incrementing seconds_value and counting n_frames from 1 to 12, then incrementing seconds_value and counting n_frames from 0 to 12, etc.).

When counting_type is equal to 3 and cnt_dropped_flag is equal to 1, n_frames shall be equal to 0 and the value of n_frames for the previous picture in output order shall not be equal to MaxFPS – 1 unless discontinuity_flag is equal to 1.

NOTE 7 – When counting_type is equal to 3, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates (e.g., 12.5 frames per second with time_scale equal to 25 and num_units_in_tick equal to 2 and nuit_field_based_flag equal to 0) can be avoided by occasionally skipping over the value n_frames equal to MaxFPS when counting (e.g., counting n_frames from 0 to 12, then incrementing seconds_value and counting n_frames from 0 to 11, then incrementing seconds_value and counting n_frames from 0 to 12, etc.).

When counting_type is equal to 4 and cnt_dropped_flag is equal to 1, n_frames shall be equal to 2 and the specified value of sS shall be zero and the specified value of mM shall not be an integer multiple of ten and n_frames for the previous picture in output order shall not be equal to 0 or 1 unless discontinuity_flag is equal to 1.

NOTE 8 – When counting_type is equal to 4, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates (e.g., 30000÷1001 frames per second with time_scale equal to 60000 and num_units_in_tick equal to 1 001 and nuit_field_based_flag equal to 1) can be reduced by occasionally skipping over the value n_frames equal to MaxFPS when counting (e.g., counting n_frames from 0 to 29, then incrementing seconds_value and counting n_frames from 0 to 29, etc., until the seconds_value is zero and minutes_value is not an integer multiple of ten, then counting n_frames from 2 to 29, then incrementing seconds_value and counting n_frames from 0 to 29, etc.). This counting method is well known in industry and is often referred to as "NTSC drop-frame" counting.

When counting_type is equal to 5 or 6 and cnt_dropped_flag is equal to 1, n_frames shall not be equal to 1 plus the value of n_frames for the previous picture in output order modulo MaxFPS unless discontinuity_flag is equal to 1.

NOTE 9 – When counting_type is equal to 5 or 6, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates can be avoided by occasionally skipping over some values of n_frames when counting. The specific values of n_frames that are skipped are not specified when counting_type is equal to 5 or 6.

seconds_flag equal to 1 specifies that seconds_value and minutes_flag are present when full_timestamp_flag is equal to 0. seconds_flag equal to 0 specifies that seconds_value and minutes_flag are not present.

seconds_value specifies the value of sS used to compute clockTimestamp. The value of seconds_value shall be in the range of 0 to 59, inclusive. When seconds_value is not present, the previous seconds_value in decoding order shall be used as sS to compute clockTimestamp.

minutes_flag equal to 1 specifies that minutes_value and hours_flag are present when full_timestamp_flag is equal to 0 and seconds_flag is equal to 1. minutes_flag equal to 0 specifies that minutes_value and hours_flag are not present.

minutes_value specifies the value of mM used to compute clockTimestamp. The value of minutes_value shall be in the range of 0 to 59, inclusive. When minutes_value is not present, the previous minutes_value in decoding order shall be used as mM to compute clockTimestamp.

hours_flag equal to 1 specifies that hours_value is present when full_timestamp_flag is equal to 0 and seconds_flag is equal to 1 and minutes_flag is equal to 1.

hours_value specifies the value of hH used to compute clockTimestamp. The value of hours_value shall be in the range of 0 to 23, inclusive. When hours_value is not present, the previous hours_value in decoding order shall be used as hH to compute clockTimestamp.

time_offset specifies the value of tOffset used to compute clockTimestamp. The number of bits used to represent time_offset shall be equal to time_offset_length. When time_offset is not present, the value 0 shall be used as tOffset to compute clockTimestamp.

D.2.3 Pan-scan rectangle SEI message semantics

The pan-scan rectangle SEI message syntax elements specify the coordinates of a rectangle relative to the cropping rectangle of the sequence parameter set. Each coordinate of this rectangle is specified in units of one-sixteenth sample spacing relative to the luma sampling grid.

pan_scan_rect_id contains an identifying number that may be used to identify the purpose of the pan-scan rectangle (for example, to identify the rectangle as the area to be shown on a particular display device or as the area that contains a particular actor in the scene). The value of pan_scan_rect_id shall be in the range of 0 to $2^{32} – 1$, inclusive.

Values of pan_scan_rect_id from 0 to 255 and from 512 to 2^{31}-1 may be used as determined by the application. Values of pan_scan_rect_id from 256 to 511 and from 2^{31} to 2^{32}-1 are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of pan_scan_rect_id in the range of 256 to 511 or in the range of 2^{31} to 2^{32} - 1 shall ignore (remove from the bitstream and discard) it.

pan_scan_rect_cancel_flag equal to 1 indicates that the SEI message cancels the persistence of any previous pan-scan rectangle SEI message in output order. pan_scan_rect_cancel_flag equal to 0 indicates that pan-scan rectangle information follows.

pan_scan_cnt_minus1 specifies the number of pan-scan rectangles that are present in the SEI message. pan_scan_cnt_minus1 shall be in the range of 0 to 2, inclusive. pan_scan_cnt_minus1 equal to 0 indicates that a single pan-scan rectangle is present that applies to all fields of the decoded picture. pan_scan_cnt_minus1 shall be equal to 0 when the current picture is a field. pan_scan_cnt_minus1 equal to 1 indicates that two pan-scan rectangles are present, the first of which applies to the first field of the picture in output order and the second of which applies to the second field of the picture in output order. pan_scan_cnt_minus1 equal to 2 indicates that three pan-scan rectangles are present, the first of which applies to the first field of the picture in output order, the second of which applies to the second field of the picture in output order, and the third of which applies to a repetition of the first field as a third field in output order.

pan_scan_rect_left_offset[i **]**, **pan_scan_rect_right_offset[** i **]**, **pan_scan_rect_top_offset[** i **]**, and **pan_scan_rect_bottom_offset[** i **]**, specify, as signed integer quantities in units of one-sixteenth sample spacing relative to the luma sampling grid, the location of the pan-scan rectangle. The values of each of these four syntax elements shall be in the range of -2^{31} to 2^{31} - 1, inclusive.

The pan-scan rectangle is specified, in units of one-sixteenth sample spacing relative to a luma frame sampling grid, as the region with frame horizontal coordinates from 16*CropUnitX * frame_crop_left_offset + pan_scan_rect_left_offset[i] to 16 * (16 * PicWidthInMbs – CropUnitX * frame_crop_right_offset) + pan_scan_rect_right_offset[i] – 1 and with vertical coordinates from 16 *CropUnitY * frame_crop_top_offset + pan_scan_rect_top_offset[i] to 16 * (16 * PicHeightInMbs – CropUnitY * frame_crop_bottom_offset) + pan_scan_rect_bottom_offset[i] – 1, inclusive. The value of 16 * CropUnitX * frame_crop_left_offset + pan_scan_rect_left_offset[i] shall be less than or equal to 16 * (16 * PicWidthInMbs – CropUnitX * frame_crop_right_offset) + pan_scan_rect_right_offset[i] – 1; and the value of 16 CropUnitY * frame_crop_top_offset + pan_scan_rect_top_offset[i] shall be less than or equal to 16 * (16 * PicHeightInMbs – CropUnitY * frame_crop_bottom_offset) + pan_scan_rect_bottom_offset[i] – 1.

When the pan-scan rectangular area includes samples outside of the cropping rectangle, the region outside of the cropping rectangle may be filled with synthesized content (such as black video content or neutral grey video content) for display.

pan_scan_rect_repetition_period specifies the persistence of the pan-scan rectangle SEI message and may specify a picture order count interval within which another pan-scan rectangle SEI message with the same value of pan_scan_rect_id or the end of the coded video sequence shall be present in the bitstream. The value of pan_scan_rect_repetition_period shall be in the range of 0 to 16 384, inclusive. When pan_scan_cnt_minus1 is greater than 0, pan_scan_rect_repetition_period shall not be greater than 1.

pan_scan_rect_repetition_period equal to 0 specifies that the pan-scan rectangle information applies to the current decoded picture only.

pan_scan_rect_repetition_period equal to 1 specifies that the pan-scan rectangle information persists in output order until any of the following conditions are true.

- A new coded video sequence begins
- A picture in an access unit containing a pan-scan rectangle SEI message with the same value of pan_scan_rect_id is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic).

pan_scan_rect_repetition_period equal to 0 or equal to 1 indicates that another pan-scan rectangle SEI message with the same value of pan_scan_rect_id may or may not be present.

pan_scan_rect_repetition_period greater than 1 specifies that the pan-scan rectangle information persists until any of the following conditions are true.

- A new coded video sequence begins
- A picture in an access unit containing a pan-scan rectangle SEI message with the same value of pan_scan_rect_id is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + pan_scan_rect_repetition_period.

pan_scan_rect_repetition_period greater than 1 indicates that another pan-scan rectangle SEI message with the same value of pan_scan_rect_id shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater

than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + pan_scan_rect_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

D.2.4 Filler payload SEI message semantics

This message contains a series of payloadSize bytes of value 0xFF, which can be discarded.

ff_byte shall be a byte having the value 0xFF.

D.2.5 User data registered by ITU-T Rec. T.35 SEI message semantics

This message contains user data registered as specified by ITU-T Rec. T.35, the contents of which are not specified by this Recommendation | International Standard.

itu_t_t35_country_code shall be a byte having a value specified as a country code by ITU-T Rec. T.35 Annex A.

itu_t_t35_country_code_extension_byte shall be a byte having a value specified as a country code by ITU-T Rec. T.35 Annex B.

itu_t_t35_payload_byte shall be a byte containing data registered as specified by ITU-T Rec. T.35.

The ITU-T T.35 terminal provider code and terminal provider oriented code shall be contained in the first one or more bytes of the itu_t_t35_payload_byte, in the format specified by the Administration that issued the terminal provider code. Any remaining itu_t_t35_payload_byte data shall be data having syntax and semantics as specified by the entity identified by the ITU-T T.35 country code and terminal provider code.

D.2.6 User data unregistered SEI message semantics

This message contains unregistered user data identified by a UUID, the contents of which are not specified by this Recommendation | International Standard.

uuid_iso_iec_11578 shall have a value specified as a UUID according to the procedures of ISO/IEC 11578:1996 Annex A.

user_data_payload_byte shall be a byte containing data having syntax and semantics as specified by the UUID generator.

D.2.7 Recovery point SEI message semantics

The recovery point SEI message assists a decoder in determining when the decoding process will produce acceptable pictures for display after the decoder initiates random access or after the encoder indicates a broken link in the sequence. When the decoding process is started with the access unit in decoding order associated with the recovery point SEI message, all decoded pictures at or subsequent to the recovery point in output order specified in this SEI message are indicated to be correct or approximately correct in content. Decoded pictures produced by random access at or before the picture associated with the recovery point SEI message need not be correct in content until the indicated recovery point, and the operation of the decoding process starting at the picture associated with the recovery point SEI message may contain references to pictures not available in the decoded picture buffer.

In addition, by use of the broken_link_flag, the recovery point SEI message can indicate to the decoder the location of some pictures in the bitstream that can result in serious visual artefacts when displayed, even when the decoding process was begun at the location of a previous IDR access unit in decoding order.

> NOTE 1 – The broken_link_flag can be used by encoders to indicate the location of a point after which the decoding process for the decoding of some pictures may cause references to pictures that, though available for use in the decoding process, are not the pictures that were used for reference when the bitstream was originally encoded (e.g., due to a splicing operation performed during the generation of the bitstream).

The recovery point is specified as a count in units of frame_num increments subsequent to the frame_num of the current access unit at the position of the SEI message.

> NOTE 2 – When HRD information is present in the bitstream, a buffering period SEI message should be associated with the access unit associated with the recovery point SEI message in order to establish initialisation of the HRD buffer model after a random access.

recovery_frame_cnt specifies the recovery point of output pictures in output order. All decoded pictures in output order are indicated to be correct or approximately correct in content starting at the output order position of the reference picture having the frame_num equal to the frame_num of the VCL NAL units for the current access unit incremented by recovery_frame_cnt in modulo MaxFrameNum arithmetic. recovery_frame_cnt shall be in the range of 0 to MaxFrameNum – 1, inclusive.

exact_match_flag indicates whether decoded pictures at and subsequent to the specified recovery point in output order derived by starting the decoding process at the access unit associated with the recovery point SEI message shall be an

exact match to the pictures that would be produced by starting the decoding process at the location of a previous IDR access unit in the NAL unit stream. The value 0 indicates that the match need not be exact and the value 1 indicates that the match shall be exact.

When decoding starts from the location of the recovery point SEI message, all references to not available reference pictures shall be inferred as references to pictures containing only macroblocks coded using Intra macroblock prediction modes and having sample values given by Y samples equal to 128, Cb samples equal to 128, and Cr samples equal to 128 (mid-level grey) for purposes of determining the conformance of the value of exact_match_flag.

NOTE 3 – When performing random access, decoders should infer all references to not available reference pictures as references to pictures containing only intra macroblocks and having sample values given by Y equal to 128, Cb equal to 128, and Cr equal to 128 (mid-level grey), regardless of the value of exact_match_flag.

When exact_match_flag is equal to 0, the quality of the approximation at the recovery point is chosen by the encoding process and is not specified by this Recommendation | International Standard.

broken_link_flag indicates the presence or absence of a broken link in the NAL unit stream at the location of the recovery point SEI message and is assigned further semantics as follows.

- If broken_link_flag is equal to 1, pictures produced by starting the decoding process at the location of a previous IDR access unit may contain undesirable visual artefacts to the extent that decoded pictures at and subsequent to the access unit associated with the recovery point SEI message in decoding order should not be displayed until the specified recovery point in output order.
- Otherwise (broken_link_flag is equal to 0), no indication is given regarding any potential presence of visual artefacts.

Regardless of the value of the broken_link_flag, pictures subsequent to the specified recovery point in output order are specified to be correct or approximately correct in content.

NOTE 4 – When a sub-sequence information SEI message is present in conjunction with a recovery point SEI message in which broken_link_flag is equal to 1 and when sub_seq_layer_num is equal to 0, sub_seq_id should be different from the latest sub_seq_id for sub_seq_layer_num equal to 0 that was decoded prior to the location of the recovery point SEI message. When broken_link_flag is equal to 0, the sub_seq_id in sub-sequence layer 0 should remain unchanged.

changing_slice_group_idc equal to 0 indicates that decoded pictures are correct or approximately correct in content at and subsequent to the recovery point in output order when all macroblocks of the primary coded pictures are decoded within the changing slice group period, i.e., the period between the access unit associated with the recovery point SEI message (inclusive) and the specified recovery point (inclusive) in decoding order. changing_slice_group_idc shall be equal to 0 when num_slice_groups_minus1 is equal to 0 in any primary coded picture within the changing slice group period.

When changing_slice_group_idc is equal to 1 or 2, num_slice_groups_minus1 shall be equal to 1 and the macroblock-to-slice-group map type 3, 4, or 5 shall be applied in each primary coded picture in the changing slice group period.

changing_slice_group_idc equal to 1 indicates that within the changing slice group period no sample values outside the decoded macroblocks covered by slice group 0 are used for inter prediction of any macroblock within slice group 0. In addition, changing_slice_group_idc equal to 1 indicates that when all macroblocks in slice group 0 within the changing slice group period are decoded, decoded pictures will be correct or approximately correct in content at and subsequent to the specified recovery point in output order regardless of whether any macroblock in slice group 1 within the changing slice group period is decoded.

changing_slice_group_idc equal to 2 indicates that within the changing slice group period no sample values outside the decoded macroblocks covered by slice group 1 are used for inter prediction of any macroblock within slice group 1. In addition, changing_slice_group_idc equal to 2 indicates that when all macroblocks in slice group 1 within the changing slice group period are decoded, decoded pictures will be correct or approximately correct in content at and subsequent to the specified recovery point in output order regardless of whether any macroblock in slice group 0 within the changing slice group period is decoded.

changing_slice_group_idc shall be in the range of 0 to 2, inclusive.

D.2.8 Decoded reference picture marking repetition SEI message semantics

The decoded reference picture marking repetition SEI message is used to repeat the decoded reference picture marking syntax structure that was located in the slice header of an earlier picture in the sequence in decoding order.

original_idr_flag shall be equal to 1 when the decoded reference picture marking syntax structure occurred originally in an IDR picture. original_idr_flag shall be equal to 0 when the repeated decoded reference picture marking syntax structure did not occur in an IDR picture originally.

original_frame_num shall be equal to the frame_num of the picture where the repeated decoded reference picture marking syntax structure originally occurred. The picture indicated by original_frame_num is the previous coded picture having the specified value of frame_num. The value of original_frame_num used to refer to a picture having a memory_management_control_operation equal to 5 shall be 0.

original_field_pic_flag shall be equal to the field_pic_flag of the picture where the repeated decoded reference picture marking syntax structure originally occurred.

original_bottom_field_flag shall be equal to the bottom_field_flag of the picture where the repeated decoded reference picture marking syntax structure originally occurred.

dec_ref_pic_marking( ) shall contain a copy of the decoded reference picture marking syntax structure of the picture whose frame_num was original_frame_num. The nal_unit_type used for specification of the repeated dec_ref_pic_marking( ) syntax structure shall be the nal_unit_type of the slice header(s) of the picture whose frame_num was original_frame_num (i.e., nal_unit_type as used in subclause 7.3.3.3 shall be considered equal to 5 when original_idr_flag is equal to 1 and shall not be considered equal to 5 when original_idr_flag is equal to 0).

D.2.9 Spare picture SEI message semantics

This SEI message indicates that certain slice group map units, called spare slice group map units, in one or more decoded reference pictures resemble the co-located slice group map units in a specified decoded picture called the target picture. A spare slice group map unit may be used to replace a co-located, incorrectly decoded slice group map unit, in the target picture. A decoded picture containing spare slice group map units is called a spare picture.

For all spare pictures identified in a spare picture SEI message, the value of frame_mbs_only_flag shall be equal to the value of frame_mbs_only_flag of the target picture in the same SEI message. The spare pictures in the SEI message are constrained as follows.

- If the target picture is a decoded field, all spare pictures identified in the same SEI message shall be decoded fields.
- Otherwise (the target picture is a decoded frame), all spare pictures identified in the same SEI message shall be decoded frames.

For all spare pictures identified in a spare picture SEI message, the values of pic_width_in_mbs_minus1 and pic_height_in_map_units_minus1 shall be equal to the values of pic_width_in_mbs_minus1 and pic_height_in_map_units_minus1, respectively, of the target picture in the same SEI message. The picture associated (as specified in subclause 7.4.1.2.3) with this message shall appear after the target picture, in decoding order.

target_frame_num indicates the frame_num of the target picture.

spare_field_flag equal to 0 indicates that the target picture and the spare pictures are decoded frames. spare_field_flag equal to 1 indicates that the target picture and the spare pictures are decoded fields.

target_bottom_field_flag equal to 0 indicates that the target picture is a top field. target_bottom_field_flag equal to 1 indicates that the target picture is a bottom field.

A target picture is a decoded reference picture whose corresponding primary coded picture precedes the current picture, in decoding order, and in which the values of frame_num, field_pic_flag (when present) and bottom_field_flag (when present) are equal to target_frame_num, spare_field_flag and target_bottom_field_flag, respectively.

num_spare_pics_minus1 indicates the number of spare pictures for the specified target picture. The number of spare pictures is equal to num_spare_pics_minus1 + 1. The value of num_spare_pics_minus1 shall be in the range of 0 to 15, inclusive.

delta_spare_frame_num[i **]** is used to identify the spare picture that contains the i-th set of spare slice group map units, hereafter called the i-th spare picture, as specified below. The value of delta_spare_frame_num[i] shall be in the range of 0 to MaxFrameNum - 1 - !spare_field_flag, inclusive.

The frame_num of the i-th spare picture, spareFrameNum[i], is derived as follows for all values of i from 0 to num_spare_pics_minus1, inclusive:

```
candidateSpareFrameNum = target_frame_num - !spare_field_flag
for ( i = 0; i <= num_spare_pics_minus1; i++ ) {
    if( candidateSpareFrameNum < 0 )
        candidateSpareFrameNum = MaxFrameNum – 1
    spareFrameNum[ i ] = candidateSpareFrameNum – delta_spare_frame_num[ i ]          (D-3)
    if( spareFrameNum[ i ] < 0 )
        spareFrameNum[ i ] = MaxFrameNum + spareFrameNum[ i ]
```

```
        candidateSpareFrameNum = spareFrameNum[ i ] - !spare_field_flag
    }
```

spare_bottom_field_flag[i **]** equal to 0 indicates that the i-th spare picture is a top field. spare_bottom_field_flag[i] equal to 1 indicates that the i-th spare picture is a bottom field.

The 0-th spare picture is a decoded reference picture whose corresponding primary coded picture precedes the target picture, in decoding order, and in which the values of frame_num, field_pic_flag (when present) and bottom_field_flag (when present) are equal to spareFrameNum[0], spare_field_flag and spare_bottom_field_flag[0], respectively. The i-th spare picture is a decoded reference picture whose corresponding primary coded picture precedes the (i - 1)-th spare picture, in decoding order, and in which the values of frame_num, field_pic_flag (when present) and bottom_field_flag (when present) are equal to spareFrameNum[i], spare_field_flag and spare_bottom_field_flag[i], respectively.

spare_area_idc[i **]** indicates the method used to identify the spare slice group map units in the i-th spare picture. spare_area_idc[i] shall be in the range of 0 to 2, inclusive. spare_area_idc[i] equal to 0 indicates that all slice group map units in the i-th spare picture are spare units. spare_area_idc[i] equal to 1 indicates that the value of the syntax element spare_unit_flag[i][j] is used to identify the spare slice group map units. spare_area_idc[i] equal to 2 indicates that the zero_run_length[i][j] syntax element is used to derive the values of spareUnitFlagInBoxOutOrder[i][j], as described below.

spare_unit_flag[i **][** j **]** equal to 0 indicates that the j-th slice group map unit in raster scan order in the i-th spare picture is a spare unit. spare_unit_flag[i][j] equal to 1 indicates that the j-th slice group map unit in raster scan order in the i-th spare picture is not a spare unit.

zero_run_length[i **][** j **]** is used to derive the values of spareUnitFlagInBoxOutOrder[i][j] when spare_area_idc[i] is equal to 2. In this case, the spare slice group map units identified in spareUnitFlagInBoxOutOrder[i][j] appear in counter-clockwise box-out order, as specified in subclause 8.2.2.4, for each spare picture. spareUnitFlagInBoxOutOrder[i][j] equal to 0 indicates that the j-th slice group map unit in counter-clockwise box-out order in the i-th spare picture is a spare unit. spareUnitFlagInBoxOutOrder[i][j] equal to 1 indicates that the j-th slice group map unit in counter-clockwise box-out order in the i-th spare picture is not a spare unit.

When spare_area_idc[0] is equal to 2, spareUnitFlagInBoxOutOrder[0][j] is derived as follows:

```
for( j = 0, loop = 0; j < PicSizeInMapUnits; loop++ ) {
   for( k = 0; k < zero_run_length[ 0 ][ loop ]; k++ )
      spareUnitFlagInBoxOutOrder[ 0 ][ j++ ] = 0                                    (D-4)
   spareUnitFlagInBoxOutOrder[ 0 ][ j++ ] = 1
}
```

When spare_area_idc[i] is equal to 2 and the value of i is greater than 0, spareUnitFlagInBoxOutOrder[i][j] is derived as follows:

```
for( j = 0, loop = 0; j < PicSizeInMapUnits; loop++ ) {
   for( k = 0; k < zero_run_length[ i ][ loop ]; k++ )
      spareUnitFlagInBoxOutOrder[ i ][ j ] = spareUnitFlagInBoxOutOrder[ i - 1 ][ j++ ]   (D-5)
   spareUnitFlagInBoxOutOrder[ i ][ j ] = !spareUnitFlagInBoxOutOrder[ i - 1 ][ j++ ]
}
```

D.2.10 Scene information SEI message semantics

A scene and a scene transition are herein defined as a set of consecutive pictures in output order.

NOTE 1 – Decoded pictures within one scene generally have similar content. The scene information SEI message is used to label pictures with scene identifiers and to indicate scene changes. The message specifies how the source pictures for the labelled pictures were created. The decoder may use the information to select an appropriate algorithm to conceal transmission errors. For example, a specific algorithm may be used to conceal transmission errors that occurred in pictures belonging to a gradual scene transition. Furthermore, the scene information SEI message may be used in a manner determined by the application, such as for indexing the scenes of a coded sequence.

A scene information SEI message labels all pictures, in decoding order, from the primary coded picture to which the SEI message is associated (inclusive), as specified in subclause 7.4.1.2.3, to the primary coded picture to which the next scene information SEI message (if present) in decoding order is associated (exclusive) or (otherwise) to the last access unit in the bitstream (inclusive). These pictures are herein referred to as the target pictures.

scene_info_present_flag equal to 0 indicates that the scene or scene transition to which the target pictures belong is unspecified. scene_info_present_flag equal to 1 indicates that the target pictures belong to the same scene or scene transition.

scene_id identifies the scene to which the target pictures belong. When the value of scene_transition_type of the target pictures is less than 4, and the previous picture in output order is marked with a value of scene_transition_type less than 4, and the value of scene_id is the same as the value of scene_id of the previous picture in output order, this indicates that the source scene for the target pictures and the source scene for the previous picture (in output order) are considered by the encoder to have been the same scene. When the value of scene_transition_type of the target pictures is greater than 3, and the previous picture in output order is marked with a value of scene_transition_type less than 4, and the value of scene_id is the same as the value of scene_id of the previous picture in output order, this indicates that one of the source scenes for the target pictures and the source scene for the previous picture (in output order) are considered by the encoder to have been the same scene. When the value of scene_id is not equal to the value of scene_id of the previous picture in output order, this indicates that the target pictures and the previous picture (in output order) are considered by the encoder to have been from different source scenes.

The value of scene_id shall be in the range of 0 to 2^{32}-1, inclusive. Values of scene_id in the range of 0 to 255, inclusive, and in the range of 512 to $2^{31} - 1$, inclusive, may be used as determined by the application. Values of scene_id in the range of 256 to 511, inclusive, and in the range of 2^{31} to $2^{32} - 1$, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of scene_id in the range of 256 to 511, inclusive, or in the range of 2^{31} to 2^{32} - 1, inclusive, shall ignore (remove from the bitstream and discard) it.

scene_transition_type specifies in which type of a scene transition (if any) the target pictures are involved. The valid values of scene_transition_type are specified in Table D-4.

Table D-4 – scene_transition_type values

Value	Description
0	No transition
1	Fade to black
2	Fade from black
3	Unspecified transition from or to constant colour
4	Dissolve
5	Wipe
6	Unspecified mixture of two scenes

When scene_transition_type is greater than 3, the target pictures include contents both from the scene labelled by its scene_id and the next scene, in output order, which is labelled by second_scene_id (see below). The term “the current scene” is used to indicate the scene labelled by scene_id. The term “the next scene” is used to indicate the scene labelled by second_scene_id. It is not required for any following picture, in output order, to be labelled with scene_id equal to second_scene_id of the current SEI message.

Scene transition types are specified as follows.

“No transition” specifies that the target pictures are not involved in a gradual scene transition.

NOTE 2 – When two consecutive pictures in output order have scene_transition_type equal to 0 and different values of scene_id, a scene cut occurred between the two pictures.

“Fade to black” indicates that the target pictures are part of a sequence of pictures, in output order, involved in a fade to black scene transition, i.e., the luma samples of the scene gradually approach zero and the chroma samples of the scene gradually approach 128.

NOTE 3 – When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Fade to black", the later one, in output order, is darker than the previous one.

“Fade from black” indicates that the target pictures are part of a sequence of pictures, in output order, involved in a fade from black scene transition, i.e., the luma samples of the scene gradually diverge from zero and the chroma samples of the scene may gradually diverge from 128.

NOTE 4 – When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Fade from black", the later one in output order is lighter than the previous one.

“Dissolve” indicates that the sample values of each target picture (before encoding) were generated by calculating a sum of co-located weighted sample values of a picture from the current scene and a picture from the next scene. The

weight of the current scene gradually decreases from full level to zero level, whereas the weight of the next scene gradually increases from zero level to full level. When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Dissolve", the weight of the current scene for the later one, in output order, is less than the weight of the current scene for the previous one, and the weight of the next scene for the later one, in output order, is greater than the weight of the next scene for the previous one.

"Wipe" indicates that some of the sample values of each target picture (before encoding) were generated by copying co-located sample values of a picture in the current scene and the remaining sample values of each target picture (before encoding) were generated by copying co-located sample values of a picture in the next scene. When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Wipe", the number of samples copied from the next scene to the later picture in output order is greater than the number of samples copied from the next scene to the previous picture.

second_scene_id identifies the next scene in the gradual scene transition in which the target pictures are involved. The value of second_scene_id shall not be equal to the value of scene_id. The value of second_scene_id shall not be equal to the value of scene_id in the previous picture in output order. When the next picture in output order is marked with a value of scene_transition_type less than 4, and the value of second_scene_id is the same as the value of scene_id of the next picture in output order, this indicates that the encoder considers one of the source scenes for the target pictures and the source scene for the next picture (in output order) to have been the same scene. When the value of second_scene_id is not equal to the value of scene_id or second_scene_id (if present) of the next picture in output order, this indicates that the encoder considers the target pictures and the next picture (in output order) to have been from different source scenes.

When the value of scene_id of a picture is equal to the value of scene_id of the following picture in output order and the value of scene_transition_type in both of these pictures is less than 4, this indicates that the encoder considers the two pictures to have been from the same source scene. When the values of scene_id, scene_transition_type and second_scene_id (if present) of a picture are equal to the values of scene_id, scene_transition_type and second_scene_id (respectively) of the following picture in output order and the value of scene_transition_type is greater than 0, this indicates that the encoder considers the two pictures to have been from the same source gradual scene transition.

The value of second_scene_id shall be in the range of 0 to 2^{32}-1, inclusive. Values of second_scene_id in the range of 0 to 255, inclusive, and in the range of 512 to 2^{31}-1, inclusive, may be used as determined by the application. Values of second_scene_id in the range of 256 to 511, inclusive, and in the range of 2^{31} to 2^{32}-1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of second_scene_id in the range of 256 to 511, inclusive, or in the range of 2^{31} to 2^{32}-1, inclusive, shall ignore (remove from the bitstream and discard) it.

D.2.11 Sub-sequence information SEI message semantics

The sub-sequence information SEI message is used to indicate the position of a picture in data dependency hierarchy that consists of sub-sequence layers and sub-sequences.

A sub-sequence layer contains a subset of the coded pictures in a sequence. Sub-sequence layers are numbered with non-negative integers. A layer having a larger layer number is a higher layer than a layer having a smaller layer number. The layers are ordered hierarchically based on their dependency on each other so that any picture in a layer shall not be predicted from any picture on any higher layer.

NOTE 1 – In other words, any picture in layer 0 must not be predicted from any picture in layer 1 or above, pictures in layer 1 may be predicted from layer 0, pictures in layer 2 may be predicted from layers 0 and 1, etc.

NOTE 2 – The subjective quality is expected to increase along with the number of decoded layers.

A sub-sequence is a set of coded pictures within a sub-sequence layer. A picture shall reside in one sub-sequence layer and in one sub-sequence only. Any picture in a sub-sequence shall not be predicted from any picture in another sub-sequence in the same or in a higher sub-sequence layer. A sub-sequence in layer 0 can be decoded independently of any picture that does not belong to the sub-sequence.

The sub-sequence information SEI message concerns the current access unit. The primary coded picture in the access unit is herein referred to as the current picture.

The sub-sequence information SEI message shall not be present unless gaps_in_frame_num_value_allowed_flag in the sequence parameter set referenced by the picture associated with the sub-sequence SEI message is equal to 1.

sub_seq_layer_num specifies the sub-sequence layer number of the current picture. When sub_seq_layer_num is greater than 0, memory management control operations shall not be used in any slice header of the current picture. When the current picture resides in a sub-sequence whose first picture in decoding order is an IDR picture, the value of sub_seq_layer_num shall be equal to 0. For a non-paired reference field, the value of sub_seq_layer_num shall be equal to 0. sub_seq_layer_num shall be in the range of 0 to 255, inclusive.

sub_seq_id identifies the sub-sequence within a layer. When the current picture resides in a sub-sequence whose first picture in decoding order is an IDR picture, the value of sub_seq_id shall be the same as the value of idr_pic_id of the IDR picture. sub_seq_id shall be in the range of 0 to 65535, inclusive.

first_ref_pic_flag equal to 1 specifies that the current picture is the first reference picture of the sub-sequence in decoding order. When the current picture is not the first picture of the sub-sequence in decoding order, the first_ref_pic_flag shall be equal to 0.

leading_non_ref_pic_flag equal to 1 specifies that the current picture is a non-reference picture preceding any reference picture in decoding order within the sub-sequence or that the sub-sequence contains no reference pictures. When the current picture is a reference picture or the current picture is a non-reference picture succeeding at least one reference picture in decoding order within the sub-sequence, the leading_non_ref_pic_flag shall be equal to 0.

last_pic_flag equal to 1 indicates that the current picture is the last picture of the sub-sequence (in decoding order), including all reference and non-reference pictures of the sub-sequence. When the current picture is not the last picture of the sub-sequence (in decoding order), last_pic_flag shall be equal to 0.

The current picture is assigned to a sub-sequence as follows.

- If one or more of the following conditions is true, the current picture is the first picture of a sub-sequence in decoding order.
    - no earlier picture in decoding order is labelled with the same values of sub_seq_id and sub_seq_layer_num as the current picture
    - the value of leading_non_ref_pic_flag is equal to 1 and the value of leading_non_ref_pic_flag is equal to 0 in the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture
    - the value of first_ref_pic_flag is equal to 1 and the value of leading_non_ref_pic_flag is equal to 0 in the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture
    - the value of last_pic_flag is equal to 1 in the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture
- Otherwise, the current picture belongs to the same sub-sequence as the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture.

sub_seq_frame_num_flag equal to 0 specifies that sub_seq_frame_num is not present. sub_seq_frame_num_flag equal to 1 specifies that sub_seq_frame_num is present.

sub_seq_frame_num shall be equal to 0 for the first reference picture of the sub-sequence and for any non-reference picture preceding the first reference picture of the sub-sequence in decoding order. sub_seq_frame_num is further constrained as follows.

- If the current picture is not the second field of a complementary field pair, sub_seq_frame_num shall be incremented by 1, in modulo MaxFrameNum operation, relative to the previous reference picture, in decoding order, that belongs to the sub-sequence.
- Otherwise (the current picture is the second field of a complementary field pair), the value of sub_seq_frame_num shall be the same as the value of sub_seq_frame_num for the first field of the complementary field pair.

sub_seq_frame_num shall be in the range of 0 to MaxFrameNum – 1, inclusive.

When the current picture is an IDR picture, it shall start a new sub-sequence in sub-sequence layer 0. Thus, the sub_seq_layer_num shall be 0, the sub_seq_id shall be different from the previous sub-sequence in sub-sequence layer 0, first_ref_pic_flag shall be 1, and leading_non_ref_pic_flag shall be equal to 0.

When the sub-sequence information SEI message is present for both coded fields of a complementary field pair, the values of sub_seq_layer_num, sub_seq_id, leading_non_ref_pic_flag and sub_seq_frame_num, when present, shall be identical for both of these pictures.

When the sub-sequence information SEI message is present only for one coded field of a complementary field pair, the values of sub_seq_layer_num, sub_seq_id, leading_non_ref_pic_flag and sub_seq_frame_num, when present, are also applicable to the other coded field of the complementary field pair.

D.2.12 Sub-sequence layer characteristics SEI message semantics

The sub-sequence layer characteristics SEI message specifies the characteristics of sub-sequence layers.

num_sub_seq_layers_minus1 plus 1 specifies the number of sub-sequence layers in the sequence. num_sub_seq_layers_minus1 shall be in the range of 0 to 255, inclusive.

A pair of average_bit_rate and average_frame_rate characterizes each sub-sequence layer. The first pair of average_bit_rate and average_frame_rate specifies the characteristics of sub-sequence layer 0. When present, the second pair specifies the characteristics of sub-sequence layers 0 and 1 jointly. Each pair in decoding order specifies the characteristics for a range of sub-sequence layers from layer number 0 to the layer number specified by the layer loop counter. The values are in effect from the point they are decoded until an update of the values is decoded.

accurate_statistics_flag equal to 1 indicates that the values of average_bit_rate and average_frame_rate are rounded from statistically correct values. accurate_statistics_flag equal to 0 indicates that the average_bit_rate and the average_frame_rate are estimates and may deviate somewhat from the correct values.

When accurate_statistics_flag is equal to 0, the quality of the approximation used in the computation of the values of average_bit_rate and the average_frame_rate is chosen by the encoding process and is not specified by this Recommendation | International Standard.

average_bit_rate indicates the average bit rate in units of 1000 bits per second. All NAL units in the range of sub-sequence layers specified above are taken into account in the calculation. The average bit rate is derived according to the access unit removal time specified in Annex C of the Recommendation | International Standard. In the following, bTotal is the number of bits in all NAL units succeeding a sub-sequence layer characteristics SEI message (including the bits of the NAL units of the current access unit) and preceding the next access unit (in decoding order) including a sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise). t_1 is the removal time (in seconds) of the current access unit, and t_2 is the removal time (in seconds) of the latest access unit (in decoding order) before the next sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If t_1 is not equal to t_2, the following condition shall be true

$$\text{average\_bit\_rate} == \text{Round}(\text{bTotal} \div ((t_2 - t_1) * 1000))) \quad \text{(D-6)}$$

– Otherwise (t_1 is equal to t_2), the following condition shall be true

$$\text{average\_bit\_rate} == 0 \quad \text{(D-7)}$$

average_frame_rate indicates the average frame rate in units of frames/(256 seconds). All NAL units in the range of sub-sequence layers specified above are taken into account in the calculation. In the following, fTotal is the number of frames, complementary field pairs and non-paired fields between the current picture (inclusive) and the next sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise). t_1 is the removal time (in seconds) of the current access unit, and t_2 is the removal time (in seconds) of the latest access unit (in decoding order) before the next sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If t_1 is not equal to t_2, the following condition shall be true

$$\text{average\_frame\_rate} == \text{Round}(\text{fTotal} * 256 \div (t_2 - t_1)) \quad \text{(D-8)}$$

– Otherwise (t_1 is equal to t_2), the following condition shall be true

$$\text{average\_frame\_rate} == 0 \quad \text{(D-9)}$$

D.2.13 Sub-sequence characteristics SEI message semantics

The sub-sequence characteristics SEI message indicates the characteristics of a sub-sequence. It also indicates inter prediction dependencies between sub-sequences. This message shall be contained in the first access unit in decoding order of the sub-sequence to which the sub-sequence characteristics SEI message applies. This sub-sequence is herein called the target sub-sequence.

sub_seq_layer_num identifies the sub-sequence layer number of the target sub-sequence. sub_seq_layer_num shall be in the range of 0 to 255, inclusive.

sub_seq_id identifies the target sub-sequence. sub_seq_id shall be in the range of 0 to 65535, inclusive.

duration_flag equal to 0 indicates that the duration of the target sub-sequence is not specified.

sub_seq_duration specifies the duration of the target sub-sequence in clock ticks of a 90-kHz clock.

average_rate_flag equal to 0 indicates that the average bit rate and the average frame rate of the target sub-sequence are unspecified.

accurate_statistics_flag indicates how reliable the values of average_bit_rate and average_frame_rate are. accurate_statistics_flag equal to 1, indicates that the average_bit_rate and the average_frame_rate are rounded from statistically correct values. accurate_statistics_flag equal to 0 indicates that the average_bit_rate and the average_frame_rate are estimates and may deviate from the statistically correct values.

average_bit_rate indicates the average bit rate in (1000 bits)/second of the target sub-sequence. All NAL units of the target sub-sequence are taken into account in the calculation. The average bit rate is derived according to the access unit removal time specified in subclause C.1.2. In the following, nB is the number of bits in all NAL units in the sub-sequence. t_1 is the removal time (in seconds) of the first access unit of the sub-sequence (in decoding order), and t_2 is the removal time (in seconds) of the last access unit of the sub-sequence (in decoding order).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If t_1 is not equal to t_2, the following condition shall be true

$$\text{average\_bit\_rate} == \text{Round}(nB \div ((t_2 - t_1) * 1000)) \quad \text{(D-10)}$$

– Otherwise (t_1 is equal to t_2), the following condition shall be true

$$\text{average\_bit\_rate} == 0 \quad \text{(D-11)}$$

average_frame_rate indicates the average frame rate in units of frames/(256 seconds) of the target sub-sequence. All NAL units of the target sub-sequence are taken into account in the calculation. The average frame rate is derived according to the access unit removal time specified in subclause C.1.2. In the following, fC is the number of frames, complementary field pairs and non-paired fields in the sub-sequence. t_1 is the removal time (in seconds) of the first access unit of the sub-sequence (in decoding order), and t_2 is the removal time (in seconds) of the last access unit of the sub-sequence (in decoding order).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If t_1 is not equal to t_2, the following condition shall be true

$$\text{average\_frame\_rate} == \text{Round}(fC * 256 \div (t_2 - t_1)) \quad \text{(D-12)}$$

– Otherwise (t_1 is equal to t_2), the following condition shall be true

$$\text{average\_frame\_rate} == 0 \quad \text{(D-13)}$$

num_referenced_subseqs specifies the number of sub-sequences that contain pictures that are used as reference pictures for inter prediction in the pictures of the target sub-sequence. num_referenced_subseqs shall be in the range of 0 to 255, inclusive.

ref_sub_seq_layer_num, ref_sub_seq_id, and **ref_sub_seq_direction** identify the sub-sequence that contains pictures that are used as reference pictures for inter prediction in the pictures of the target sub-sequence. Depending on ref_sub_seq_direction, the following applies.

– If ref_sub_seq_direction is equal to 0, a set of candidate sub-sequences consists of the sub-sequences whose sub_seq_id is equal to ref_sub_seq_id, which reside in the sub-sequence layer having sub_seq_layer_num equal to ref_sub_seq_layer_num, and whose first picture in decoding order precedes the first picture of the target sub-sequence in decoding order.

– Otherwise (ref_sub_seq_direction is equal to 1), a set of candidate sub-sequences consists of the sub-sequences whose sub_seq_id is equal to ref_sub_seq_id, which reside in the sub-sequence layer having sub_seq_layer_num equal to ref_sub_seq_layer_num, and whose first picture in decoding order succeeds the first picture of the target sub-sequence in decoding order.

The sub-sequence used as a reference for the target sub-sequence is the sub-sequence among the set of candidate sub-sequences whose first picture is the closest to the first picture of the target sub-sequence in decoding order.

D.2.14 Full-frame freeze SEI message semantics

The full-frame freeze SEI message indicates that the current picture and any subsequent pictures in output order that meet specified conditions should not affect the content of the display. No more than one full-frame freeze SEI message shall be present in any access unit.

full_frame_freeze_repetition_period specifies the persistence of the full-frame freeze SEI message and may specify a picture order count interval within which another full-frame freeze SEI message or a full-frame freeze release SEI or the end of the coded video sequence shall be present in the bitstream. The value of full_frame_freeze_repetition_period shall be in the range of 0 to 16 384, inclusive.

full_frame_freeze_repetition_period equal to 0 specifies that the full-frame freeze SEI message applies to the current decoded picture only.

full_frame_freeze_repetition_period equal to 1 specifies that the full-frame freeze SEI message persists in output order until any of the following conditions are true.

- A new coded video sequence begins
- A picture in an access unit containing a full-frame freeze SEI message or a full-frame freeze release SEI message is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic).

full_frame_freeze_repetition_period greater than 1 specifies that the full-frame freeze SEI message persists until any of the following conditions are true.

- A new coded video sequence begins
- A picture in an access unit containing a full-frame freeze SEI message or a full-frame freeze release SEI message is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + full_frame_freeze_repetition_period.

full_frame_freeze_repetition_period greater than 1 indicates that another full-frame freeze SEI message or a full-frame freeze release SEI message shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + full_frame_freeze_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

D.2.15 Full-frame freeze release SEI message semantics

The full-frame freeze release SEI message cancels the effect of any full-frame freeze SEI message sent with pictures that precede the current picture in output order. The full-frame freeze release SEI message indicates that the current picture and subsequent pictures in output order should affect the contents of the display.

No more than one full-frame freeze release SEI message shall be present in any access unit. A full-frame freeze release SEI message shall not be present in an access unit containing a full-frame freeze SEI message. When a full-frame freeze SEI message is present in an access unit containing a field of a complementary field pair in which the values of PicOrderCnt(CurrPic) for the two fields of the complementary field pair are equal to each other, a full-frame freeze release SEI message shall not be present in either of the two access units.

D.2.16 Full-frame snapshot SEI message semantics

The full-frame snapshot SEI message indicates that the current frame is labelled for use as determined by the application as a still-image snapshot of the video content.

snapshot_id specifies a snapshot identification number. snapshot_id shall be in the range of 0 to 2^{32} - 1, inclusive.

Values of snapshot_id in the range of 0 to 255, inclusive, and in the range of 512 to 2^{31}-1, inclusive, may be used as determined by the application. Values of snapshot_id in the range of 256 to 511, inclusive, and in the range of 2^{31} to 2^{32}-1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of snapshot_id in the range of 256 to 511, inclusive, or in the range of 2^{31} to 2^{32}-1, inclusive, shall ignore (remove from the bitstream and discard) it.

D.2.17 Progressive refinement segment start SEI message semantics

The progressive refinement segment start SEI message specifies the beginning of a set of consecutive coded pictures that is labelled as the current picture followed by a sequence of one or more pictures of refinement of the quality of the current picture, rather than as a representation of a continually moving scene.

The tagged set of consecutive coded pictures shall continue until one of the following conditions is true. When a condition below becomes true, the next slice to be decoded does not belong to the tagged set of consecutive coded pictures.

1. The next slice to be decoded belongs to an IDR picture.

2. num_refinement_steps_minus1 is greater than 0 and the frame_num of the next slice to be decoded is (currFrameNum + num_refinement_steps_minus1 + 1) % MaxFrameNum, where currFrameNum is the value of frame_num of the picture in the access unit containing the SEI message.

3. num_refinement_steps_minus1 is 0 and a progressive refinement segment end SEI message with the same progressive_refinement_id as the one in this SEI message is decoded.

The decoding order of picture within the tagged set of consecutive pictures should be the same as their output order. **progressive_refinement_id** specifies an identification number for the progressive refinement operation. progressive_refinement_id shall be in the range of 0 to 2^{32} - 1, inclusive.

Values of progressive_refinement_id in the range of 0 to 255, inclusive, and in the range of 512 to 2^{31} - 1, inclusive, may be used as determined by the application. Values of progressive_refinement_id in the range of 256 to 511, inclusive, and in the range of 2^{31} to 2^{32}-1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of progressive_refinement_id in the range of 256 to 511, inclusive, or in the range of 2^{31} to 2^{32} - 1, inclusive, shall ignore (remove from the bitstream and discard) it.

num_refinement_steps_minus1 specifies the number of reference frames in the tagged set of consecutive coded pictures as follows.

– If num_refinement_steps_minus1 is equal to 0, the number of reference frames in the tagged set of consecutive coded pictures is unknown.

– Otherwise, the number of reference frames in the tagged set of consecutive coded pictures is equal to num_refinement_steps_minus1 + 1.

num_refinement_steps_minus1 shall be in the range of 0 to MaxFrameNum - 1, inclusive.

D.2.18 Progressive refinement segment end SEI message semantics

The progressive refinement segment end SEI message specifies the end of a set of consecutive coded pictures that has been labelled by use of a progressive refinement segment start SEI message as an initial picture followed by a sequence of one or more pictures of the refinement of the quality of the initial picture, and ending with the current picture.

progressive_refinement_id specifies an identification number for the progressive refinement operation. progressive_refinement_id shall be in the range of 0 to 2^{32} - 1, inclusive.

The progressive refinement segment end SEI message specifies the end of any progressive refinement segment previously started using a progressive refinement segment start SEI message with the same value of progressive_refinement_id.

Values of progressive_refinement_id in the range of 0 to 255, inclusive, and in the range of 512 to 2^{31} - 1, inclusive, may be used as determined by the application. Values of progressive_refinement_id in the range of 256 to 511, inclusive, and in the range of 2^{31} to 2^{32} - 1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of progressive_refinement_id in the range of 256 to 511, inclusive, or in the range of 2^{31} to 2^{32} - 1, inclusive, shall ignore (remove from the bitstream and discard) it.

D.2.19 Motion-constrained slice group set SEI message semantics

This SEI message indicates that inter prediction over slice group boundaries is constrained as specified below. When present, the message shall only appear where it is associated, as specified in subclause 7.4.1.2.3, with an IDR access unit.

The target picture set for this SEI message contains all consecutive primary coded pictures in decoding order starting with the associated primary coded IDR picture (inclusive) and ending with the following primary coded IDR picture (exclusive) or with the very last primary coded picture in the bitstream (inclusive) in decoding order when there is no following primary coded IDR picture. The slice group set is a collection of one or more slice groups, identified by the slice_group_id[i] syntax element.

This SEI message indicates that, for each picture in the target picture set, the inter prediction process is constrained as follows: No sample value outside the slice group set, and no sample value at a fractional sample position that is derived using one or more sample values outside the slice group set is used to inter predict any sample within the slice group set.

num_slice_groups_in_set_minus1 + 1 specifies the number of slice groups in the slice group set. The allowed range of num_slice_groups_in_set_minus1 is 0 to num_slice_groups_minus1, inclusive. The allowed range of num_slice_groups_minus1 is specified in Annex A.

slice_group_id[i **]** identifies the slice group(s) contained within the slice group set. The allowed range is from 0 to num_slice_groups_in_set_minus1, inclusive. The size of the slice_group_id[i] syntax element is Ceil(Log2(num_slice_groups_minus1 + 1)) bits.

exact_sample_value_match_flag equal to 0 indicates that, within the target picture set, when the macroblocks that do not belong to the slice group set are not decoded, the value of each sample in the slice group set need not be exactly the same as the value of the same sample when all the macroblocks are decoded. exact_sample_value_match_flag equal to 1 indicates that, within the target picture set, when the macroblocks that do not belong to the slice group set are not decoded, the value of each sample in the slice group set shall be exactly the same as the value of the same sample when all the macroblocks in the target picture set are decoded.

NOTE 1 – When disable_deblocking_filter_idc is equal to 2 in all slices in the target picture set, exact_sample_value_match_flag should be 1.

pan_scan_rect_flag equal to 0 specifies that pan_scan_rect_id is not present. pan_scan_rect_flag equal to 1 specifies that pan_scan_rect_id is present.

pan_scan_rect_id indicates that the specified slice group set covers at least the pan-scan rectangle identified by pan_scan_rect_id within the target picture set.

NOTE 2 – Multiple motion_constrained_slice_group_set SEI messages may be associated with the same IDR picture. Consequently, more than one slice group set may be active within a target picture set.

NOTE 3 – The size, shape, and location of the slice groups in the slice group set may change within the target picture set.

D.2.20 Film grain characteristics SEI message semantics

This SEI message provides the decoder with a parameterised model for film grain synthesis. For example, an encoder may use the film grain characteristics SEI message to characterise film grain that was present in the original source video material and was removed by pre-processing filtering techniques. Synthesis of simulated film grain on the decoded images for the display process is optional and does not affect the decoding process specified in this Recommendation | International Standard. If synthesis of simulated film grain on the decoded images for the display process is performed, there is no requirement that the method by which the synthesis is performed be the same as the parameterised model for the film grain as provided in the film grain characteristics SEI message.

NOTE 1 – The display process is not specified in this Recommendation | International Standard.

film_grain_characteristics_cancel_flag equal to 1 indicates that the SEI message cancels the persistence of any previous film grain characteristics SEI message in output order. film_grain_characteristics_cancel_flag equal to 0 indicates that film grain modelling information follows.

model_id identifies the film grain simulation model as specified in Table D-5. The value of model_id shall be in the range of 0 to 1, inclusive.

Table D-5 – model_id values

Value	Description
0	frequency filtering
1	auto-regression
2	reserved
3	reserved

separate_colour_description_present_flag equal to 1 indicates that a distinct colour space description for the film grain characteristics specified in the SEI message is present in the film grain characteristics SEI message syntax. separate_colour_description_present_flag equal to 0 indicates that the colour description for the film grain characteristics specified in the SEI message is the same as for the coded video sequence as specified in subclause E.2.1.

NOTE 2 – When separate_colour_description_present_flag is equal to 1, the colour space specified for the film grain characteristics specified in the SEI message may differ from the colour space specified for the coded video as specified in subclause E.2.1.

film_grain_bit_depth_luma_minus8 plus 8 specifies the bit depth used for the luma component of the film grain characteristics specified in the SEI message. When film_grain_bit_depth_luma_minus8 is not present in the film grain characteristics SEI message, the value of film_grain_bit_depth_luma_minus8 shall be inferred to be equal to bit_depth_luma_minus8.

The value of filmGrainBitDepth[0] is derived as

$$filmGrainBitDepth[\ 0\ ] = film\_grain\_bit\_depth\_luma\_minus8 + 8 \quad \text{(D-14)}$$

film_grain_bit_depth_chroma_minus8 plus 8 specifies the bit depth used for the Cb and Cr components of the film grain characteristics specified in the SEI message. When film_grain_bit_depth_chroma_minus8 is not present in the film grain characteristics SEI message, the value of film_grain_bit_depth_chroma_minus8 shall be inferred to be equal to bit_depth_chroma_minus8.

The value of filmGrainBitDepth[c] for c = 1 and 2 is derived as

$$filmGrainBitDepth[\ c\ ] = film\_grain\_bit\_depth\_chroma\_minus8 + 8 \quad \text{with } c = 1, 2 \tag{D-15}$$

film_grain_full_range_flag has the same semantics as specified in subclause E.2.1 for the video_full_range_flag syntax element, except as follows.

– film_grain_full_range_flag specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_full_range_flag is not present in the film grain characteristics SEI message, the value of film_grain_full_range_flag shall be inferred to be equal to video_full_range_flag.

film_grain_colour_primaries has the same semantics as specified in subclause E.2.1 for the colour_primaries syntax element, except as follows.

– film_grain_colour_primaries specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_colour_primaries is not present in the film grain characteristics SEI message, the value of film_grain_colour_primaries shall be inferred to be equal to colour_primaries.

film_grain_transfer_characteristics has the same semantics as specified in subclause E.2.1 for the transfer_characteristics syntax element, except as follows.

– film_grain_transfer_characteristics specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_transfer_characteristics is not present in the film grain characteristics SEI message, the value of film_grain_transfer_characteristics shall be inferred to be equal to transfer_characteristics.

film_grain_matrix_coefficients has the same semantics as specified in subclause E.2.1 for the matrix_coefficients syntax element, except as follows.

– film_grain_matrix_coefficients specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_matrix_coefficients is not present in the film grain characteristics SEI message, the value of film_grain_matrix_coefficients shall be inferred to be equal to matrix_coefficients.

– The values allowed for film_grain_matrix_coefficients are not constrained by the value of chroma_format_idc.

The chroma_format_idc of the film grain characteristics specified in the film grain characteristics SEI message shall be inferred to be equal to 3 (4:4:4).

NOTE 3 – Because the use of a specific method is not required for performing film grain generation function used by the display process, a decoder may, if desired, down-convert the model information for chroma in order to simulate film grain for other chroma formats (4:2:0 or 4:2:2) rather than up-converting the decoded video (using a method not specified by this Recommendation | International Standard) before performing film grain generation.

blending_mode_id identifies the blending mode used to blend the simulated film grain with the decoded images as specified in Table D-6. blending_mode_id shall be in the range of 0 to 1, inclusive.

Table D-6 – blending_mode_id values

Value	Description
0	additive
1	multiplicative
2	reserved
3	reserved

Depending on blending_mode_id, the blending mode is specified as follows

– If blending_mode_id is equal to 0 the blending mode is additive as specified by

$$I_{grain}[x, y, c] = Clip3(0, (1 << filmGrainBitDepth[c]) – 1, I_{decoded}[x, y, c] + G[x, y, c]) \quad \text{(D-16)}$$

– Otherwise (blending_mode_id is equal to 1), the blending mode is multiplicative as specified by

$$I_{grain}[x, y, c] = Clip3(0, (1 << filmGrainBitDepth[c]) – 1, I_{decoded}[x, y, c] * (1 + G[x, y, c])) \quad \text{(D-17)}$$

where $I_{decoded}[x, y, c]$ represents the sample value at coordinates x, y of the colour component c of the decoded image $I_{decoded}$, G[x, y, c] is the simulated film grain value at the same position and colour component, and filmGrainBitDepth[c] is the number of bits used for each sample in a fixed-length unsigned binary representation of the array $I_{grain}[x, y, c]$.

log2_scale_factor specifies a scale factor used in the film grain characterization equations.

comp_model_present_flag[c] equal to 0 indicates that film grain is not modelled on the c-th colour component, where c equal to 0 refers to the luma component, c equal to 1 refers to the Cb component, and c equal to 2 refers to the Cr component. comp_model_present_flag[c] equal to 1 indicates that syntax elements specifying modelling of film grain on colour component c are present in the SEI message.

num_intensity_intervals_minus1[c] plus 1 specifies the number of intensity intervals for which a specific set of model values has been estimated.

NOTE 4 – The intensity intervals may overlap in order to simulate multi-generational film grain.

num_model_values_minus1[c] plus 1 specifies the number of model values present for each intensity interval in which the film grain has been modelled. The value of num_model_values_minus1[c] shall be in the range of 0 to 5, inclusive.

intensity_interval_lower_bound[c][i] specifies the lower bound of the interval i of intensity levels for which the set of model values applies.

intensity_interval_upper_bound[c][i] specifies the upper bound of the interval i of intensity levels for which the set of model values applies.

Depending on model_id, the selection of the sets of model values is specified as follows.

– If model_id is equal to 0, the average value of each block b of 16x16 samples in $I_{decoded}$, referred as b_{avg}, is used to select the sets of model values with index s[j] that apply to all the samples in the block:

```
for( i = 0, j = 0; i <= num_intensity_intervals_minus1; i++ )
   if( b_avg >= intensity_interval_lower_bound[ c ][ i ] && b_avg <= intensity_interval_upper_bound[ c ][ i ] ) {
     s[ j ] = i                                                                                    (D-18)
     j++
   }
```

– Otherwise (model_id is equal to 1), the sets of model values used to generate the film grain are selected for each sample value in $I_{decoded}$ as follows:

```
for( i = 0, j = 0; i <= num_intensity_intervals_minus1; i++ )
   if( I_decoded[ x, y, c ] >= intensity_interval_lower_bound[ c ][ i ] &&
       I_decoded[ x, y, c ] <= intensity_interval_upper_bound[ c ][ i ] ) {                        (D-19)
     s[ j ] = i
     j++
   }
```

Samples that do not fall into any of the defined intervals are not modified by the grain generation function. Samples that fall into more than one interval will originate multi-generation grain. Multi-generation grain results from adding the grain computed independently for each intensity interval.

comp_model_value[c][i][j] represents each one of the model values present for the colour component c and the intensity interval i. The set of model values has different meaning depending on the value of model_id. The value of comp_model_value[c][i][j] shall be constrained as follows, and may be additionally constrained as specified elsewhere in this subclause.

– If model_id is equal to 0, comp_model_value[c][i][j] shall be in the range of 0 to $2^{filmGrainBitDepth[\ c\ ]} - 1$, inclusive.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][j] shall be in the range of $-2^{(\ filmGrainBitDepth[\ c\ ]\ -\ 1\ )}$ to $2^{(\ filmGrainBitDepth[\ c\ ]\ -\ 1\ )} - 1$, inclusive.

Depending on model_id, the synthesis of the film grain is modelled as follows.

– If model_id is equal to 0, a frequency filtering model enables simulating the original film grain for c = 0..2, x = 0..$PicWidthInSamples_L$, and y = 0..$PicHeightInSamples_L$ as specified by:

$$G[\ x, y, c\ ] = (\ comp\_model\_value[\ c\ ][\ s\ ][\ 0\ ] * Q[\ x, y, c\ ] + comp\_model\_value[\ c\ ][\ s\ ][\ 5\ ] * G[\ x, y, c\text{-}1\ ]\ ) >> log2\_scale\_factor \quad \text{(D-20)}$$

where Q[c] is a two-dimensional random process generated by filtering 16x16 blocks gaussRv with random-value elements $gaussRv_{ij}$ generated with a normalized Gaussian distribution (independent and identically distributed Gaussian random variable samples with zero mean and unity variance) and where the value of an element G[x, y, c-1] used in the right-hand side of the equation is inferred to be equal to 0 when c-1 is less than 0.

NOTE 5 – A normalized Gaussian random value can be generated from two independent, uniformly distributed random values over the interval from 0 to 1 (and not equal to 0), denoted as uRv_0 and uRv_1, using the Box-Muller transformation specified by

$$gaussRv_{ij} = \sqrt{-2 * Ln(\ uRv_0\ )} * Cos(\ 2 * \pi * uRv_1\ ) \quad \text{(D-21)}$$

where Ln(x) is the natural logarithm of x (the base-e logarithm, where e is natural logarithm base constant 2.718 281 828...), Cos(x) is the trigonometric cosine function operating on an argument x in units of radians, and π is Archimedes' constant 3.141 592 653....

The band-pass filtering of blocks gaussRv may be performed in the discrete cosine transform (DCT) domain as follows:

```
for( y = 0; y < 16; y++ )
    for( x = 0; x < 16; x++ )
        if( ( x < comp_model_value[ c ][ s ][ 3 ]  &&  y < comp_model_value[ c ][ s ][ 4 ] ) ||
            x > comp_model_value[ c ][ s ][ 1 ] || y > comp_model_value[ c ][ s ][ 2 ] )
            gaussRv[ x, y ] = 0
filteredRv = IDCT16x16( gaussRv )
```

(D-22)

where IDCT16x16(z) refers to a unitary inverse discrete cosine transformation (IDCT) operating on a 16x16 matrix argument z as specified by

$$IDCT16x16(\ z\ ) = r * z * r^T \quad \text{(D-23)}$$

where the superscript T indicates a matrix transposition and r is the 16x16 matrix with elements r_{ij} specified by

$$r_{ij} = \frac{((\ i == 0\ )\ ?\ 1 : \sqrt{2}\ )}{4} Cos\left(\frac{i * (\ 2 * j + 1\ ) * \pi}{32} \right) \quad \text{(D-24)}$$

where Cos(x) is the trigonometric cosine function operating on an argument x in units of radians and π is Archimedes' constant 3.141 592 653.

Q[c] is formed by the frequency-filtered blocks filteredRv.

NOTE 6 – Coded model values are based on blocks of 16x16, but a decoder implementation may use other block sizes. For example, decoders implementing the IDCT on 8x8 blocks, should down-convert by a factor of two the set of coded model values comp_model_value[c][s][i] for i equal to 1..4.

NOTE 7 – To reduce the degree of visible blocks that can result from mosaicing the frequency-filtered blocks filteredRv, decoders may apply a low-pass filter to the boundaries between frequency-filtered blocks.

– Otherwise (model_id is equal to 1), an auto-regression model enables simulating the original film grain for c = 0..2, x = 0..PicWidthInSamples$_L$, and y = 0..PicHeightInSamples$_L$ as specified by

```
G[ x, y, c ] = ( comp_model_value[ c ][ s ][ 0 ] * n[ x, y, c ] +
    comp_model_value[ c ][ s ][ 1 ] * ( G[ x-1, y, c ] + ( ( comp_model_value[ c ][ s ][ 4 ] * G[ x, y-1, c ] ) >>
        log2_scale_factor ) ) +
    comp_model_value[ c ][ s ][ 3 ] * ( ( ( comp_model_value[ c ][ s ][ 4 ] * G[ x-1, y-1, c ] ) >>
        log2_scale_factor ) + G[ x+1, y-1, c ] ) +
    comp_model_value[ c ][ s ][ 5 ] * ( G[ x-2, y, c ] +
        ( ( comp_model_value[ c ][ s ][ 4 ] * comp_model_value[ c ][ s ][ 4 ] * G[ x, y-2, c ] ) >>
            ( 2 * log2_scale_factor ) ) ) +
    comp_model_value[ c ][ s ][ 2 ] * G[ x, y, c-1 ] ) >> log2_scale_factor                    (D-25)
```

where n[x, y, c] is a random value with normalized Gaussian distribution (independent and identically distributed Gaussian random variable samples with zero mean and unity variance for each value of x, y, and c) and where the value of an element G[x, y, c] used in the right-hand side of the equation is inferred to be equal to 0 when any of the following conditions are true:

– x is less than 0,

– y is less than 0,

– x is greater than or equal to PicWidthInSamples$_L$,

– c is less than 0.

comp_model_value[c][i][0] provides the first model value for the model as specified by model_id. comp_model_value[c][i][0] corresponds to the standard deviation of the Gaussian noise term in the generation functions specified in Equations D-20 through D-23.

comp_model_value[c][i][1] provides the second model value for the model as specified by model_id. comp_model_value[c][i][1] shall be greater than or equal to 0 and less than 16.

When not present in the film grain characteristics SEI message, comp_model_value[c][i][1] shall be inferred as follows.

– If model_id is equal to 0, comp_model_value[c][i][1] shall be inferred to be equal to 8.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][1] shall be inferred to be equal to 0.

comp_model_value[c][i][1] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[c][i][1] indicates the horizontal high cut frequency to be used to filter the DCT of a block of 16x16 random values.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][1] indicates the first order spatial correlation for neighbouring samples (x-1, y) and (x, y-1).

comp_model_value[c][i][2] provides the third model value for the model as specified by model_id. comp_model_value[c][i][2] shall be greater than or equal to 0 and less than 16.

When not present in the film grain characteristics SEI message, comp_model_value[c][i][2] shall be inferred as follows.

– If model_id is equal to 0, comp_model_value[c][i][2] shall be inferred to be equal to comp_model_value[c][i][1]

– Otherwise (model_id is equal to 0), comp_model_value[c][i][2] shall be inferred to be equal to 0.

comp_model_value[c][i][2] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[c][i][2] indicates the vertical high cut frequency to be used to filter the DCT of a block of 16x16 random values.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][2] indicates the colour correlation between consecutive colour components.

comp_model_value[c][i][3] provides the fourth model value for the model as specified by model_id. comp_model_value[c][i][3] shall be greater than or equal to 0 and less than or equal to comp_model_value[c][i][1].

When not present in the film grain characteristics SEI message, comp_model_value[c][i][3] shall be inferred to be equal to 0.

comp_model_value[c][i][3] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[c][i][3] indicates the horizontal low cut frequency to be used to filter the DCT of a block of 16x16 random values.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][3] indicates the first order spatial correlation for neighbouring samples (x-1, y-1) and (x+1, y-1).

comp_model_value[c][i][4] provides the fifth model value for the model as specified by model_id. comp_model_value[c][i][4] shall be greater than or equal to 0 and less than or equal to comp_model_value[c][i][2].

When not present in the film grain characteristics SEI message, comp_model_value[c][i][4] shall be inferred to be equal to model_id.

comp_model_value[c][i][4] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[c][i][4] indicates the vertical low cut frequency to be used to filter the DCT of a block of 16x16 random values.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][4] indicates the aspect ratio of the modelled grain.

comp_model_value[c][i][5] provides the sixth model value for the model as specified by model_id. When not present in the film grain characteristics SEI message, comp_model_value[c][i][5] shall be inferred to be equal to 0.

comp_model_value[c][i][5] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[c][i][5] indicates the colour correlation between consecutive colour components.

– Otherwise (model_id is equal to 1), comp_model_value[c][i][5] indicates the second order spatial correlation for neighbouring samples (x, y-2) and (x-2, y).

film_grain_characteristics_repetition_period specifies the persistence of the film grain characteristics SEI message and may specify a picture order count interval within which another film grain characteristics SEI message or the end of the coded video sequence shall be present in the bitstream. The value of film_grain_characteristics_repetition_period shall be in the range 0 to 16 384, inclusive.

film_grain_characteristics_repetition_period equal to 0 specifies that the film grain characteristics SEI message applies to the current decoded picture only.

film_grain_characteristics_repetition_period equal to 1 specifies that the film grain characteristics SEI message persists in output order until any of the following conditions are true.

– A new coded video sequence begins, or

– A picture in an access unit containing a film grain characteristics SEI message that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic).

film_grain_characteristics_repetition_period greater than 1 specifies that the film grain characteristics SEI message persists until any of the following conditions are true.

– A new coded video sequence begins, or

– A picture in an access unit containing a film grain characteristics SEI message is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + film_grain_characteristics_repetition_period.

film_grain_characteristics_repetition_period greater than 1 indicates that another film grain characteristics SEI message shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + film_grain_characteristics_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

D.2.21 Deblocking filter display preference SEI message semantics

This SEI message provides the decoder with an indication of whether the display of the cropped result of the deblocking filter process specified in subclause 8.7 or of the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.12 is preferred by the encoder for the display of each decoded picture that is output.

NOTE 1 – The display process is not specified in this Recommendation | International Standard. The means by which an encoder determines what to indicate as its preference expressed in a deblocking filter display preference SEI message is also not specified in this Recommendation | International Standard, and the expression of an expressed preference in a deblocking filter display preference SEI message does not impose any requirement on the display process.

deblocking_display_preference_cancel_flag equal to 1 indicates that the SEI message cancels the persistence of any previous deblocking filter display preference SEI message in output order. deblocking_display_preference_cancel_flag equal to 0 indicates that a display_prior_to_deblocking_preferred_flag and deblocking_display_preference_repetition_period follow.

NOTE 2 – In the absence of the deblocking filter display preference SEI message, or after the receipt of a deblocking filter display preference SEI message in which deblocking_display_preference_cancel_flag is equal to 1, the decoder should infer that the display of the cropped result of the deblocking filter process specified in subclause 8.7 is preferred over the display of the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.12 for the display of each decoded picture that is output.

display_prior_to_deblocking_preferred_flag equal to 1 indicates that the encoder preference is for the display process (which is not specified in this Recommendation | International Standard) to display the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.12 rather than the cropped result of the deblocking filter process specified in subclause 8.7 for each picture that is cropped and output as specified in Annex C. display_prior_to_deblocking_preferred_flag equal to 0 indicates that the encoder preference is for the display process (which is not specified in this Recommendation | International Standard) to display the cropped result of the deblocking filter process specified in subclause 8.7 rather than the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.12 for each picture that is cropped and output as specified in Annex C.

NOTE 3 – The presence or absence of the deblocking filter display preference SEI message and the value of display_prior_to_deblocking_preferred_flag does not affect the requirements of the decoding process specified in this Recommendation | International Standard. Rather, it only provides an indication of when, in addition to fulfilling the requirements of this Recommendation | International Standard for the decoding process, enhanced visual quality might be obtained by performing the display process (which is not specified in this Recommendation | International Standard) in an alternative fashion. Encoders that use the deblocking filter display preference SEI message should be designed with an awareness that unless the encoder restricts its use of the DPB capacity specified in Annex A for the profile and level in use, some decoders may not have sufficient memory capacity for the storage of the result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.12 in addition to the storage of the result of the deblocking filter process specified in subclause 8.7 when reordering and delaying pictures for display, and such decoders would therefore not be able to benefit from the preference indication. By restricting its use of the DPB capacity, an encoder can be able to use at least half of the DPB capacity specified in Annex A while allowing the decoder to use the remaining capacity for storage of unfiltered pictures that have been indicated as preferable for display until the output time arrives for those pictures.

dec_frame_buffering_constraint_flag equal to 1 indicates that the use of the frame buffering capacity of the HRD decoded picture buffer (DPB) as specified by max_dec_frame_buffering has been constrained such that the coded video sequence will not require a decoded picture buffer with more than Max(1, max_dec_frame_buffering) frame buffers to enable the output of the decoded filtered or unfiltered pictures, as indicated by the deblocking filter display preference SEI messages, at the output times specified by the dpb_output_delay of the picture timing SEI messages. dec_frame_buffering_constraint_flag equal to 0 indicates that the use of the frame buffering capacity in the HRD may or may not be constrained in the manner that would be indicated by dec_frame_buffering_constraint_flag equal to 1.

For purposes of determining the constraint imposed when dec_frame_buffering_constraint_flag is equal to 1, the quantity of frame buffering capacity used at any given point in time by each frame buffer of the DPB that contains a picture shall be derived as follows:

- If both of the following criteria are satisfied for the frame buffer, the frame buffer is considered to use two frame buffers of capacity for its storage.
  - The frame buffer contains a frame or one or more fields that is marked as "used for reference", and
  - The frame buffer contains a picture for which both of the following criteria are fulfilled.
    - The HRD output time of the picture is greater than the given point in time, and
    - It has been indicated in a deblocking filter display preference SEI message that the encoder preference for the picture is for the display process to display the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.12 rather than the cropped result of the deblocking filter process specified in subclause 8.7, and
- Otherwise, the frame buffer is considered to use one frame buffer of DPB capacity for its storage.

When dec_frame_buffering_constraint_flag is equal to 1, the frame buffering capacity used by all of the frame buffers in the DPB that contain pictures, as derived in this manner, shall not be greater than Max(1, max_dec_frame_buffering) during the operation of the HRD for the coded video sequence.

The value of dec_frame_buffering_constraint_flag shall be the same in all deblocking filter display preference SEI messages of the coded video sequence.

deblocking_display_preference_repetition_period specifies the persistence of the film grain characteristics SEI message and may specify a picture order count interval within which another film grain characteristics SEI message or the end of the coded video sequence shall be present in the bitstream. The value of deblocking_display_preference_repetition_period shall be in the range 0 to 16 384, inclusive.

deblocking_display_preference_repetition_period equal to 0 specifies that the deblocking filter display preference SEI message applies to the current decoded picture only.

deblocking_display_preference_repetition_period equal to 1 specifies that the deblocking filter display preference SEI message persists in output order until any of the following conditions are true.

– A new coded video sequence begins

– A picture in an access unit containing a deblocking filter display preference SEI message that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic).

deblocking_display_preference_repetition_period greater than 1 specifies that the deblocking filter display preference SEI message persists until any of the following conditions are true.

– A new coded video sequence begins

– A picture in an access unit containing a deblocking filter display preference SEI message is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + deblocking_display_preference_repetition_period.

deblocking_display_preference_repetition_period greater than 1 indicates that another deblocking filter display preference SEI message shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt(CurrPic) and less than or equal to PicOrderCnt(CurrPic) + deblocking_display_preference_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

D.2.22 Stereo video information SEI message semantics

This SEI message provides the decoder with an indication that the entire coded video sequence consists of pairs of pictures forming stereo-view content.

The stereo video information SEI message shall not be present in any access unit of a coded video sequence unless a stereo video information SEI message is present in the first access unit of the coded video sequence.

field_views_flag equal to 1 indicates that all pictures in the current coded video sequence are fields and all fields of a particular parity are considered a left view and all fields of the opposite parity are considered a right view for stereo-view content. field_views_flag equal to 0 indicates that all pictures in the current coded video sequence are frames and alternating frames in output order represent a view of a stereo view. The value of field_views_flag shall be the same in all stereo video information SEI messages within a coded video sequence.

When the stereo video information SEI message is present and field_views_flag is equal to 1, the left view and right view of a stereo video pair shall be coded as a complementary field pair, the display time of the first field of the field pair in output order should be delayed to coincide with the display time of the second field of the field pair in output order, and the spatial locations of the samples in each individual field should be interpreted for display purposes as representing complete pictures as shown in Figure 6-1 rather than as spatially-distinct fields within a frame as shown in Figure 6-2.

NOTE – The display process is not specified in this Recommendation | International Standard.

top_field_is_left_view_flag equal to 1 indicates that the top fields in the coded video sequence represent a left view and the bottom fields in the coded video sequence represent a right view. top_field_is_left_view_flag equal to 0 indicates that the bottom fields in the coded video sequence represent a left view and the top fields in the coded video sequence represent a right view. When present, the value of top_field_is_left_view_flag shall be the same in all stereo video information SEI messages within a coded video sequence.

current_frame_is_left_view_flag equal to 1 indicates that the current picture is the left view of a stereo-view pair. current_frame_is_left_view_flag equal to 0 indicates that the current picture is the right view of a stereo-view pair.

next_frame_is_second_view_flag equal to 1 indicates that the current picture and the next picture in output order form a stereo-view pair, and the display time of the current picture should be delayed to coincide with the display time of the next picture in output order. next_frame_is_second_view_flag equal to 0 indicates that the current picture and the previous picture in output order form a stereo-view pair, and the display time of the current picture should not be delayed for purposes of stereo-view pairing.

left_view_self_contained_flag equal to 1 indicates that no inter prediction operations within the decoding process for the left-view pictures of the coded video sequence refer to reference pictures that are right-view pictures. left_view_self_contained_flag equal to 0 indicates that some inter prediction operations within the decoding process for the left-view pictures of the coded video sequence may or may not refer to reference pictures that are right-view pictures. Within a coded video sequence, the value of left_view_self_contained_flag in all stereo video information SEI messages shall be the same.

right_view_self_contained_flag equal to 1 indicates that no inter prediction operations within the decoding process for the right-view pictures of the coded video sequence refer to reference pictures that are left-view pictures. right_view_self_contained_flag equal to 0 indicates that some inter prediction operations within the decoding process for the right-view pictures of the coded video sequence may or may not refer to reference pictures that are left-view pictures. Within a coded video sequence, the value of right_view_self_contained_flag in all stereo video information SEI messages shall be the same.

D.2.23 Reserved SEI message semantics

This message consists of data reserved for future backward-compatible use by ITU-T | ISO/IEC. Encoders conforming to this Recommendation | International Standard shall not send reserved SEI messages until and unless the use of such messages has been specified by ITU-T | ISO/IEC. Decoders conforming to this Recommendation | International Standard that encounter reserved SEI messages shall discard their content without effect on the decoding process, except as specified in future Recommendations | International Standards specified by ITU-T | ISO/IEC.

reserved_sei_message_payload_byte is a byte reserved for future use by ITU-T | ISO/IEC.

Annex E
Video usability information

(This annex forms an integral part of this Recommendation | International Standard)

This Annex specifies syntax and semantics of the VUI parameters of the sequence parameter sets.

VUI parameters are not required for constructing the luma or chroma samples by the decoding process. Conforming decoders are not required to process this information for output order conformance to this Recommendation | International Standard (see Annex C for the specification of conformance). Some VUI parameters are required to check bitstream conformance and for output timing decoder conformance.

In Annex E, specification for presence of VUI parameters is also satisfied when those parameters (or some subset of them) are conveyed to decoders (or to the HRD) by other means not specified by this Recommendation | International Standard. When present in the bitstream, VUI parameters shall follow the syntax and semantics specified in subclauses 7.3.2.1 and 7.4.2.1 and this annex. When the content of VUI parameters is conveyed for the application by some means other than presence within the bitstream, the representation of the content of the VUI parameters is not required to use the same syntax specified in this annex. For the purpose of counting bits, only the appropriate bits that are actually present in the bitstream are counted.

E.1 VUI syntax

E.1.1 VUI parameters syntax

vui_parameters( ) {	C	Descriptor
aspect_ratio_info_present_flag	0	u(1)
if(aspect_ratio_info_present_flag) {		
aspect_ratio_idc	0	u(8)
if(aspect_ratio_idc = = Extended_SAR) {		
sar_width	0	u(16)
sar_height	0	u(16)
}		
}		
overscan_info_present_flag	0	u(1)
if(overscan_info_present_flag)		
overscan_appropriate_flag	0	u(1)
video_signal_type_present_flag	0	u(1)
if(video_signal_type_present_flag) {		
video_format	0	u(3)
video_full_range_flag	0	u(1)
colour_description_present_flag	0	u(1)
if(colour_description_present_flag) {		
colour_primaries	0	u(8)
transfer_characteristics	0	u(8)
matrix_coefficients	0	u(8)
}		
}		
chroma_loc_info_present_flag	0	u(1)
if(chroma_loc_info_present_flag) {		
chroma_sample_loc_type_top_field	0	ue(v)
chroma_sample_loc_type_bottom_field	0	ue(v)
}		
timing_info_present_flag	0	u(1)
if(timing_info_present_flag) {		
num_units_in_tick	0	u(32)
time_scale	0	u(32)
fixed_frame_rate_flag	0	u(1)
}		
nal_hrd_parameters_present_flag	0	u(1)
if(nal_hrd_parameters_present_flag)		
hrd_parameters( )		
vcl_hrd_parameters_present_flag	0	u(1)
if(vcl_hrd_parameters_present_flag)		
hrd_parameters( )		
if(nal_hrd_parameters_present_flag || vcl_hrd_parameters_present_flag)		
low_delay_hrd_flag	0	u(1)
pic_struct_present_flag	0	u(1)
bitstream_restriction_flag	0	u(1)
if(bitstream_restriction_flag) {		

motion_vectors_over_pic_boundaries_flag	0	u(1)
max_bytes_per_pic_denom	0	ue(v)
max_bits_per_mb_denom	0	ue(v)
log2_max_mv_length_horizontal	0	ue(v)
log2_max_mv_length_vertical	0	ue(v)
num_reorder_frames	0	ue(v)
max_dec_frame_buffering	0	ue(v)
}		
}		

E.1.2 HRD parameters syntax

hrd_parameters( ) {	**C**	**Descriptor**
cpb_cnt_minus1	0	ue(v)
bit_rate_scale	0	u(4)
cpb_size_scale	0	u(4)
for(SchedSelIdx = 0; SchedSelIdx <= cpb_cnt_minus1; SchedSelIdx++) {		
bit_rate_value_minus1[SchedSelIdx **]**	0	ue(v)
cpb_size_value_minus1[SchedSelIdx **]**	0	ue(v)
cbr_flag[SchedSelIdx **]**	0	u(1)
}		
initial_cpb_removal_delay_length_minus1	0	u(5)
cpb_removal_delay_length_minus1	0	u(5)
dpb_output_delay_length_minus1	0	u(5)
time_offset_length	0	u(5)
}		

E.2 VUI semantics

E.2.1 VUI parameters semantics

aspect_ratio_info_present_flag equal to 1 specifies that aspect_ratio_idc is present. aspect_ratio_info_present_flag equal to 0 specifies that aspect_ratio_idc is not present.

aspect_ratio_idc specifies the value of the sample aspect ratio of the luma samples. Table E-1 shows the meaning of the code. When aspect_ratio_idc indicates Extended_SAR, the sample aspect ratio is represented by sar_width and sar_height. When the aspect_ratio_idc syntax element is not present, aspect_ratio_idc value shall be inferred to be equal to 0.

Table E-1 – Meaning of sample aspect ratio indicator

aspect_ratio_idc	Sample aspect ratio	(informative) Examples of use
0	Unspecified	
1	1:1 ("square")	1280x720 16:9 frame without horizontal overscan 1920x1080 16:9 frame without horizontal overscan (cropped from 1920x1088) 640x480 4:3 frame without horizontal overscan
2	12:11	720x576 4:3 frame with horizontal overscan 352x288 4:3 frame without horizontal overscan
3	10:11	720x480 4:3 frame with horizontal overscan 352x240 4:3 frame without horizontal overscan
4	16:11	720x576 16:9 frame with horizontal overscan 528x576 4:3 frame without horizontal overscan
5	40:33	720x480 16:9 frame with horizontal overscan 528x480 4:3 frame without horizontal overscan
6	24:11	352x576 4:3 frame without horizontal overscan 480x576 16:9 frame with horizontal overscan
7	20:11	352x480 4:3 frame without horizontal overscan 480x480 16:9 frame with horizontal overscan
8	32:11	352x576 16:9 frame without horizontal overscan
9	80:33	352x480 16:9 frame without horizontal overscan
10	18:11	480x576 4:3 frame with horizontal overscan
11	15:11	480x480 4:3 frame with horizontal overscan
12	64:33	528x576 16:9 frame without horizontal overscan
13	160:99	528x480 16:9 frame without horizontal overscan
14	4:3	1440x1080 16:9 frame without horizontal overscan
15	3:2	1280x1080 16:9 frame without horizontal overscan
16	2:1	960x1080 16:9 frame without horizontal overscan
17..254	Reserved	
255	Extended_SAR	

sar_width indicates the horizontal size of the sample aspect ratio (in arbitrary units).

sar_height indicates the vertical size of the sample aspect ratio (in the same arbitrary units as sar_width).

sar_width and sar_height shall be relatively prime or equal to 0. When aspect_ratio_idc is equal to 0 or sar_width is equal to 0 or sar_height is equal to 0, the sample aspect ratio shall be considered unspecified by this Recommendation | International Standard.

overscan_info_present_flag equal to 1 specifies that the overscan_appropriate_flag is present. When overscan_info_present_flag is equal to 0 or is not present, the preferred display method for the video signal is unspecified.

overscan_appropriate_flag equal to 1 indicates that the cropped decoded pictures output are suitable for display using overscan. overscan_appropriate_flag equal to 0 indicates that the cropped decoded pictures output contain visually important information in the entire region out to the edges of the cropping rectangle of the picture, such that the cropped decoded pictures output should not be displayed using overscan. Instead, they should be displayed using either an exact match between the display area and the cropping rectangle, or using underscan.

NOTE 1 – For example, overscan_appropriate_flag equal to 1 might be used for entertainment television programming, or for a live view of people in a videoconference, and overscan_appropriate_flag equal to 0 might be used for computer screen capture or security camera content.

video_signal_type_present_flag equal to 1 specifies that video_format, video_full_range_flag and colour_description_present_flag are present. video_signal_type_present_flag equal to 0, specify that video_format, video_full_range_flag and colour_description_present_flag are not present.

video_format indicates the representation of the pictures as specified in Table E-2, before being coded in accordance with this Recommendation | International Standard. When the video_format syntax element is not present, video_format value shall be inferred to be equal to 5.

Table E-2 – Meaning of video_format

video_format	Meaning
0	Component
1	PAL
2	NTSC
3	SECAM
4	MAC
5	Unspecified video format
6	Reserved
7	Reserved

video_full_range_flag indicates the black level and range of the luma and chroma signals as derived from E'_Y, E'_{PB}, and E'_{PR} or E'_R, E'_G, and E'_B analogue component signals.

When the video_full_range_flag syntax element is not present, the value of video_full_range_flag shall be inferred to be equal to 0.

colour_description_present_flag equal to 1 specifies that colour_primaries, transfer_characteristics and matrix_coefficients are present. colour_description_present_flag equal to 0 specifies that colour_primaries, transfer_characteristics and matrix_coefficients are not present.

colour_primaries indicates the chromaticity coordinates of the source primaries as specified in Table E-3 in terms of the CIE 1931 definition of x and y as specified by ISO/CIE 10527.

When the colour_primaries syntax element is not present, the value of colour_primaries shall be inferred to be equal to 2 (the chromaticity is unspecified or is determined by the application).

Table E-3 – Colour primaries

Value	Primaries			Informative Remark
0	Reserved			For future use by ITU-T / ISO/IEC
1	primary	x	y	ITU-R Recommendation BT.709-5
	green	0.300	0.600	
	blue	0.150	0.060	
	red	0.640	0.330	
	white D65	0.3127	0.3290	
2	Unspecified			Image characteristics are unknown or are determined by the application.
3	Reserved			
4	primary	x	y	ITU-R Recommendation BT.470-6 System M
	green	0.21	0.71	
	blue	0.14	0.08	
	red	0.67	0.33	
	white C	0.310	0.316	
5	primary	x	y	ITU-R Recommendation BT.470-6 System B, G
	green	0.29	0.60	
	blue	0.15	0.06	
	red	0.64	0.33	
	white D65	0.3127	0.3290	
6	primary	x	y	Society of Motion Picture and Television Engineers 170M (1999)
	green	0.310	0.595	
	blue	0.155	0.070	
	red	0.630	0.340	
	white D65	0.3127	0.3290	
7	primary	x	y	Society of Motion Picture and Television Engineers 240M (1999)
	green	0.310	0.595	
	blue	0.155	0.070	
	red	0.630	0.340	
	white D65	0.3127	0.3290	
8	primary	x	y	Generic film (colour filters using Illuminant C)
	green	0.243	0.692 (Wratten 58)	
	blue	0.145	0.049 (Wratten 47)	
	red	0.681	0.319 (Wratten 25)	
	white C	0.310	0.316	
9-255	Reserved			For future use by ITU-T / ISO/IEC

transfer_characteristics indicates the opto-electronic transfer characteristic of the source picture as specified in Table E-4 as a function of a linear optical intensity input L_c with an analogue range of 0 to 1.

When the transfer_characteristics syntax element is not present, the value of transfer_characteristics shall be inferred to be equal to 2 (the transfer characteristics are unspecified or are determined by the application).

Table E-4 – Transfer characteristics

Value	Transfer Characteristic		Informative Remark
0	Reserved		For future use by ITU-T / ISO/IEC
1	$V = 1.099\ L_c^{0.45} - 0.099$ $V = 4.500\ L_c$	for $1 >= L_c >= 0.018$ for $0.018 > L_c >= 0$	ITU-R Recommendation BT.709-5
2	Unspecified		Image characteristics are unknown or are determined by the application.
3	Reserved		For future use by ITU-T / ISO/IEC
4	Assumed display gamma 2.2		ITU-R Recommendation BT.470-6 System M
5	Assumed display gamma 2.8		ITU-R Recommendation BT.470-6 System B, G
6	$V = 1.099\ L_c^{0.45} - 0.099$ $V = 4.500\ L_c$	for $1 >= L_c >= 0.018$ for $0.018 > L_c >= 0$	Society of Motion Picture and Television Engineers 170M (1999)
7	$V = 1.1115\ L_c^{0.45} - 0.1115$ $V = 4.0\ L_c$	for $1 >= L_c >= 0.0228$ for $0.0228 > L_c >= 0$	Society of Motion Picture and Television Engineers 240M (1999)
8	$V = L_C$	for $1 > L_c >= 0$	Linear transfer characteristics
9	$V = 1.0 - \text{Log10}(L_c) \div 2$ $V = 0.0$	for $1 >= L_c >= 0.01$ for $0.01 > L_c >= 0$	Logarithmic transfer characteristic (100:1 range)
10	$V = 1.0 - \text{Log10}(L_c) \div 2.5$ $V = 0.0$	for $1 >= L_c >= 0.0031622777$ for $0.0031622777 > L_c >= 0$	Logarithmic transfer characteristic (316.22777:1 range)
11..255	Reserved		For future use by ITU-T / ISO/IEC

matrix_coefficients describes the matrix coefficients used in deriving luma and chroma signals from the green, blue, and red primaries, as specified in Table E-5.

matrix_coefficients shall not be equal to 0 unless both of the following conditions are true

– BitDepth_C is equal to BitDepth_Y

– chroma_format_idc is equal to 3 (4:4:4)

The specification of the use of matrix_coefficients equal to 0 under all other conditions is reserved for future use by ITU-T | ISO/IEC.

matrix_coefficients shall not be equal to 8 unless one or both of the following conditions are true

– BitDepth_C is equal to BitDepth_Y

– BitDepth_C is equal to $\text{BitDepth}_Y + 1$ and chroma_format_idc is equal to 3 (4:4:4)

The specification of the use of matrix_coefficients equal to 8 under all other conditions is reserved for future use by ITU-T | ISO/IEC.

When the matrix_coefficients syntax element is not present, the value of matrix_coefficients shall be inferred to be equal to 2.

The interpretation of matrix_coefficients is defined as follows.

– E'_R, E'_G, and E'_B are analogue with values in the range of 0 to 1.

– White is specified as having E'_R equal to 1, E'_G equal to 1, and E'_B equal to 1.

– Black is specified as having E'_R equal to 0, E'_G equal to 0, and E'_B equal to 0.

– If video_full_range_flag is equal to 0, the following equations apply.

  – If matrix_coefficients is equal to 1, 4, 5, 6, or 7, the following equations apply.

$$Y = \text{Round}((1 << (\text{BitDepth}_Y - 8)) * (219 * E'_Y + 16)) \quad \text{(E-1)}$$

$$Cb = Round((1 << (BitDepth_C - 8)) * (224 * E'_{PB} + 128)) \quad (E\text{-}2)$$

$$Cr = Round((1 << (BitDepth_C - 8)) * (224 * E'_{PR} + 128)) \quad (E\text{-}3)$$

– Otherwise, if matrix_coefficients is equal to 0 or 8, the following equations apply.

$$R = (1 << (BitDepth_Y - 8)) * (219 * E'_R + 16) \quad (E\text{-}4)$$

$$G = (1 << (BitDepth_Y - 8)) * (219 * E'_G + 16) \quad (E\text{-}5)$$

$$B = (1 << (BitDepth_Y - 8)) * (219 * E'_B + 16) \quad (E\text{-}6)$$

– Otherwise, if matrix_coefficients is equal to 2, the interpretation of the matrix_coefficients syntax element is unknown or is determined by the application.

– Otherwise (matrix_coefficients is not equal to 0, 1, 2, 4, 5, 6, 7, or 8), the interpretation of the matrix_coefficients syntax element is reserved for future definition by ITU-T | ISO/IEC.

– Otherwise (video_full_range_flag is equal to 1), the following equations apply.

– If matrix_coefficients is equal to 1, 4, 5, 6, or 7, the following equations apply.

$$Y = Round(((1 << BitDepth_Y) - 1) * E'_Y) \quad (E\text{-}7)$$

$$Cb = Round(((1 << BitDepth_C) - 1) * E'_{PB} + (1 << (BitDepth_C - 1))) \quad (E\text{-}8)$$

$$Cr = Round(((1 << BitDepth_C) - 1) * E'_{PR} + (1 << (BitDepth_C - 1))) \quad (E\text{-}9)$$

– Otherwise, if matrix_coefficients is equal to 0 or 8, the following equations apply.

$$R = ((1 << BitDepth_Y) - 1) * E'_R \quad (E\text{-}10)$$

$$G = ((1 << BitDepth_Y) - 1) * E'_G \quad (E\text{-}11)$$

$$B = ((1 << BitDepth_Y) - 1) * E'_B \quad (E\text{-}12)$$

– Otherwise, if matrix_coefficients is equal to 2, the interpretation of the matrix_coefficients syntax element is unknown or is determined by the application.

– Otherwise (matrix_coefficients is not equal to 0, 1, 2, 4, 5, 6, 7, or 8), the interpretation of the matrix_coefficients syntax element is reserved for future definition by ITU-T | ISO/IEC.

– If matrix_coefficients is not equal to 0 or 8, the following equations apply.

$$E'_Y = K_R * E'_R + (1 - K_R - K_B) * E'_G + K_B * E'_B \quad (E\text{-}13)$$

$$E'_{PB} = 0.5 * (E'_B - E'_Y) \div (1 - K_B) \quad (E\text{-}14)$$

$$E'_{PR} = 0.5 * (E'_R - E'_Y) \div (1 - K_R) \quad (E\text{-}15)$$

NOTE 2 – Then E'_Y is analogue with values in the range of 0 to 1, E'_{PB} and E'_{PR} are analogue with values in the range of -0.5 to 0.5, and white is equivalently given by $E'_Y = 1$, $E'_{PB} = 0$, $E'_{PR} = 0$.

– Otherwise, if matrix_coefficients is equal to 0, the following equations apply.

$$Y = \text{Round}(G) \quad \text{(E-16)}$$

$$Cb = \text{Round}(B) \quad \text{(E-17)}$$

$$Cr = \text{Round}(R) \quad \text{(E-18)}$$

– Otherwise (matrix_coefficients is equal to 8), the following applies.

  – If $BitDepth_C$ is equal to $BitDepth_Y$, the following equations apply.

$$Y = \text{Round}(0.5 * G + 0.25 * (R + B)) \quad \text{(E-19)}$$

$$Cb = \text{Round}(0.5 * G – 0.25 (R + B)) \quad \text{(E-20)}$$

$$Cr = \text{Round}(0.5 * (R – B)) \quad \text{(E-21)}$$

NOTE 3 – For purposes of the YCgCo nomenclature used in Table E-5, Cb and Cr of Equations E-20 and E-21 may be referred to as Cg and Co, respectively. The inverse conversion for the above four equations should be computed as.

$$t = Y – Cb \quad \text{(E-22)}$$

$$G = Y + Cb \quad \text{(E-23)}$$

$$B = t – Cr \quad \text{(E-24)}$$

$$R = t + Cr \quad \text{(E-25)}$$

  – Otherwise ($BitDepth_C$ is not equal to $BitDepth_Y$), the following equations apply.

$$Cr = \text{Round}(R) – \text{Round}(B) \quad \text{(E-26)}$$

$$t = \text{Round}(B) + (Cr >> 1) \quad \text{(E-27)}$$

$$Cb = \text{Round}(G) – t \quad \text{(E-28)}$$

$$Y = t + (Cb >> 1) \quad \text{(E-29)}$$

NOTE 4 – For purposes of the YCgCo nomenclature used in Table E-5, Cb and Cr of Equations E-28 and E-26 may be referred to as Cg and Co, respectively. The inverse conversion for the above four equations should be computed as.

$$t = Y – (Cb >> 1) \quad \text{(E-30)}$$

$$G = t + Cb \quad \text{(E-31)}$$

$$B = t – (Cr >> 1) \quad \text{(E-32)}$$

$$R = B + Cr \quad \text{(E-33)}$$

Table E-5 – Matrix coefficients

Value	Matrix	Informative remark
0	GBR	Typically referred to as RGB; see Equations E-16 to E-18
1	$K_R = 0.2126$; $K_B = 0.0722$	ITU-R Recommendation BT.709-5 and Society of Motion Picture and Television Engineers RP177 (1993)
2	Unspecified	Image characteristics are unknown or are determined by the application.
3	Reserved	For future use by ITU-T / ISO/IEC
4	$K_R = 0.30$; $K_B = 0.11$	United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20)
5	$K_R = 0.299$; $K_B = 0.114$	ITU-R Recommendation BT.470-6 System B, G
6	$K_R = 0.299$; $K_B = 0.114$	Society of Motion Picture and Television Engineers 170M (1999)
7	$K_R = 0.212$; $K_B = 0.087$	Society of Motion Picture and Television Engineers 240M (1999)
8	YCgCo	See Equations E-19 to E-33
9-255	Reserved	For future use by ITU-T / ISO/IEC

chroma_loc_info_present_flag equal to 1 specifies that chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are present. chroma_loc_info_present_flag equal to 0 specifies that chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are not present.

chroma_sample_loc_type_top_field and **chroma_sample_loc_type_bottom_field** specify the location of chroma samples for the top field and the bottom field as shown in Figure E-1. The value of chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall be in the range of 0 to 5, inclusive. When the chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are not present, the values of chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall be inferred to be equal to 0.

NOTE 5 – When coding progressive source material, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should have the same value.

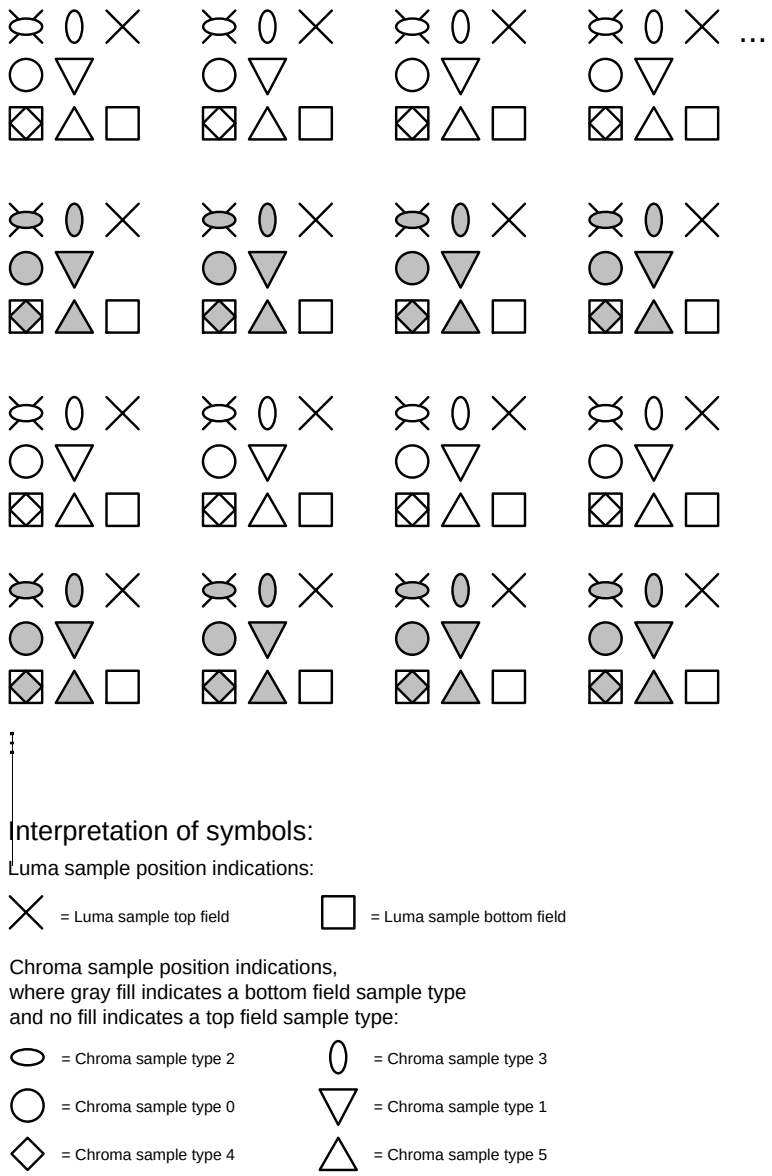


Figure E-1 – Location of chroma samples for top and bottom fields as a function of chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field

timing_info_present_flag equal to 1 specifies that num_units_in_tick, time_scale and fixed_frame_rate_flag are present in the bitstream. timing_info_present_flag equal to 0 specifies that num_units_in_tick, time_scale and fixed_frame_rate_flag are not present in the bitstream.

num_units_in_tick is the number of time units of a clock operating at the frequency time_scale Hz that corresponds to one increment (called a clock tick) of a clock tick counter. num_units_in_tick shall be greater than 0. A clock tick is the minimum interval of time that can be represented in the coded data. For example, when the clock frequency of a video signal is 60 000 ÷ 1001 Hz, time_scale may be equal to 60 000 and num_units_in_tick may be equal to 1001. See Equation C-1.

time_scale is the number of time units that pass in one second. For example, a time coordinate system that measures time using a 27 MHz clock has a time_scale of 27 000 000. time_scale shall be greater than 0.

fixed_frame_rate_flag equal to 1 indicates that the temporal distance between the HRD output times of any two consecutive pictures in output order is constrained as follows. fixed_frame_rate_flag equal to 0 indicates that no such constraints apply to the temporal distance between the HRD output times of any two consecutive pictures in output order.

For each picture n where n indicates the n-th picture (in output order) that is output and picture n is not the last picture in the bitstream (in output order) that is output, the value of $\Delta t_{fi,dpb}(n)$ is specified by

$$\Delta t_{fi,dpb}(n) = \Delta t_{o,dpb}(n) \div \text{DeltaTfiDivisor} \quad \text{(E-34)}$$

where $\Delta t_{o,dpb}(n)$ is specified in Equation C-13 and DeltaTfiDivisor is specified by Table E-6 based on the value of pic_struct_present_flag, field_pic_flag, and pic_struct for the coded video sequence containing picture n. Entries marked "-" in Table E-6 indicate a lack of dependence of DeltaTfiDivisor on the corresponding syntax element.

When fixed_frame_rate_flag is equal to 1 for a coded video sequence containing picture n, the value computed for $\Delta t_{fi,dpb}(n)$ shall be equal to t_c as specified in Equation C-1 (using the value of t_c for the coded video sequence containing picture n) when either or both of the following conditions are true for the following picture n_n that is specified for use in Equation C-13.

– picture n_n is in the same coded video sequence as picture n.

– picture n_n is in a different coded video sequence and fixed_frame_rate_flag is equal to 1 in the coded video sequence containing picture n_n and the value of num_units_in_tick ÷ time_scale is the same for both coded video sequences.

Table E-6 – Divisor for computation of $\Delta t_{fi,dpb}(n)$

pic_struct_present_flag	field_pic_flag	pic_struct	DeltaTfiDivisor
0	1	-	1
1	-	1	1
1	-	2	1
0	0	-	2
1	-	0	2
1	-	3	2
1	-	4	2
1	-	5	3
1	-	6	3
1	-	7	4
1	-	8	6

nal_hrd_parameters_present_flag equal to 1 specifies that NAL HRD parameters (pertaining to Type II bitstream conformance) are present. nal_hrd_parameters_present_flag equal to 0 specifies that NAL HRD parameters are not present.

NOTE 6 – When nal_hrd_parameters_present_flag is equal to 0, the conformance of the bitstream cannot be verified without provision of the NAL HRD parameters, including the NAL sequence HRD parameter information and all buffering period and picture timing SEI messages, by some means not specified in this Recommendation | International Standard.

When nal_hrd_parameters_present_flag is equal to 1, NAL HRD parameters (subclauses E.1.2 and E.2.2) immediately follow the flag.

The variable NalHrdBpPresentFlag is derived as follows.

– If any of the following is true, the value of NalHrdBpPresentFlag shall be set equal to 1.
  – nal_hrd_parameters_present_flag is present in the bitstream and is equal to 1
  – the need for presence of buffering periods for NAL HRD operation to be present in the bitstream in buffering period SEI messages is determined by the application, by some means not specified in this Recommendation | International Standard.

- Otherwise, the value of NalHrdBpPresentFlag shall be set equal to 0.

vcl_hrd_parameters_present_flag equal to 1 specifies that VCL HRD parameters (pertaining to all bitstream conformance) are present. vcl_hrd_parameters_present_flag equal to 0 specifies that VCL HRD parameters are not present.

NOTE 7 – When vcl_hrd_parameters_present_flag is equal to 0, the conformance of the bitstream cannot be verified without provision of the VCL HRD parameters and all buffering period and picture timing SEI messages, by some means not specified in this Recommendation | International Standard.

When vcl_hrd_parameters_present_flag is equal to 1, VCL HRD parameters (subclauses E.1.2 and E.2.2) immediately follow the flag.

The variable VclHrdBpPresentFlag is derived as follows.

– If any of the following is true, the value of VclHrdBpPresentFlag shall be set equal to 1.
  – vcl_hrd_parameters_present_flag is present in the bitstream and is equal to 1
  – the need for presence of buffering periods for VCL HRD operation to be present in the bitstream in buffering period SEI messages is determined by the application, by some means not specified in this Recommendation | International Standard.
– Otherwise, the value of VclHrdBpPresentFlag shall be set equal to 0.

The variable CpbDpbDelaysPresentFlag is derived as follows.

– If any of the following is true, the value of CpbDpbDelaysPresentFlag shall be set equal to 1.
  – nal_hrd_parameters_present_flag is present in the bitstream and is equal to 1
  – vcl_hrd_parameters_present_flag is present in the bitstream and is equal to 1
  – the need for presence of CPB and DPB output delays to be present in the bitstream in picture timing SEI messages is determined by the application, by some means not specified in this Recommendation | International Standard.
– Otherwise, the value of CpbDpbDelaysPresentFlag shall be set equal to 0.

low_delay_hrd_flag specifies the HRD operational mode as specified in Annex C. When fixed_frame_rate_flag is equal to 1, low_delay_hrd_flag shall be equal to 0.

NOTE 8 – When low_delay_hrd_flag is equal to 1, "big pictures" that violate the nominal CPB removal times due to the number of bits used by an access unit are permitted. It is expected, but not required, that such "big pictures" occur only occasionally.

pic_struct_present_flag equal to 1 specifies that picture timing SEI messages (subclause D.2.2) are present that include the pic_struct syntax element. pic_struct_present_flag equal to 0 specifies that the pic_struct syntax element is not present in picture timing SEI messages. When pic_struct_present_flag is not present, its value shall be inferred to be equal to 0.

bitstream_restriction_flag equal to 1, specifies that the following coded video sequence bitstream restriction parameters are present. bitstream_restriction_flag equal to 0, specifies that the following coded video sequence bitstream restriction parameters are not present.

motion_vectors_over_pic_boundaries_flag equal to 0 indicates that no sample outside the picture boundaries and no sample at a fractional sample position whose value is derived using one or more samples outside the picture boundaries is used to inter predict any sample. motion_vectors_over_pic_boundaries_flag equal to 1 indicates that one or more samples outside picture boundaries may be used in inter prediction. When the motion_vectors_over_pic_boundaries_flag syntax element is not present, motion_vectors_over_pic_boundaries_flag value shall be inferred to be equal to 1.

max_bytes_per_pic_denom indicates a number of bytes not exceeded by the sum of the sizes of the VCL NAL units associated with any coded picture in the coded video sequence.

The number of bytes that represent a picture in the NAL unit stream is specified for this purpose as the total number of bytes of VCL NAL unit data (i.e., the total of the NumBytesInNALunit variables for the VCL NAL units) for the picture. The value of max_bytes_per_pic_denom shall be in the range of 0 to 16, inclusive.

Depending on max_bytes_per_pic_denom the following applies.

– If max_bytes_per_pic_denom is equal to 0, no limits are indicated.
– Otherwise (max_bytes_per_pic_denom is not equal to 0), no coded picture shall be represented in the coded video sequence by more than the following number of bytes.

$$(PicSizeInMbs * RawMbBits) \div (8 * max\_bytes\_per\_pic\_denom) \quad (E\text{-}35)$$

When the max_bytes_per_pic_denom syntax element is not present, the value of max_bytes_per_pic_denom shall be inferred to be equal to 2.

max_bits_per_mb_denom indicates the maximum number of coded bits of macroblock_layer( ) data for any macroblock in any picture of the coded video sequence. The value of max_bits_per_mb_denom shall be in the range of 0 to 16, inclusive.

Depending on max_bits_per_mb_denom the following applies.

– If max_bits_per_mb_denom is equal to 0, no limit is specified.

– Otherwise (max_bits_per_mb_denom is not equal to 0), no coded macroblock_layer( ) shall be represented in the bitstream by more than the following number of bits.

$$(128 + RawMbBits) \div max\_bits\_per\_mb\_denom \quad \text{(E-36)}$$

Depending on entropy_coding_mode_flag, the bits of macroblock_layer( ) data are counted as follows.

– If entropy_coding_mode_flag is equal to 0, the number of bits of macroblock_layer( ) data is given by the number of bits in the macroblock_layer( ) syntax structure for a macroblock.

– Otherwise (entropy_coding_mode_flag is equal to 1), the number of bits of macroblock_layer( ) data for a macroblock is given by the number of times read_bits(1) is called in subclauses 9.3.3.2.2 and 9.3.3.2.3 when parsing the macroblock_layer( ) associated with the macroblock.

When the max_bits_per_mb_denom is not present, the value of max_bits_per_mb_denom shall be inferred to be equal to 1.

log2_max_mv_length_horizontal and **log2_max_mv_length_vertical** indicate the maximum absolute value of a decoded horizontal and vertical motion vector component, respectively, in ¼ luma sample units, for all pictures in the coded video sequence. A value of n asserts that no value of a motion vector component shall exceed the range from -2^n to 2^n-1, inclusive, in units of ¼ luma sample displacement. The value of log2_max_mv_length_horizontal shall be in the range of 0 to 16, inclusive. The value of log2_max_mv_length_vertical shall be in the range of 0 to 16, inclusive. When log2_max_mv_length_horizontal is not present, the values of log2_max_mv_length_horizontal and log2_max_mv_length_vertical shall be inferred to be equal to 16.

NOTE 9 – The maximum absolute value of a decoded vertical or horizontal motion vector component is also constrained by profile and level limits as specified in Annex A.

num_reorder_frames indicates the maximum number of frames, complementary field pairs, or non-paired fields that precede any frame, complementary field pair, or non-paired field in the coded video sequence in decoding order and follow it in output order. The value of num_reorder_frames shall be in the range of 0 to max_dec_frame_buffering, inclusive. When the num_reorder_frames syntax element is not present, the value of num_reorder_frames value shall be inferred to be equal to max_dec_frame_buffering.

max_dec_frame_buffering specifies the required size of the HRD decoded picture buffer (DPB) in units of frame buffers. The coded video sequence shall not require a decoded picture buffer with size of more than Max(1, max_dec_frame_buffering) frame buffers to enable the output of decoded pictures at the output times specified by dpb_output_delay of the picture timing SEI messages. The value of max_dec_frame_buffering shall be in the range of num_ref_frames to MaxDpbSize (as specified in subclause A.3.1 or A.3.2), inclusive. When the max_dec_frame_buffering syntax element is not present, the value of max_dec_frame_buffering shall be inferred to be equal to MaxDpbSize.

E.2.2 HRD parameters semantics

cpb_cnt_minus1 plus 1 specifies the number of alternative CPB specifications in the bitstream. The value of cpb_cnt_minus1 shall be in the range of 0 to 31, inclusive. When low_delay_hrd_flag is equal to 1, cpb_cnt_minus1 shall be equal to 0. When cpb_cnt_minus1 is not present, it shall be inferred to be equal to 0.

bit_rate_scale (together with bit_rate_value_minus1[SchedSelIdx]) specifies the maximum input bit rate of the SchedSelIdx-th CPB.

cpb_size_scale (together with cpb_size_value_minus1[SchedSelIdx]) specifies the CPB size of the SchedSelIdx-th CPB.

bit_rate_value_minus1[SchedSelIdx **]** (together with bit_rate_scale) specifies the maximum input bit rate for the SchedSelIdx-th CPB. bit_rate_value_minus1[SchedSelIdx] shall be in the range of 0 to $2^{32} - 2$, inclusive. For any SchedSelIdx > 0, bit_rate_value_minus1[SchedSelIdx] shall be greater than bit_rate_value_minus1[SchedSelIdx - 1]. The bit rate in bits per second is given by

$$BitRate[SchedSelIdx] = (bit\_rate\_value\_minus1[SchedSelIdx] + 1) * 2^{(6 + bit\_rate\_scale)} \quad \text{(E-37)}$$

When the bit_rate_value_minus1[SchedSelIdx] syntax element is not present, the value of BitRate[SchedSelIdx] shall be inferred as follows.

– If profile_idc is equal to 66, 77, or 88, BitRate[SchedSelIdx] shall be inferred to be equal to 1000 * MaxBR for VCL HRD parameters and to be equal to 1200 * MaxBR for NAL HRD parameters, where MaxBR is specified in subclause A.3.1.

– Otherwise, BitRate[SchedSelIdx] shall be inferred to be equal to cpbBrVclFactor * MaxBR for VCL HRD parameters and to be equal to cpbBrNalFactor * MaxBR for NAL HRD parameters, where cpbBrVclFactor, cpbBrNalFactor, and MaxBR are specified in subclause A.3.3.

cpb_size_value_minus1[SchedSelIdx **]** is used together with cpb_size_scale to specify the SchedSelIdx-th CPB size. cpb_size_value_minus1[SchedSelIdx] shall be in the range of 0 to 2^{32} - 2, inclusive. For any SchedSelIdx greater than 0, cpb_size_value_minus1[SchedSelIdx] shall be less than or equal to cpb_size_value_minus1[SchedSelIdx -1].

The CPB size in bits is given by

$$CpbSize[SchedSelIdx] = (cpb\_size\_value\_minus1[SchedSelIdx] + 1) * 2^{(4 + cpb\_size\_scale)} \quad \text{(E-38)}$$

When the cpb_size_value_minus1[SchedSelIdx] syntax element is not present, the value of CpbSize[SchedSelIdx] shall be inferred as follows.

– If profile_idc is equal to 66, 77, or 88, CpbSize[SchedSelIdx] shall be inferred to be equal to 1000 * MaxCPB for VCL HRD parameters and to be equal to 1200 * MaxCPB for NAL HRD parameters, where MaxCPB is specified in subclause A.3.1.

– Otherwise, CpbSize[SchedSelIdx] shall be inferred to be equal to cpbBrVclFactor * MaxCPB for VCL HRD parameters and to be equal to cpbBrNalFactor * MaxCPB for NAL HRD parameters, where cpbBrVclFactor, cpbBrNalFactor, and MaxCPB are specified in subclause A.3.3.

cbr_flag[SchedSelIdx **]** equal to 0 specifies that to decode this bitstream by the HRD using the SchedSelIdx-th CPB specification, the hypothetical stream delivery scheduler (HSS) operates in an intermittent bit rate mode. cbr_flag[SchedSelIdx] equal to 1 specifies that the HSS operates in a constant bit rate (CBR) mode. When the cbr_flag[SchedSelIdx] syntax element is not present, the value of cbr_flag shall be inferred to be equal to 0.

initial_cpb_removal_delay_length_minus1 specifies the length in bits of the initial_cpb_removal_delay[SchedSelIdx] and initial_cpb_removal_delay_offset[SchedSelIdx] syntax elements of the buffering period SEI message. The length of initial_cpb_removal_delay[SchedSelIdx] and of initial_cpb_removal_delay_offset[SchedSelIdx] is initial_cpb_removal_delay_length_minus1 + 1. When the initial_cpb_removal_delay_length_minus1 syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the initial_cpb_removal_delay_length_minus1 parameters shall be equal in both hrd_parameters( ) syntax structures. When the initial_cpb_removal_delay_length_minus1 syntax element is not present, it shall be inferred to be equal to 23.

cpb_removal_delay_length_minus1 specifies the length in bits of the cpb_removal_delay syntax element. The length of the cpb_removal_delay syntax element of the picture timing SEI message is cpb_removal_delay_length_minus1 + 1. When the cpb_removal_delay_length_minus1 syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the cpb_removal_delay_length_minus1 parameters shall be equal in both hrd_parameters( ) syntax structures. When the cpb_removal_delay_length_minus1 syntax element is not present, it shall be inferred to be equal to 23.

dpb_output_delay_length_minus1 specifies the length in bits of the dpb_output_delay syntax element. The length of the dpb_output_delay syntax element of the picture timing SEI message is dpb_output_delay_length_minus1 + 1. When the dpb_output_delay_length_minus1 syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the dpb_output_delay_length_minus1 parameters shall be equal in both hrd_parameters( ) syntax structures. When the dpb_output_delay_length_minus1 syntax element is not present, it shall be inferred to be equal to 23.

time_offset_length greater than 0 specifies the length in bits of the time_offset syntax element. time_offset_length equal to 0 specifies that the time_offset syntax element is not present. When the time_offset_length syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the time_offset_length parameters shall be equal in both hrd_parameters( ) syntax structures. When the time_offset_length syntax element is not present, it shall be inferred to be equal to 24.

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Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	**Audiovisual and multimedia systems**
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APPENDIX H26410

Series A : Organization of the work of ITU-T

Number	*Approval Date*	*Recommendation Title*	*Status*
		Organization of the work of ITU-T	
A.1	10-2004	Work methods for study groups of the ITU Telecommunication Standardization Sector (ITU-T)	
A.2	10-2004	Presentation of contributions relative to the study of Questions assigned to ITU-T	
A.4	06-2002	Communication process between ITU-T and Forums and Consortia	
A.5	11-2001	Generic procedures for including references to documents of other organizations in ITU-T Recommendations	
A.6	06-2002	Cooperation and exchange of information between ITU-T and national and regional standards development organizations	
A.7	10-2004	Focus groups: Working methods and procedures	
A.8	10-2004	Alternative approval process for new and revised Recommendations	
A.9	11-2003	Working procedures for the Special Study Group on IMT-2000 and Beyond	
A.11	10-2004	Publication of ITU-T Recommendations and WTSA proceedings	
A.12	10-2004	Identification and layout of ITU-T Recommendations	
A.13	10-2000	Supplements to ITU-T Recommendations	
A.23	10-1996	Collaboration with the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) on information technology	Not available, contact sales@itu.int.
A.23 Annex A	11-2001	Guide to ITU-T and ISO/IEC JTC1 cooperation	
A.Sup2	06-2000	Guidelines on interoperability experiments	
A.Sup3	11-2001	IETF and ITU-T collaboration guidelines	

Recommendation count: 15

Series D : General tariff principles

Number	Approval Date	Recommendation Title	Status
		General tariff principles	
D.000	06-2002	Terms and definitions for the D-series Recommendations	
D.1	07-1991	General principles for the lease of international (continental and intercontinental) private telecommunication circuits and networks	
D.3	06-1992	Principles for the lease of analogue international circuits for private service	
D.4	12-1998	Special conditions for the lease of international (continental and intercontinental) sound- and television-programme circuits for private service	
D.4 (1998) Amendment 1	06-2004		
D.5	11-1988	Costs and value of services rendered as factors in the fixing of rates	
D.7	01-1992	Concept and implementation of "one-stop shopping" for international private leased telecommunication circuits	
D.8	11-1988	Special conditions for the lease of international end-to-end digital circuits for private service	
D.9	11-1988	Private leasing of transmitters or receivers	
D.10	07-1991	General tariff principles for international public data communication services	
D.11	03-1991	Special tariff principles for international packet-switched public data communication services by means of the virtual call facility	
D.12	11-1988	Measurement unit for charging by volume in the international packet-switched data communication service	
D.13	11-1988	Guiding principles to govern the apportionment of accounting rates in international packet-switched public data communication relations	
D.15	11-1988	General charging and accounting principles for non-voice services provided by interworking between public data networks	
D.20	11-1988	Special tariff principles for the international circuit-switched public data communication services	
D.21	11-1988	Special tariff principles for short transaction transmissions on the international packet-switched public data networks using the fast select facility with restriction	
D.30	11-1988	Implementation of reverse charging on international public data communication services	
D.35	01-1992	General charging principles in the international public message handling services and associated applications	
D.36	03-1995	General accounting principles applicable to message handling services and associated applications	
D.37	07-1996	Accounting and settlement principles applicable to the provision of public directory services between interconnected Directory Management Domains	

D.40	06-1992	General tariff principles applicable to telegrams exchanged in the international public telegram service
D.41	11-1988	Introduction of accounting rates by zones in the international public telegram service
D.42	11-1988	Accounting in the international public telegram service
D.43	11-1988	Partial and total refund of charges in the international public telegram service
D.45	06-1992	Charging and accounting principles for the international telemessage service
D.50	10-2000	International Internet connection
D.50 (2000) Amendment 1	06-2004	New Appendix I – General considerations for charging criteria and options for international Internet connectivity
D.60	07-1991	Guiding principles to govern the apportionment of accounting rates in intercontinental telex relations
D.61	11-1988	Charging and accounting provisions relating to the measurement of the chargeable duration of a telex call
D.65	11-1988	General charging and accounting principles in the international telex service for multi-address messages via store-and-forward units
D.67	03-1995	Charging and accounting in the international telex service
D.70	06-1992	General tariff principles for the international public facsimile service between public bureaux (bureaufax service)
D.71	06-1992	General tariff principles for the public facsimile service between subscriber stations (telefax service)
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D.81	11-1988	Accounting and refunds for private phototelegraph calls
D.83	11-1988	Rates for phototelegrams and private phototelegraph calls
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D.94	01-1992	Charging, billing and accounting principles for international aeronautical mobile service, and international aeronautical mobile-satellite service
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D.103	06-1992	Charging in automatic service for calls terminating on a recorded announcement stating the reason for the call not being completed
D.104	11-1988	Charging for calls to subscriber's station connected either to the absent subscriber's service or to a device substituting a subscriber in his absence
D.105	11-1988	Charging for calls from or to a public call office
D.106	11-1988	Introduction of reduced rates during periods of light traffic in the international telephone service
D.110	06-1992	Charging and accounting for conference calls
D.115	06-2004	Tariff principles and accounting for the International Freephone Service (IFS)
D.116	06-2004	Charging and accounting principles relating to the home country direct telephone service
D.117	06-1999	Charging and accounting principles for the international premium rate service (IPRS)
D.120	07-1996	Charging and accounting principles for the international telecommunication charge card service
D.140	06-2002	Accounting rate principles for the international telephone service
D.140 (2002) Amendment 1	12-2002	New Appendix to Annex C: Guidelines
D.140 (2002) Amendment 2	06-2003	Revision to Annex E
D.140 (2002) Amendment 3	11-2003	Revised Annex A – Guidelines for the cost elements to be taken into account when determining accounting rates and accounting rate shares for the international telephone service
D.140 Supplement 1	06-2002	Updated teledensities and indicative target settlement rates
D.140 Supplement 2	06-2003	Updated teledensities and indicative target settlement rates (1 January 2003)
D.140 Supplement 3	06-2004	Updated teledensities and indicative target settlement rates (1 January 2004)
D.150	06-1999	New system for accounting in international telephony
D.151	11-1988	Old system for accounting in international telephony
D.155	07-1996	Guiding principles governing the apportionment of accounting rates in intercontinental telephone relations
D.160	11-1988	Mode of application of the flat-rate price procedure set forth in Recommendation D.67 and Recommendation D.150 for remuneration of facilities made available to the Administrations of other countries
D.170	06-1998	Monthly telephone and telex accounts
D.171	11-1988	Adjustments and refunds in the international telephone service

D.172	11-1988	Accounting for calls circulated over international routes for which accounting rates have not been established
D.173	11-1988	Defaulting subscribers
D.174	11-1988	Conventional transmission of information necessary for billing and accounting regarding collect and credit card calls
D.176	12-1997	Transmission in encoded form of telephone reversed charge billing and accounting information
D.176 (1997) Amendment 1	06-1998	Year 2000 issue and its impact on ITU-T D.176 application
D.177	11-1988	Adjustment of charges and refunds in the international telex service
D.178	03-1993	Monthly accounts for semi-automatic telephone calls (ordinary and urgent calls, with or without special facilities)
D.180	06-2002	Occasional provision of circuits for international sound- and television-programme transmissions
D.180 Amendment 1	06-2004	
D.185	11-1988	General tariff and accounting principles for international one-way point-to-multipoint satellite services
D.186	10-1996	General tariff and accounting principles for international two-way multipoint telecommunication service via satellite
D.188	10-1992	General charging and accounting principles applicable to an international videoconferencing service
D.190	06-2002	Exchange of international traffic accounting data between Administrations using electronic data interchange (EDI) techniques
D.192	06-1992	Principles for charging and accounting of service telecommunications
D.193	11-1988	Special tariff principles for privilege telecommunications
D.195	11-2003	Time-scale for settlement of accounts for international telecommunication services
D.196	06-1992	Clearing of international telecommunication balances of accounts
D.197	07-1991	Notification of change of address(es) for accounting and settlement purposes
D.201	12-2002	General principles regarding call-back practices
D.210	09-1994	General charging and accounting principles for international telecommunication services provided over the Integrated Services Digital Network (ISDN)
D.211	12-1998	International accounting for the use of the signal transfer point and/or signalling point for relay in Signalling System No. 7
D.212	10-1996	Charging and accounting principles for the use of Signalling System No. 7
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D.224	12-1999	Charging and accounting principles for ATM/B-ISDN

D.225	12-1997	Charging and accounting principles to be applied to frame relay data transmission service
D.230	03-1995	General charging and accounting principles for supplementary services associated with international telecommunication services provided over the Integrated Services Digital Network (ISDN)
D.231	11-1988	Charging and accounting principles relating to the User-to-User Information (UUI) supplementary service
D.232	05-1997	Specific tariff and accounting principles applicable to ISDN supplementary services
D.233	07-1996	Charging and accounting principles to be applied to the reversed charge supplementary service
D.240	03-1991	Charging and accounting principles for teleservices supported by the ISDN
D.250	07-1991	General charging and accounting principles for non-voice services provided by interworking between the ISDN and existing public data networks
D.251	11-1988	General charging and accounting principles for the basic telephone service provided over the ISDN or by interconnection between the ISDN and the public switched telephone network
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D.280	03-1995	Principles for charging and billing, accounting and reimbursements for universal personal telecommunication
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D.300R	03-1995	Determination of accounting rate shares in telephone relations between countries in Europe and the Mediterranean Basin
D.301R	03-1995	Determination of accounting rate shares and collection charges in telex relations between countries in Europe and the Mediterranean Basin
D.302R	03-1995	Determination of the accounting rate shares and collection charges for the international public telegram service applicable to telegrams exchanged between countries in Europe and the Mediterranean Basin
D.303R	03-1995	Determination of accounting rate shares and collection charges applicable by countries in Europe and the Mediterranean Basin to the occasional provision of circuits for sound- and television-programme transmissions
D.306R	07-1991	Remuneration of public packet-switched data transmission networks between the countries of Europe and the Mediterranean Basin
D.307R	03-1995	Remuneration of digital systems and channels used in telecommunication relations between the countries of Europe and the Mediterranean Basin
D.310R	03-1995	Determination of rentals for the lease of international programme (sound- and television-) circuits and associated control circuits for private service in relations between countries in Europe and the Mediterranean Basin
D.400R	12-1999	Accounting rates applicable to direct traffic relations in voice telephony between countries in Latin America and the Caribbean
D.500R	06-1998	Accounting rates applicable to telephone relations between countries in Asia and Oceania

D.501R	10-1993	Accounting rates applicable to telex relations between countries in Asia and Oceania	
D.600R	10-2000	Cost methodology for the regional tariff group for Africa applicable to the international automatic telephone service	
D.601R	10-1993	Determination of accounting rate shares and collection charges in telex relations between countries in Africa	
D.602R	12-2002	Application of the “sender pays transit” principle in transit relation	
D.603R	12-2002	Minimizing collection charges on inter-African calls	
D.604R	01-2005	The last international transit center pays the traffic	
D.606R	11-1988	Preferential rates in telecommunication relations between countries in Africa	
D.Sup1	11-1988	Cost and tariff study method	Available only in PDF.
D.Sup2	11-1988	Method for carrying out a cost price study by regional tariff groups	
D.Sup3	03-1993	Handbook on the methodology for determining costs and establishing national tariffs	

Recommendation count: ***124***

Series E : Overall network operation, telephone service, service operation and human factors

Number	*Approval Date*	*Recommendation Title*	*Status*
		Overall network operation, telephone service, service operation and human factors	
E.100	11-1988	Definitions of terms used in international telephone operation	
E.104	02-1995	International telephone directory assistance service and public access	
E.105	08-1992	International telephone service	
E.106	10-2003	International Emergency Preference Scheme (IEPS) for disaster relief operations	
E.109	02-1995	International billed number screening procedures for collect and third-party calling	
E.110	11-1988	Organization of the international telephone network	
E.111	11-1988	Extension of international telephone services	
E.112	11-1988	Arrangements to be made for controlling the telephone services between two countries	
E.113	05-1997	Validation procedures for the international telecommunications charge card service	
E.114	11-1988	Supply of lists of subscribers (directories and other means)	
E.115	02-1995	Computerized directory assistance	
E.116	05-1997	International telecommunication charge card service	
E.117	06-1994	Terminal devices used in connection with the public telephone service (other than telephones)	
E.118	02-2001	The international telecommunication charge card	
E.120	11-1988	Instructions for users of the international telephone service	
E.121	06-2004	Pictograms, symbols and icons to assist users of the telephone and telefax services	
E.121 (2004) Erratum 1	10-2004		
E.122	11-1988	Measures to reduce customer difficulties in the international telephone service	
E.123	02-2001	Notation for national and international telephone numbers, e-mail addresses and Web addresses	
E.124	11-1988	Discouragement of frivolous international calling to unassigned or vacant numbers answered by recorded announcements without charge	
E.125	10-1984	Inquiries among users of the international telephone service	
E.126	11-1988	Harmonization of the general information pages of the telephone directories published by Administrations	
E.127	11-1988	Pages in the telephone directory intended for foreign visitors	

E.128	11-1988	Leaflet to be distributed to foreign visitors	
E.129	09-2002	Presentation of national numbering plans	
E.130	11-1988	Choice of the most useful and desirable supplementary telephone services	
E.131	11-1988	Subscriber control procedures for supplementary telephone services	
E.132	11-1988	Standardization of elements of control procedures for supplementary telephone services	
E.133	11-1988	Operating procedures for cardphones	
E.134	03-1993	Human factors aspects of public terminals: Generic operating procedures	
E.135	10-1995	Human factors aspects of public telecommunication terminals for people with disabilities	
E.136	05-1997	Specification of a tactile identifier for use with telecommunication cards	
E.137	05-1997	User instructions for payphones	
E.138	06-2002	Human factors aspects of public telephones to improve their usability for older people	
E.138 Erratum 1	02-2003		
E.140	08-1992	Operator-assisted telephone service	
E.148	11-1988	Routing of traffic by automatic transit exchanges	
E.149	11-1988	Presentation of routing data	
E.151	08-1992	Telephone conference calls	
E.152	02-2001	International freephone service	
E.153	10-1996	Home country direct	
E.154	03-1998	International Shared Cost Service	
E.155	03-1998	International Premium Rate Service	
E.155 (1998) Amendment 1	02-2001		
E.161	02-2001	Arrangement of digits, letters and symbols on telephones and other devices that can be used for gaining access to a telephone network	
E.164	02-2005	The international public telecommunication numbering plan	Pre-published.
E.164 Supplement 1	03-1998	Alternatives for carrier selection and network identification	
E.164 Supplement 2	11-1998	Number Portability	
E.164 Supplement 3	05-2004	Operational and administrative issues associated with national implementations of the ENUM functions	
E.164 Supplement 4	05-2004	Operational and administrative issues associated with the implementation of ENUM for non-geographic country codes	

E.164.1	02-2005	Criteria and procedures for the reservation, assignment and reclamation of E.164 country codes and associated identification codes (ICs)	
E.164.2	02-2001	E.164 numbering resources for trials	
E.164.3	09-2001	Principles, criteria and procedures for the assignment and reclamation of E.164 country codes and associated identification codes for groups of countries	
E.165	11-1988	Timetable for coordinated implementation of the full capability of the numbering plan for the ISDN era (Recommendation E.164)	
E.165.1	10-1996	Use of escape code "0" within the E.164 numbering plan during the transition period to implementation of NPI mechanism	
E.166/X.122	03-1998	Numbering plan interworking for the E.164 and X.121 numbering plans	
E.167	11-1988	ISDN Network Identification Codes	
E.168	05-2002	Application of E.164 numbering plan for UPT	
E.168 Amendment 1	05-2004	New Appendix I	
E.168.1	02-2005	Assignment procedures for universal personal telecommunications (UPT) numbers in the provisioning of the international UPT service	Pre-published.
E.169	05-2002	Application of Recommendation E.164 numbering plan for universal international numbers for international telecommunications services using country codes for global services	
E.169.1	09-2001	Application of Recommendation E.164 numbering plan for universal international freephone numbers for international freephone service	
E.169.2	10-2000	Application of Recommendation E.164 numbering plan for universal international premium rate numbers for the international premium rate service	
E.169.3	10-2000	Application of Recommendation E.164 numbering plan for universal international shared cost numbers for international shared cost service	
E.170	10-1992	Traffic routing	
E.172	10-1992	ISDN routing plan	
E.173	08-1991	Routing plan for interconnection between public land mobile networks and fixed terminal networks	
E.174	04-1995	Routing principles and guidance for Universal Personal Telecommunications (UPT)	
E.175	11-1988	Models for international network planning	
E.177	10-1996	B-ISDN routing	
E.180/Q.35	03-1998	Technical characteristics of tones for the telephone service	
E.181	11-1988	Customer recognition of foreign tones	
E.182	03-1998	Application of tones and recorded announcements in telephone services	
E.183	03-1998	Guiding principles for telephone announcements	
E.184	11-1988	Indications to users of ISDN terminals	

E.190	05-1997	Principles and responsibilities for the management, assignment and reclamation of E-series international numbering resources	
E.191	03-2000	B-ISDN addressing	
E.191 (2000) Corrigendum 1	02-2002		
E.191.1	02-2001	Criteria and procedures for the allocation of ITU-T International Network Designator addresses	
E.193	03-2000	E.164 country code expansion	
E.195	10-2000	ITU-T International numbering resource administration	
E.202	10-1992	Network operational principles for future public mobile systems and services	
E.210	11-1988	Ship station identification for VHF/UHF and maritime mobile-satellite services	
E.212	05-2004	The international identification plan for mobile terminals and mobile users	
E.212 (2004) Erratum 1	10-2004		
E.213	11-1988	Telephone and ISDN numbering plan for land mobile stations in public land mobile networks (PLMN)	
E.214	02-2005	Structure of the land mobile global title for the signalling connection control part (SCCP)	Pre-published.
E.217	05-2002	Maritime communications – Ship station identity	
E.218	05-2004	Management of the allocation of terrestrial trunk radio Mobile Country Codes	
E.220	02-1996	Interconnection of public land mobile networks (PLMN)	
E.230	08-1992	Chargeable duration of calls	
D.103	06-1992	Charging in automatic service for calls terminating on a recorded announcement stating the reason for the call not being completed	
D.104	11-1988	Charging for calls to subscriber's station connected either to the absent subscriber's service or to a device substituting a subscriber in his absence	
E.260	11-1988	Basic technical problems concerning the measurement and recording of call durations	
E.261	11-1988	Devices for measuring and recording call durations	
D.170	06-1998	Monthly telephone and telex accounts	
E.300	11-1988	Special uses of circuits normally employed for automatic telephone traffic	
E.301	03-1993	Impact of non-voice applications on the telephone network	
E.320	11-1988	Speeding up the establishment and clearing of phototelegraph calls	
F.107	11-1988	Rules for phototelegraph calls established over circuits normally used for telephone traffic	
E.330	11-1988	User control of ISDN-supported services	

E.331	10-1991	Minimum user-terminal interface for a human user entering address information into an ISDN terminal
Z.323	11-1988	Man-machine interaction
E.350	03-2000	Dynamic routing interworking
E.351	03-2000	Routing of multimedia connections across TDM-, ATM- and IP-based networks
E.352	03-2000	Routing guidelines for efficient routing methods
E.353	02-2001	Routing of calls when using international network routing addresses
E.360.1	05-2002	Framework for QoS routing and related traffic engineering methods for IP-, ATM-, and TDM-based multiservice networks
E.360.2	05-2002	QoS routing and related traffic engineering methods – Call routing and connection routing methods
E.360.3	05-2002	QoS routing and related traffic engineering methods – QoS resource management methods
E.360.4	05-2002	QoS routing and related traffic engineering methods – Routing table management methods and requirements
E.360.5	05-2002	QoS routing and related traffic engineering methods – Transport routing methods
E.360.6	05-2002	QoS routing and related traffic engineering methods – Capacity management methods
E.360.7	05-2002	QoS routing and related traffic engineering methods – Traffic engineering operational requirements
E.361	05-2003	QoS routing support for interworking of QoS service classes across routing technologies
E.370	02-2001	Service principles when public circuit-switched international telecommunication networks interwork with IP-based networks
E.401	11-1988	Statistics for the international telephone service (number of circuits in operation and volume of traffic)
E.408	05-2004	Telecommunication networks security requirements
E.409	05-2004	Incident organization and security incident handling: Guidelines for telecommunication organizations
E.410	03-1998	International network management – General information
E.411	03-2000	International network management – Operational guidance
E.411 (2000) Amendment 1	03-2001	
E.412	01-2003	Network management controls
E.413	11-1988	International network management – Planning
E.414	11-1988	International network management – Organization
E.415	08-1991	International network management guidance for common channel signalling system No. 7
E.416	03-2000	Network management principles and functions for B-ISDN traffic

E.417	02-2005	Framework for the network management of IP-based networks	Pre-published.
E.418	05-2003	Framework for network management of IMT-2000 networks	
E.420	11-1988	Checking the quality of the international telephone service – General considerations	
E.421	11-1988	Service quality observations on a statistical basis	
E.422	02-1996	Observations on international outgoing telephone calls for quality of service	
E.423	11-1988	Observations on traffic set up by operators	
E.424	10-1992	Test calls	
E.425	03-2002	Internal automatic observations	
E.426	10-1992	General guide to the percentage of effective attempts which should be observed for international telephone calls	
E.427	11-1988	Collection and statistical analysis of special quality of service observation data for measurements of customer difficulties in the international automatic service	
E.428	10-1992	Connection retention	
E.430	06-1992	Quality of service framework	
E.431	06-1992	Service quality assessment for connection set-up and release delays	
E.432	06-1992	Connection quality	
E.433	06-1992	Billing integrity	
E.434	06-1992	Subscriber-to-subscriber measurement of the public switched telephone network	
E.436	03-1998	Customer Affecting Incidents and blocking Defects Per Million	
E.437	05-1999	Comparative metrics for network performance management	
E.438	03-2000	Performance parameters and measurement methods to assess N-ISDN 64 kbit/s circuit-switched bearer service UDI in operation	
E.439	03-2000	Test call measurement to assess N-ISDN 64 kbit/s circuit-switched bearer service UDI in operation	
E.440	02-1996	Customer satisfaction point	
E.450	03-1998	Facsimile quality of service on public networks – General aspects	
E.451	02-2001	Facsimile call cut-off performance	
E.452	03-1993	Facsimile modem speed reductions and transaction time	
E.453	08-1994	Facsimile image quality as corrupted by transmission-induced scan line errors	
E.454	10-1996	Transmission performance metrics based on Error Correction Mode (ECM) facsimile	
E.456	03-1998	Test transaction for facsimile transmission performance	

E.457	02-1996	Facsimile measurement methodologies	
E.458	02-1996	Figure of merit for facsimile transmission performance	
E.459	03-1998	Measurements and metrics for characterizing facsimile transmission performance using non-intrusive techniques	
E.460	03-2000	Measurements and metrics for monitoring the performance of V.34 Group 3 Facsimile	
E.470	02-2005	Operational considerations for QoS of voice over IP-based networks with PSTN-IP-PSTN architecture	Pre-published.
E.490	06-1992	Traffic measurement and evaluation – General survey	
E.490.1	01-2003	Overview of Recommendations on traffic engineering	
E.491	05-1997	Traffic measurement by destination	
E.492	02-1996	Traffic reference period	
E.493	02-1996	Grade of service (GOS) monitoring	
E.500	11-1998	Traffic intensity measurement principles	
E.501	05-1997	Estimation of traffic offered in the network	
E.502	02-2001	Traffic measurement requirements for digital telecommunication exchanges	
E.503	06-1992	Traffic measurement data analysis	
E.504	11-1988	Traffic measurement administration	
E.505	06-1992	Measurements of the performance of common channel signalling network	
E.506	06-1992	Forecasting international traffic	
E.507	11-1988	Models for forecasting international traffic	
E.508	10-1992	Forecasting new telecommunication services	
E.520	11-1988	Number of circuits to be provided in automatic and/or semiautomatic operation, without overflow facilities	
E.521	11-1988	Calculation of the number of circuits in a group carrying overflow traffic	
E.522	11-1988	Number of circuits in a high-usage group	
E.523	11-1988	Standard traffic profiles for international traffic streams	
E.524	05-1999	Overflow approximations for non-random inputs	
E.525	06-1992	Designing networks to control grade of service	
E.526	03-1993	Dimensioning a circuit group with multi-slot bearer services and no overflow inputs	
E.527	03-2000	Dimensioning at a circuit group with multi-slot bearer services and overflow traffic	
E.528	02-1996	Dimensioning of digital circuit multiplication equipment (DCME) systems	

E.529	05-1997	Network dimensioning using end-to-end GOS objectives
E.540	11-1988	Overall grade of service of the international part of an international connection
E.541	11-1988	Overall grade of service for international connections (subscriber-to-subscriber)
E.543	11-1988	Grades of service in digital international telephone exchanges
E.550	03-1993	Grade-of-service and new performance criteria under failure conditions in international telephone exchanges
E.600	03-1993	Terms and definitions of traffic engineering
E.651	03-2000	Reference connections for traffic engineering of IP access networks
E.671	03-2000	Post-selection delay in PSTN/ISDN networks using Internet telephony for a portion of the connection
E.681	10-2001	Traffic engineering methods for IP acess networks based on hybrid fiber/coax system
E.700	10-1992	Framework of the E.700-Series Recommendations
E.701	10-1992	Reference connections for traffic engineering
E.711	10-1992	User demand modelling
E.712	10-1992	User plane traffic modelling
E.713	10-1992	Control plane traffic modelling
E.716	10-1996	User demand modelling in Broadband-ISDN
E.720	11-1988	ISDN grade of service concept
E.721	05-1999	Network grade of service parameters and target values for circuit-switched services in the evolving ISDN
E.723	06-1992	Grade-of-service parameters for Signalling System No. 7 networks
E.724	02-1996	GOS parameters and target GOS objectives for IN services
E.726	03-2000	Network grade of service parameters and target values for B-ISDN
E.728	03-1998	Grade-of-service parameters for B-ISDN signalling
E.731	10-1992	Methods for dimensioning resources operating in circuit-switched mode
E.733	11-1998	Methods for dimensioning resources in Signalling System No. 7 networks
E.734	10-1996	Methods for allocating and dimensioning Intelligent Network (IN) resources
E.735	05-1997	Framework for traffic control and dimensioning in B-ISDN
E.736	03-2000	Methods for cell level traffic control in B-ISDN
E.737	02-2001	Dimensioning methods for B-ISDN
E.743	04-1995	Traffic measurements for SS No. 7 dimensioning and planning

E.744	10-1996	Traffic and congestion control requirements for SS No. 7 and IN-structured networks
E.745	03-2000	Cell level measurement requirements for the B-ISDN
E.750	03-2000	Introduction to the E.750 series of Recommendations on traffic engineering aspects of networks supporting personnal communications services
E.751	02-1996	Reference connections for traffic engineering of land mobile networks
E.752	10-1996	Reference connections for traffic engineering of maritime and aeronautical systems
E.755	02-1996	Reference connections for UPT traffic performance and GOS
E.760	03-2000	Terminal mobility traffic modelling
E.770	03-1993	Land mobile and fixed network interconnection traffic grade of service concept
E.771	10-1996	Network grade of service parameters and target values for circuit-switched public land mobile services
E.773	10-1996	Maritime and aeronautical mobile grade of service concept
E.774	10-1996	Network grade of service parameters and target values for maritime and aeronautical mobile services
E.775	02-1996	UPT grade of service concept
E.776	10-1996	Network grade of service parameters for UPT
E.800	08-1994	Terms and definitions related to quality of service and network performance including dependability
E.801	10-1996	Framework for Service Quality Agreement
E.810	10-1992	Framework of the Recommendations on the serveability performance and service integrity for telecommunication services
E.820	10-1992	Call models for serveability and service integrity performance
E.830	10-1992	Models for the specification, evaluation and allocation of serveability and service integrity
E.845	11-1988	Connection accessibility objective for the international telephone service
E.846	03-1993	Accessibility for 64 kbit/s circuit-switched international end-to-end ISDN connection types
E.850	10-1992	Connection retainability objective for the international telephone service
E.855	11-1988	Connection integrity objective for the international telephone service
E.860	06-2002	Framework of a service level agreement
E.862	06-1992	Dependability planning of telecommunication networks
E.880	11-1988	Field data collection and evaluation on the performance of equipment, networks and services
E.300 Series Supplement 1	11-1988	List of possible supplementary telephone services which may be offered to subscribers

E.300 Series Supplement 3	11-1988	North american precise audible tone plan
E.300 Series Supplement 4	11-1988	Treatment of calls considered as terminating abnormally
E.300 Series Supplement 5	10-1984	Modelling of an experimental test design for the determination of inexperienced user difficulties in setting up international calls using nationally available instructions, or to compare different sets of instructions
E.300 Series Supplement 6	11-1988	Preparation of information to customers travelling abroad
E.300 Series Supplement 7	11-1988	Description of INMARSAT existing and planned systems
E.800 Series Supplement 1	11-1988	Table of the Erlang formula
E.800 Series Supplement 2	11-1988	Curves showing the relation between the traffic offered and the number of circuits required
E.800 Series Supplement 5	11-1988	Teletraffic implications for international switching and operational procedures resulting from a failure of a transmission facility
E.800 Series Supplement 7	11-1988	Guide for evaluating and implementing alternate routing networks

Recommendation count: ***245***

Series F : Non-telephone telecommunication services

Number	*Approval Date*	*Recommendation Title*	*Status*
		Non-telephone telecommunication services	
F.1	03-1998	Operational provisions for the international public telegram service	
F.2	11-1988	Operational provisions for the collection of telegram charges	
F.4	11-1988	Plain and secret language	
F.10	11-1988	Character error rate objective for telegraph communication using 5-unit start-stop equipment	
F.11	10-1991	Continued availability of traditional services	
F.14	08-1992	General provisions for one-stop-shopping arrangements	
F.15	08-1992	Evaluating the success of new services	
F.16	02-1995	Global virtual network service	
F.17	08-1992	Operational aspects of service telecommunications	
F.18	03-1998	Guidelines on harmonization of international public bureau services	
F.19	10-1996	Collection and dissemination of official service information	
F.20	11-1988	The international gentex service	
F.21	11-1988	Composition of answer-back codes for the international gentex service	
F.23	11-1988	Grade of service for long-distance international gentex circuits	
F.24	11-1988	Average grade of service from country to country in the gentex service	
F.30	03-1993	Use of various sequences of combinations for special purposes	
F.31	11-1988	Telegram retransmission system	
F.32	10-1995	Telegram destination indicators	
F.35	11-1988	Provisions applying to the operation of an international public automatic message switching service for equipments utilizing the International Telegraph Alphabet No. 2	
F.40	03-1991	International public telemessage service	
F.41	03-1991	Interworking between the telemessage service and the international public telegram service	
F.59	10-1996	General characteristics of the international telex service	
F.60	08-1992	Operational provisions for the international telex service	
F.61	11-1988	Operational provisions relating to the chargeable duration of a telex call	
F.63	03-1993	Additional facilities in the international telex service	

F.64	11-1988	Determination of the number of international telex circuits required to carry a given volume of traffic
F.65	11-1988	Time-to-answer by operators at international telex positions
F.68	11-1988	Establishment of the automatic intercontinental telex network
F.69	06-1994	The international telex service – Service and operational provisions of telex destination codes and telex network identification codes
F.70	11-1988	Evaluating the quality of the international telex service
F.71	11-1988	Interconnection of private teleprinter networks with the telex network
F.72	10-1996	The international telex service – General principles and operational aspects of a store and forward facility
F.74	08-1992	Intermediate storage devices accessed from the international telex service using single stage selection – Answerback format
F.80	10-1991	Basic requirements for interworking relations between the international telex service and other services
F.82	10-1991	Operational provisions to permit interworking between the international telex service and the intex service
F.83	07-1990	Operational principles for communication between terminals of the international telex service and data terminal equipment on packet-switched public data networks
F.421	11-1988	Message handling services: Intercommunication between the IPM service and the telex service
F.421 Errata	12-1999	
F.87	03-1991	Operational principles for the transfer of messages from terminals on the telex network to Group 3 facsimile terminals connected to the public switched telephone network
F.89	08-1992	Status enquiry function in the international telex service
F.100	11-1988	Scheduled radiocommunication service
F.104	10-1991	International leased circuit services – Customer circuit designations
F.105	11-1988	Operational provisions for phototelegrams
F.106	11-1988	Operational provisions for private phototelegraph calls
F.107	11-1988	Rules for phototelegraph calls established over circuits normally used for telephone traffic
F.108	11-1988	Operating rules for international phototelegraph calls to multiple destinations
F.110	07-1996	Operational provisions for the maritime mobile service
F.111	03-1991	Principles of service for mobile systems
F.112	11-1988	Quality objectives for 50-baud start-stop telegraph transmission in the maritime mobile-satellite service
F.113	08-1992	Service provisions for aeronautical passenger communications supported by mobile-satellite systems

F.115	02-1995	Service objectives and principles for future public land mobile telecommunication systems
F.116	03-2000	Service features and operational provisions in IMT-2000
E.210	11-1988	Ship station identification for VHF/UHF and maritime mobile-satellite services
F.122	11-1988	Operational procedures for the maritime satellite data transmission service
F.127	10-1996	Operational procedures for interworking between the international telex service and the service offered by the INMARSAT-C system
F.130	11-1988	Maritime answer-back codes
F.131	11-1988	Radiotelex service codes
F.140	03-1993	Point-to-multipoint telecommunication service via satellite
F.141	06-1994	International two-way multipoint telecommunication service via satellite
F.150	10-1991	Service and operational provisions for the Intex service
F.162	07-1996	Service and operational requirements of store-and-forward facsimile service
F.163	07-1996	Operational requirements of the interconnection of facsimile store-and-forward units
F.170	03-1998	Operational provisions for the international public facsimile service between public bureaux (Bureaufax)
F.171	11-1988	Operational provisions relating to the use of store-and-forward switching nodes within the bureaufax service
F.182bis	10-1996	Guidelines for the support of the communication of documents using Group 3 facsimile between user terminals via public networks
F.185	06-1998	Internet facsimile: Guidelines for the support of the communication of facsimile documents
F.190	08-1992	Operational provisions for the international facsimile service between public bureaux and subscriber stations and vice versa (bureaufax-telefax and vice versa)
F.350	11-1988	Application of Series T Recommendations
F.351	11-1988	General principles on the presentation of terminal identification to users of the telematic services
F.353	11-1988	Provision of telematic and data transmission services on integrated services digital network (ISDN)
F.400/X.400	06-1999	Message handling system and service overview
F.401	08-1992	Message handling services: Naming and addressing for public message handling services
F.410	08-1992	Message handling services: The public message transfer service
F.415	11-1988	Message handling services: Intercommunication with public physical delivery services
F.420	08-1992	Message handling services: The public interpersonal messaging service

F.421	11-1988	Message handling services: Intercommunication between the IPM service and the telex service	
F.421 Errata	12-1999		
F.423	08-1992	Message handling services: Intercommunication between the interpersonal messaging service and the telefax service	
F.435	06-1999	Message handling services: Electronic Data Interchange messaging service	
F.440	08-1992	Message handling services: The voice messaging service	
F.471	08-1997	Operational requirements for the interconnection of voice-mail store-and-forward units	
F.471 (1997) Corrigendum 1	09-1998		
F.472	08-1997	Service and operational requirements of the voice-mail store-and-forward service	
F.500	08-1992	International public directory services	
F.510	02-2003	Automated directory assistance – White pages service definition	
F.515	04-2003	Unified Directory specification	
F.581	03-1993	Guidelines for programming communication interfaces (PCIs) definition: Service Recommendation	
F.600	04-2004	Service and operational principles for public data transmission service	
F.700	11-2000	Framework Recommendation for multimedia services	
F.701	11-2000	Guideline Recommendation for identifying multimedia service requirements	
F.702	07-1996	Multimedia conference services	
F.703	11-2000	Multimedia conversational services	
F.720	08-1992	Videotelephony services – General	
F.721	08-1992	Videotelephony teleservice for ISDN	
F.723	07-1996	Videophone service in the Public Switched Telephone Network (PSTN)	
F.731	07-1997	Multimedia Conference Services in the ISDN	
F.732	10-1996	Multimedia conference services in the B-ISDN	
F.740	08-1993	Audiovisual interactive services	
F.750	02-2005	Metadata framework	Pre-published.
F.761	11-1988	Service-oriented requirements for telewriting applications	
F.811	07-1996	Broadband connection-oriented bearer service	
F.812	08-1992	Broadband connectionless data bearer service	
F.813	02-1995	Virtual path service for reserved and permanent communications	

F.850	03-1993	Principles of Universal Personal Telecommunication (UPT)
F.851	02-1995	Universal Personal Telecommunication (UPT) – Service description (service set 1)
F.852	03-2000	Universal Personal Telecommunication (UPT) – Service description (service set 2)
F.853	11-1998	Supplementary services in the Universal Personal Telecommunication (UPT) environment
F.901	03-1993	Usability evaluation of telecommunication services
F.902	02-1995	Interactive services design guidelines
F.910	02-1995	Procedures for designing, evaluating and selecting symbols, pictograms and icons
F.Sup1	11-1988	Definitions relating to telegraph, telematic and data transmission services
F.Sup2	11-1988	Terms and definitions for telex

Recommendation count: 112

Number	Approval Date	Recommendation Title	Status
		Transmission systems and media, digital systems and networks	
G.100	02-2001	Definitions used in Recommendations on general characteristics of international telephone connections and circuits	
G.100.1	11-2001	The use of the decibel and of relative levels in speechband telecommunications	
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Recommendation count: 505

Number	*Approval Date*	*Recommendation Title*	*Status*
		Audiovisual and multimedia systems	
H.100	11-1988	Visual telephone systems	
H.110	11-1988	Hypothetical reference connections for videoconferencing using primary digital group transmission	
H.120	03-1993	Codecs for videoconferencing using primary digital group transmission	
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H.222.0 (2000) Amendment 5	01-2005	New audio profile and level signalling and change to audio_type table entry	Pre-published.
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H.223	07-2001	Multiplexing protocol for low bit rate multimedia communication	

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H.235	08-2003	Security and encryption for H-series (H.323 and other H.245-based) multimedia terminals	
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H.239	07-2003	Role management and additional media channels for H.300-series terminals	
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H.248.26	01-2005	Gateway control protocol: Enhanced analog lines packages	Not available, contact sales@itu.int.
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H.248.28	03-2004	Gateway control protocol: International CAS packages	
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H.264	03-2005	Advanced video coding for generic audiovisual services	Pre-published.
H.264.1	03-2005	Conformance specification for H.264 advanced video coding	Pre-published.
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H.324	03-2002	Terminal for low bit-rate multimedia communication	
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H.450.6	05-1999	Call waiting supplementary service for H.323	
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H.460.7	11-2002	Digit maps within H.323 systems	
H.460.8	11-2002	Querying for alternate routes within H.323 systems	
H.460.9	11-2002	Support for online QoS-monitoring reporting within H.323 systems	
H.460.9 (2002) Amendment 1	03-2004	New Annex B – Extended performance metrics	

H.460.10	03-2004	Call party category within H.323 systems	
H.460.11	03-2004	Delayed call establishment within H.323 systems	
H.460.12	03-2004	Glare control indicator within H.323 systems	
H.460.13	03-2004	Called user release control within H.323 systems	
H.460.14	03-2004	Support for Multi-Level Precedence and Preemption (MLPP) within H.323 systems	
H.460.15	03-2004	Call signalling transport channel suspension and redirection within H.323 systems	
H.460.16	01-2005	Multiple message release sequence capability	Pre-published.
H.501	03-2002	Protocol for mobility management and intra/inter-domain communication in multimedia systems	
H.510	03-2002	Mobility for H.323 multimedia systems and services	
H.530	03-2002	Symmetric security procedures for H.323 mobility in H.510	
H.530 Corrigendum 1	07-2003		
H.610	07-2003	Full service VDSL – System architecture and customer premises equipment	
H.611	07-2003	Full-Service VDSL – Operations, Administration Maintenance & Provision aspects	
H.Sup1	05-1999	Application profile – Sign language and lip-reading real-time conversation using low bit rate video communication	
H.Sup3	05-2003	Operator requirements for full-service VDSL in ITU-T Recommendations H.610 and H.611	

Recommendation count: 165

Series I : Integrated services digital network

Number	*Approval Date*	*Recommendation Title*	*Status*
		Integrated services digital network	
I.112	03-1993	Vocabulary of terms for ISDNs	
I.112 Appendix I	02-2002	General telecommunication terminology and definitions	
I.113	06-1997	Vocabulary of terms for broadband aspects of ISDN	
I.114	03-1993	Vocabulary of terms for universal personal telecommunication	
I.120	03-1993	Integrated services digital networks (ISDNs)	
I.121	04-1991	Broadband aspects of ISDN	
I.122	03-1993	Framework for frame mode bearer services	
I.130	11-1988	Method for the characterization of telecommunication services supported by an ISDN and network capabilities of an ISDN	
I.140	03-1993	Attribute technique for the characterization of telecommunication services supported by an ISDN and network capabilities of an ISDN	
I.141	11-1988	ISDN network charging capabilities attributes	
I.150	02-1999	B-ISDN asynchronous transfer mode functional characteristics	
I.200	11-1988	Guidance to the I.200-series of Recommendations	
I.210	03-1993	Principles of telecommunication services supported by an ISDN and the means to describe them	
I.211	03-1993	B-ISDN service aspects	
I.220	11-1988	Common dynamic description of basic telecommunication services	
I.221	03-1993	Common specific characteristics of services	
I.230	11-1988	Definition of bearer service categories	
		Circuit-mode bearer service categories	
I.231.1	11-1988	Circuit-mode 64 kbit/s unrestricted, 8 kHz structured bearer service	
I.231.2	11-1988	Circuit-mode 64 kbit/s, 8 kHz structured bearer service usable for speech information transfer	
I.231.3	11-1988	Circuit-mode 64 kbit/s, 8 kHz structured bearer service usable for 3.1 kHz audio information transfer	
I.231.4	11-1988	Circuit-mode, alternate speech / 64 kbit/s unrestricted, 8 kHz structured bearer service	
I.231.5	11-1988	Circuit-mode 2 x 64 kbit/s unrestricted, 8 kHz structured bearer service	
I.231.6	07-1996	Circuit-mode 384 kbit/s unrestricted, 8 kHz structured bearer service	
I.231.7	07-1996	Circuit-mode 1536 kbit/s unrestricted, 8 kHz structured bearer service	

I.231.8	07-1996	Circuit-mode 1920 kbit/s unrestricted, 8 kHz structured bearer service	
I.231.9	03-1993	Circuit-mode 64 kbit/s 8 kHz structured multi-use bearer service	
I.231.10	08-1992	Circuit-mode multiple-rate unrestricted 8 kHz structured bearer service	
		Packet-mode bearer services categories	
I.232.1	11-1988	Virtual call and permanent virtual circuit bearer service category	
I.232.2	11-1988	Connectionless bearer service category	Not available, contact sales@itu.int.
I.232.3	03-1993	User signalling bearer service category (USBS)	
		Frame mode bearer services	
I.233.1	10-1991	ISDN frame relaying bearer service	
I.233.1 Annex F	07-1996	Frame relay multicast	
I.233.2	10-1991	ISDN frame switching bearer service	
I.240	11-1988	Definition of teleservices	
		Teleservices supported by an ISDN	
I.241.1	11-1988	Telephony	
I.241.2	11-1988	Teletex	
I.241.3	11-1988	Telefax 4	
I.241.4	11-1988	Mixed mode	
I.241.5	11-1988	Videotex	
I.241.6	11-1988	Telex	
I.241.7	03-1993	Telephony 7 kHz teleservice	
I.241.8	10-1995	Teleaction stage one service description	
I.250	11-1988	Definition of supplementary services	
		Number identification supplementary services	
I.251.1	08-1992	Direct-dialling-In	Available only in PDF.
I.251.2	08-1992	Multiple Subscriber Number	
I.251.3	08-1992	Calling Line Identification Presentation	
I.251.4	08-1992	Calling Line Identification Restriction	
I.251.5	02-1995	Connected Line Identification Presentation (COLP)	
I.251.6	02-1995	Connected Line Identification Restriction (COLR)	

I.251.7	08-1992	Malicious call Identification	
I.251.8	08-1992	Sub-addressing supplementary service	
I.251.9	07-1996	Calling name identification presentation	
I.251.10	07-1996	Calling name identification restriction	
		Call offering supplementary services	
I.252.1	11-1988	Call Transfer	
I.252.2	08-1992	Call Forwarding Busy	
I.252.3	08-1992	Call Forwarding No Reply	
I.252.4	08-1992	Call Forwarding Unconditional	
I.252.5	08-1992	Call Deflection	
I.252.6	11-1988	Line Hunting (LH)	
I.252.7	05-1997	Explicit call transfer	
		Call completion supplementary services	
I.253.1	11-1988	Call waiting (CW) supplementary service	
I.253.2	08-1992	Call Hold	
I.253.3	07-1996	Completion of calls to busy subscribers	
I.253.4	07-1996	Completion of calls on no reply	
		Multiparty supplementary services	
I.254.1	11-1988	Conference calling (CONF)	
I.254.2	08-1992	Three-Party Supplementary Service	
I.254.5	05-1997	Meet-me conference	
		Community of interest supplementary services	
I.255.1	08-1992	Closed User Group	
I.255.2	07-1996	Support of Private Numbering Plans	
I.255.3	07-1990	Multi-level precedence and preemption service (MLPP)	
I.255.4	07-1990	Priority service	
I.255.5	08-1992	Outgoing call barring	
		Charging supplementary services	
I.256.1	11-1988	Credit card calling (CRED)	Not available, contact sales@itu.int.

I.256.2a	03-1993	Advice of charge: charging information at call set-up time (AOC-S)	
I.256.2b	03-1993	Advice of charge: charging information during the call (AOC-D)	
I.256.2c	03-1993	Advice of charge: charging information at the end of the call (AOC-E)	
I.256.3	08-1992	Reverse charging	
		Additional information transfer supplementary services	
I.257.1	10-1995	User-to-User Signalling (UUS)	
		Mobility and modification supplementary services	
I.258.1	10-1995	Terminal portability (TP)	
I.258.2	02-1995	In-call modification (IM)	
		Screening supplementary services	
I.259.1	07-1996	Address screening (ADS)	
I.310	03-1993	ISDN – Network functional principles	
I.311	08-1996	B-ISDN general network aspects	
I.311 (1996) Amendment 1	03-2000		
I.312/Q.1201	10-1992	Principles of intelligent network architecture	
I.313	09-1997	B-ISDN network requirements	
I.320	11-1993	ISDN protocol reference model	
I.321	04-1991	B-ISDN protocol reference model and its application	
I.322	02-1999	Generic protocol reference model for telecommunication networks	
I.324	10-1991	ISDN network architecture	
I.325	03-1993	Reference configurations for ISDN connection types	
I.326	03-2003	Functional architecture of transport networks based on ATM	
I.327	03-1993	B-ISDN functional architecture	
I.328/Q.1202	09-1997	Intelligent network – Service plane architecture	
I.329/Q.1203	09-1997	Intelligent network – Global functional plane architecture	
I.330	11-1988	ISDN numbering and addressing principles	
E.164	02-2005	The international public telecommunication numbering plan	Pre-published.
E.164 Supplement 1	03-1998	Alternatives for carrier selection and network identification	
E.164 Supplement 2	11-1998	Number Portability	

E.164 Supplement 3	05-2004	Operational and administrative issues associated with national implementations of the ENUM functions
E.164 Supplement 4	05-2004	Operational and administrative issues associated with the implementation of ENUM for non-geographic country codes
I.333	03-1993	Terminal selection in ISDN
I.334	11-1988	Principles relating ISDN numbers/sub-addresses to the OSI reference model network layer addresses
I.340	11-1988	ISDN connection types
I.350	03-1993	General aspects of quality of service and network performance in digital networks, including ISDNs
G.820/I.351/Y.1501	07-2004	Relationships among ISDN, IP-based network and physical layer performance Recommendations
I.352	03-1993	Network performance objectives for connection processing delays in an ISDN
I.353	08-1996	Reference events for defining ISDN and B-ISDN performance parameters
I.354	03-1993	Network performance objectives for packet-mode communication in an ISDN
I.355	10-2000	ISDN 64 kbit/s connection type availability performance
I.356	03-2000	B-ISDN ATM layer cell transfer performance
I.356 (2000) Amendment 1	02-2004	New Appendix V – Support of Y.1541 QoS classes 0 and 2 in ATM-based networks
I.357	11-2000	B-ISDN semi-permanent connection availability
I.358	09-2003	Call processing performance for switched virtual channel connections (VCCs) in a B-ISDN
I.359	02-1999	Accuracy and dependability of ISDN 64 kbit/s circuit-mode connection types
I.361	02-1999	B-ISDN ATM layer specification
		B-ISDN ATM Adaptation Layer specification
I.363.1	08-1996	Type 1 AAL
I.363.2	11-2000	Type 2 AAL
I.363.3	08-1996	Type 3/4 AAL
I.363.5	08-1996	Type 5 AAL
I.364	02-1999	Support of the broadband connectionless data bearer service by the B-ISDN
		B-ISDN ATM adaptation layer sublayers
I.365.1	11-1993	Frame relaying service specific convergence sublayer (FR-SSCS)
I.365.2	11-1995	Service-specific coordination function to provide the connection-oriented network service

I.365.3	11-1995	Service-specific coordination function to provide the connection-oriented transport service	
I.365.4	08-1996	Service-specific convergence sublayer for HDLC applications	
I.366.1	06-1998	Segmentation and Reassembly Service Specific Convergence Sublayer for the AAL type 2	
I.366.2	11-2000	AAL type 2 service specific convergence sublayer for narrow-band services	
I.366.2 (2000) Corrigendum 1	03-2002		
I.370	10-1991	Congestion management for the ISDN frame relaying bearer service	
I.371	03-2004	Traffic control and congestion control in B-ISDN	Pre-published.
I.372	03-1993	Frame relaying bearer service network-to-network interface requirements	
I.373	03-1993	Network capabilities to support universal personal telecommunication (UPT)	
		Network capabilities to support multimedia services	
I.375.1	06-1998	General aspects	
I.375.2	06-1998	Example of multimedia retrieval service class – Video-on-demand service using an ATM-based network	
I.375.3	03-2000	Example of multimedia distribution service class – Switched digital broadcasting	
I.376	03-1995	ISDN network capabilities for the support of the teleaction service	
I.377	10-2000	Network requirements to support charging and accounting in B-ISDN	
I.378	12-2002	Traffic control and congestion control at the ATM Adaptation Layer type 2	
I.378 (2002) Amendment 1	08-2003	New Appendix IV: Deriving AAL 2 traffic parameters from AAL 2 link characteristics	
I.381	03-2001	ATM adaptation layer (AAL) Performance	
I.410	11-1988	General aspects and principles relating to Recommendations on ISDN user-network interfaces	
I.411	03-1993	ISDN user-network interfaces – Reference configurations	
I.412	11-1988	ISDN user-network interfaces – Interface structures and access capabilities	
I.413	03-1993	B-ISDN user-network interface	
I.414	09-1997	Overview of Recommendations on layer 1 for ISDN and B-ISDN customer accesses	
I.420	11-1988	Basic user-network interface	
I.421	11-1988	Primary rate user-network interface	
I.430	11-1995	Basic user-network interface – Layer 1 specification	
I.431	03-1993	Primary rate user-network interface – Layer 1 specification	

I.431 (1993) Amendment 1	06-1997	
		B-ISDN user-network interface – Physical layer specification
I.432.1	02-1999	General characteristics
I.432.2	02-1999	155 520 kbit/s and 622 080 kbit/s operation
I.432.3	02-1999	1544 kbit/s and 2048 kbit/s operation
I.432.4	02-1999	51 840 kbit/s operation
I.432.5	06-1997	25 600 kbit/s operation
Q.920	03-1993	ISDN user-network interface data link layer – General aspects
Q.920 (1993) Amendment 1	06-2000	
Q.921	09-1997	ISDN user-network interface – Data link layer specification
Q.921 (1997) Amendment 1	06-2000	
Q.930	03-1993	ISDN user-network interface layer 3 – General aspects
Q.931	05-1998	ISDN user-network interface layer 3 specification for basic call control
Q.931 (1998) Amendment 1	12-2002	Extensions for the support of digital multiplexing equipment
Q.931 (1998) Erratum 1	02-2003	
I.460	02-1999	Multiplexing, rate adaption and support of existing interfaces
X.30	03-1993	Support of X.21, X.21 bis and X.20 bis based Data Terminal Equipments (DTEs) by an Integrated Services Digital Network (ISDN)
X.31	11-1995	Support of packet mode terminal equipment by an ISDN
V.110	02-2000	Support by an ISDN of data terminal equipments with V-series type interfaces
I.464	02-1999	Multiplexing, rate adaption and support of existing interfaces for restricted 64 kbit/s transfer capability
V.120	10-1996	Support by an ISDN of data terminal equipment with V-series type interfaces with provision for statistical multiplexing
V.120 (1996) Corrigendum 1	05-1999	
I.470	11-1988	Relationship of terminal functions to ISDN
I.480	03-2000	1+1 protection switching for cell-based physical layer
I.500	03-1993	General structure of the ISDN interworking Recommendations
I.501	03-1993	Service interworking
I.510	03-1993	Definitions and general principles for ISDN interworking

I.511	11-1988	ISDN-to-ISDN layer 1 internetwork interface
I.515	03-1993	Parameter exchange for ISDN interworking
I.520	03-1993	General arrangements for network interworking between ISDNs
I.525	08-1996	Interworking between networks operating at bit rates less than 64 kbit/s with 64 kbit/s-based ISDN and B-ISDN
I.530	03-1993	Network interworking between an ISDN and a public switched telephone network (PSTN)
X.321	10-1996	General arrangements for interworking between Circuit-Switched Public Data Networks (CSPDNs) and Integrated Services Digital Networks (ISDNs) for the provision of data transmission services
X.325	10-1996	General arrangements for interworking between Packet-Switched Public Data Networks (PSPDNs) and Integrated Services Digital Networks (ISDNs) for the provision of data transmission services
I.555	09-1997	Frame Relaying Bearer Service interworking
U.202	03-1993	Technical requirements to be met in providing the international telex service within an integrated services digital network
I.570	03-1993	Public/private ISDN interworking
I.571	08-1996	Connection of VSAT based private networks to the public ISDN
I.572	03-2000	VSAT interconnection with the PSTN
I.580	11-1995	General arrangements for interworking between B-ISDN and 64 kbit/s based ISDN
I.581	09-1997	General arrangements for B-ISDN interworking
I.601	11-1988	General maintenance principles of ISDN subscriber access and subscriber installation
I.610	02-1999	B-ISDN operation and maintenance principles and functions
I.610 (1999) Corrigendum 1	03-2000	
I.610 (1999) Amendment 1	03-2000	
I.630	02-1999	ATM protection switching
I.630 (1999) Corrigendum 1	03-2000	
I.630 (1999) Amendment 1	03-2000	
I.731	10-2000	Types and general characteristics of ATM equipment
I.732	10-2000	Functional characteristics of ATM equipment
I.741	07-1999	Interworking and interconnection between ATM and switched telephone networks for the transmission of speech, voiceband data and audio signals
I.751	03-1996	Asynchronous transfer mode management of the network element view

I.761	03-2000	Inverse multiplexing for ATM (IMA)
I.762	03-2000	ATM over fractional physical links
I.Sup1	03-1998	Generic service descriptions for ten supplementary services defined in I.250-Series Recommendations

Recommendation count: 220

Number	Approval Date	Recommendation Title	Status
		Cable networks and transmission of television, sound programme and other multimedia signals	
J.2	09-1999	Guidelines on the use of some ITU-T Recommendations in the J series	
J.11	11-1988	Hypothetical reference circuits for sound-programme transmissions	
J.12	11-1988	Types of sound-programme circuits established over the international telephone network	
J.13	11-1988	Definitions for international sound-programme circuits	
J.14	11-1988	Relative levels and impedances on an international sound-programme connection	
J.15	11-1988	Lining-up and monitoring an international sound-programme connection	
J.16	11-1988	Measurement of weighted noise in sound-programme circuits	
J.17	11-1988	Pre-emphasis used on sound-programme circuits	
J.18	11-1988	Crosstalk in sound-programme circuits set up on carrier systems	
J.19	11-1988	A conventional test signal simulating sound-programme signals for measuring interference in other channels	
J.21	08-1994	Performance characteristics of 15 kHz-type sound-programme circuits – Circuits for high quality monophonic and stereophonic transmissions	
J.23	11-1988	Performance characteristics of 7 kHz type (narrow bandwidth) sound-programme circuits	
J.24	02-1982	Modulation of signals carried by sound-programme circuits by interfering signals from power supply sources	
J.25	05-1986	Estimation of transmission performance of sound-programme circuits shorter or longer than the hypothetical reference circuit	
J.26	06-1990	Test signals to be used on international sound-programme connections	
J.27	06-1990	Signals for the alignment of international sound-programme connections	
J.41	11-1988	Characteristics of equipment for the coding of analogue high quality sound programme signals for transmission on 384 kbit/s channels	
J.42	11-1988	Characteristics of equipment for the coding of analogue medium quality sound-programme signals for transmission on 384-kbit/s channels	
J.51	08-1994	General principles and user requirements for the digital transmission of high quality sound programmes	
J.52	07-1996	Digital transmission of high-quality sound-programme signals using one, two or three 64 kbit/s channels per mono signal (and up to six per stereo signal)	
J.52 (1996) Amendment 1	09-1999	New Appendix II – Extracts from EBU specification of an ISDN Codec capable of delivering high-quality audio	

J.53	05-2000	Sampling frequencies to be used for the digital transmission of studio-quality and high-quality sound-programme signals	
J.54	05-1986	Transmission of analogue high-quality sound-programme signals on mixed analogue-and-digital circuits using 384 kbit/s channels	
J.55	06-1990	Digital transmission of high-quality sound-programme signals on distribution circuits using 480 kbit/s (496 kbit/s) per audio channel	
J.57	06-1990	Transmission of digital studio quality sound signals over H1 channels	
J.61	06-1990	Transmission performance of television circuits designed for use in international connections	Available only in PDF.
J.62	02-1978	Single value of the signal-to-noise ratio for all television systems	
J.63	06-1990	Insertion of test signals in the field-blanking interval of monochrome and colour television signals	
J.64	02-1986	Definitions of parameters for simplified automatic measurement of television insertion test signals	
J.65	02-1978	Standard test signal for conventional loading of a television channel	
J.66	02-1978	Transmission of one sound programme associated with analogue television signal by means of time division multiplex in the line synchronizing pulse	
J.67	03-2001	Test signals and measurement techniques for transmission circuits carrying MAC/packet signals	
J.68	02-1982	Hypothetical reference chain for television transmissions over very long distances	
J.80	09-1993	Transmission of component-coded digital television signals for contribution-quality applications at bit rates near 140 Mbit/s	
J.81	09-1993	Transmission of component-coded digital television signals for contribution-quality applications at the third hierarchical level of ITU-T Recommendation G.702	
J.81 (1993) Amendment 1	10-1995	Appendix II to Annex A to Recommendation J.81 – Guidelines for implementation of a complete television codec	
J.81 (1993) Corrigendum 1	10-1996		
J.81 (1993) Amendment 2	03-1998	Appendix IV to Annex A – Results of 34 Mbit/s codec interworking tests (February 1996)	
J.82	07-1996	Transport of MPEG-2 constant bit rate television signals in B-ISDN	
J.83	04-1997	Digital multi-programme systems for television, sound and data services for cable distribution	
J.83 (1997) Erratum 1	07-1998		
J.84	03-2001	Distribution of digital multi-programme signals for television, sound and data services through SMATV networks	
J.85	06-1990	Digital television transmission over long distances – General principles	
J.86	06-1990	Mixed analogue-and-digital transmission of analogue composite television signals over long distances	
J.87	03-2001	Use of hybrid cable television links for the secondary distribution of television into the user's premises	

J.88	09-1999	Transmission of enhanced definition television signals over digital links	
J.89	09-1999	Transport Mechanism for component-coded digital television signals using MPEG-2 4:2:2 P@ML including all service elements for contribution and primary distribution	
J.90	05-2000	Electronic programme guides for delivery by digital cable television and similar methods – Reference operating scenario and requirements	
J.91	08-1994	Technical methods for ensuring privacy in long-distance international television transmission	
J.92	04-1997	Recommended operating guidelines for point-to-point transmission of television programmes	
J.93	03-1998	Requirements for conditional access in the secondary distribution of digital television on cable television systems	
J.94	11-1998	Service information for digital broadcasting in cable television systems	
J.94 (1998) Amendment 1	10-2000	Annex B – Service information delivered out of band for digital cable television systems	
J.94 (1998) Amendment 2	03-2001	Revised Annex C – Service information for digital multi-programme System C	
J.95	09-1999	Copy protection of intellectual property for content delivered on cable television systems	
J.96	07-2002	Technical method for ensuring privacy in long-distance international MPEG-2 television transmission conforming to ITU-T Recommendation J.89	
J.97	07-2002	Metadata on cable networks	
J.98	05-2003	Metadata requirements for video-on-demand in cable networks	
J.100	06-1990	Tolerances for transmission time differences between the vision and sound components of a television signal	
J.101	06-1990	Measurement methods and test procedures for teletext signals	
J.110	04-1997	Basic principles for a worldwide common family of systems for the provision of interactive television services	
J.111	03-1998	Network independent protocols for interactive systems	
J.112	03-1998	Transmission systems for interactive cable television services	
J.112 Annex A	03-2001	Digital Video Broadcasting: DVB interaction channel for Cable TV (CATV) distribution systems	
J.112 Annex B	03-2004	Data-over-cable service interface specifications: Radio-frequency interface specification	Pre-published.
J.112 Annex C	02-2002	Data-over-cable service interface specifications: Radio-frequency interface specification using QAM technique	
J.113	03-1998	Digital video broadcasting interaction channel through the PSTN/ISDN	
J.114	09-1999	Interaction channel using digital enhanced cordless telecommunications	
J.115	09-1999	Interaction channel using the global system for mobile communications	
J.116	05-2000	Interaction channel for local multipoint distribution systems	

J.117	09-1999	Home digital network interface specification	
J.118	05-2000	Access systems for interactive services on SMATV/MATV networks	
J.120	05-2000	Distribution of sound and television programs over the IP network	Available only in MS Word.
J.121	02-2002	Quality control protocol for webcasting	
J.122	12-2002	Second-generation transmission systems for interactive cable television services – IP cable modems	
J.123	07-2002	Multiplexing format for webcasting on the TCP/IP network	
J.124	03-2004	Multiplexing format for multimedia webcasting over TCP/IP networks	
J.125	04-2004	Link privacy for cable modem implementations	
J.126	04-2004	Embedded Cable Modem device specification	
J.127	06-2004	Transmission protocol for multimedia webcasting over TCP/IP networks	
J.131	03-1998	Transport of MPEG-2 signals in PDH networks	
J.132	03-1998	Transport of MPEG-2 signals in SDH networks	
J.133	07-2002	Measurement of MPEG-2 transport streams in networks	
J.140	03-1998	Subjective picture quality assessment for digital cable television systems	
J.141	09-1999	Performance indicators for data services delivered over digital cable television systems	
J.142	05-2000	Methods for the measurement of parameters in the transmission of digital cable television signals	
J.143	05-2000	User requirements for objective perceptual video quality measurements in digital cable television	
J.144	03-2004	Objective perceptual video quality measurement techniques for digital cable television in the presence of a full reference	Pre-published.
J.145	03-2001	Measurement and control of the quality of service for sound transmission over contribution and distribution networks	
J.146	07-2002	Loop latency issues in contribution circuits for conversational TV programmes	
J.147	07-2002	Objective picture quality measurement method by use of in-service test signals	
J.148	05-2003	Requirements for an objective perceptual multimedia quality model	
J.149	03-2004	Method for specifying accuracy and cross-calibration of Video Quality Metrics (VQM)	Pre-published.
J.150	03-1998	Operational functionalities for the delivery of digital multiprogramme television, sound and data services through multichannel, multipoint distribution systems (MMDS)	
J.150 (1998) Amendment 1	09-1999	Additions to Recommendation J.150 to also encompass local multipoint distribution systems (LMDS)	
J.150 (1998) Amendment 2	03-2001		

J.151	10-2000	RF remodulator interface for digital television	
J.160	02-2002	Architectural framework for the delivery of time-critical services over cable television networks using cable modems	
J.161	03-2001	Audio codec requirements for the provision of bidirectional audio service over cable television networks using cable modems	
J.162	03-2004	Network call signalling protocol for the delivery of time-critical services over cable television networks using cable modems	
J.163	03-2004	Dynamic quality of service for the provision of real-time services over cable television networks using cable modems	
J.164	03-2001	Event message requirements for the support of real-time services over cable television networks using cable modems	
J.165	05-2003	IPCablecom Internet signalling transport protocol (ISTP)	
J.166	03-2001	IPCablecom Management Information Base (MIB) framework	
J.167	03-2001	Media terminal adapter (MTA) device provisioning requirements for the delivery of real-time services over cable television networks using cable modems	
J.168	03-2001	IPCablecom Media Terminal Adapter (MTA) MIB requirements	
J.169	03-2001	IPCablecom network call signalling (NCS) MIB requirements	
J.170	02-2002	IPCablecom security specification	Pre-published.
J.171	02-2002	IPCablecom Trunking Gateway Control Protocol (TGCP)	
J.171 (2002) Amendment 1	05-2003	TGCP Profile 2	
J.172	02-2002	IPCablecom management event mechanism	
J.173	02-2002	IPCablecom embedded MTA primary line support	
J.174	02-2002	IPCablecom interdomain quality of service	
J.175	07-2002	Audio server protocol	
J.176	07-2002	IPCablecom management event mechanism MIB	
J.177	05-2003	IPCablecom CMS subscriber provisioning specification	
J.178	05-2003	IPCablecom CMS to CMS signalling	Pre-published.
J.179	04-2004	IPCablecom support for multimedia	
J.180	05-2000	User requirements for statistical multiplexing of several programmes on a transmission channel	
J.181	06-2004	Digital program insertion cueing message for cable television systems	
J.182	03-2001	Parameter sets for analogue interface specifications for the interconnection of set-top boxes and presentation devices in the home	
J.183	03-2001	Time-division multiplexing of multiple MPEG-2 transport streams over cable television systems	
J.184	03-2001	Digital broadband delivery system: Out-of-band transport	

J.185	02-2002	Transmission equipment for transferring multi-channel television signals over optical access networks by FM conversion	
J.186	02-2002	Transmission equipment for multi-channel television signals over optical access networks by sub-carrier multiplexing (SCM)	
J.187	07-2002	Transport mechanism for component-coded digital high-definition television signals using MPEG-2 video coding including all service elements for contribution and primary distribution	
J.187 (2002) Corrigendum 1	04-2003		
J.188	07-2002	A framework for an efficient parallel video transmission system including codecs with functions of failure detection and picture quality evaluation	
J.189	07-2002	Seamless splicing for MPEG-2 bit streams	
J.189 (2002) Corrigendum 1	04-2003		
J.190	07-2002	Architecture of MediaHomeNet that supports cable-based services	
J.191	03-2004	IP feature package to enhance cable modems	
J.192	03-2004	A residential gateway to support the delivery of cable data services	Pre-published.
J.193	06-2004	Requirements for the next generation of set-top-boxes	
J.200	03-2001	Worldwide common core – Application environment for digital interactive television services	
J.200 (2001) Corrigendum 1	05-2004		
J.201	07-2004	Harmonization of declarative content format for interactive television applications	
J.201 (2004) Amendment 1	03-2005	Additionnal media types	Pre-published.
J.202	05-2003	Harmonization of procedural content formats for interactive TV applications	
J.240	06-2004	Framework for remote monitoring of transmitted picture signal-to-noise ratio using spread-spectrum and orthogonal transform	
J.241	04-2005	Quality of service ranking and measurement methods for digital video services delivered over broadband IP networks	Pre-published.
J.260	01-2005	Requirements for preferential telecommunications over IPCablecom networks	
J.280	03-2004	Digital Program Insertion: Splicing application programming interface	Not available, contact sales@itu.int.
J.281	03-2005	Requirements for multichannel video signal transmission over IP-based fibre network	Pre-published.
J.600	06-2004	Transport of Large Screen Digital Imagery (LSDI) applications that employ MPEG-2 encoded HDTV signals	
J.Sup1	11-1998	Example of linking options between annexes of ITU-T Recommendation J.112 and annexes of ITU-T Recommendation J.83	

J.Sup2	11-1998	Guidelines for the implementation of annex A of Recommendation J.112, "Transmission systems for interactive cable television services" – Example of digital video broadcasting (DVB) interaction channel for cable television distribution
J.Sup3	11-1998	Guidelines for the implementation of Recommendation J.111 "Network independent protocols" – Example of digital video broadcasting (DVB) systems for interactive services
J.Sup5	09-1999	Guidelines on the use of some ITU-T Recommendations in the J series

Recommendation count: 149

Series K : Protection against interference

Number	*Approval Date*	*Recommendation Title*	*Status*
		Protection against interference	
K.5	11-1988	Joint use of poles for electricity distribution and for telecommunications	
K.6	11-1988	Precautions at crossings	
K.7	11-1988	Protection against acoustic shock	
K.8	11-1988	Separation in the soil between telecommunication cables and earthing system of power facilities	
K.9	11-1988	Protection of telecommunication staff and plant against a large earth potential due to a neighbouring electric traction line	
K.10	10-1996	Low frequency interference due to unbalance about earth of telecommunication equipment	
K.11	10-1993	Principles of protection against overvoltages and overcurrents	
K.12	02-2000	Characteristics of gas discharge tubes for the protection of telecommunications installations	
K.13	11-1988	Induced voltages in cables with plastic-insulated conductors	
K.14	11-1988	Provision of a metallic screen in plastic-sheathed cables	
K.18	11-1988	Calculation of voltage induced into telecommunication lines from radio station broadcasts and methods of reducing interference	
K.19	11-1988	Joint use of trenches and tunnels for telecommunication and power cables	
K.20	07-2003	Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents	
K.20 (2003) Erratum 1	01-2004	Correction to table 7/K.20	
K.20 (2003) Amendment 1	11-2004	New Appendix I – Floating transverse power induction and earth potential rise test for ports connected to external symmetric pair cables	
K.21	07-2003	Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents	
K.21 (2003) Erratum 1	01-2004	Correction to table 7/K.21	
K.23	11-1988	Types of induced noise and description of noise voltage parameters for ISDN basic user networks	
K.24	11-1988	Method for measuring radio-frequency induced noise on telecommunications pairs	
K.25	02-2000	Protection of optical fibre cables	
K.26	11-1988	Protection of telecommunication lines against harmful effects from electric power and electrified railway lines	
K.27	05-1996	Bonding configurations and earthing inside a telecommunication building	

K.28	03-1993	Characteristics of semi-conductor arrester assemblies for the protection of telecommunications installations
K.29	01-1992	Coordinated protection schemes for telecommunication cables below ground
K.30	12-2004	Self-restoring overcurrent protectors
K.31	03-1993	Bonding configurations and earthing of telecommunication installations inside a subscriber's building
K.33	10-1996	Limits for people safety related to coupling into telecommunications system from a.c. electric power and a.c. electrified railway installations in fault conditions
K.34	07-2003	Classification of electromagnetic environmental conditions for telecommunication equipment – Basic EMC Recommendation
K.35	05-1996	Bonding configurations and earthing at remote electronic sites
K.36	05-1996	Selection of protective devices
K.37	02-1999	Low and high frequency EMC mitigation techniques for telecommunication installations and systems – Basic EMC Recommendation
K.38	10-1996	Radiated emission test procedure for physically large systems
K.39	10-1996	Risk assessment of damages to telecommunication sites due to lightning discharges
K.40	10-1996	Protection against LEMP in telecommunications centres
K.42	05-1998	Preparation of emission and immunity requirements for telecommunication equipment – General principles
K.43	07-2003	Immunity requirements for telecommunication equipment
K.43 (2003) Amendment 1	11-2004	
K.44	07-2003	Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation
K.45	07-2003	Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents
K.46	07-2003	Protection of telecommunication lines using metallic symmetric conductors against lightning-induced surges
K.47	12-2000	Protection of telecommunication lines using metallic conductors against direct lightning discharges
K.48	07-2003	EMC requirements for each telecommunication equipment – Product family Recommendation
K.49	02-2000	Test condition and performance criteria for voice terminal subject to disturbance from digital mobile phone
K.50	02-2000	Safe limits of operating voltages and currents for telecommunication systems powered over the network
K.51	02-2000	Safety criteria for telecommunication equipment
K.52	12-2004	Guidance on complying with limits for human exposure to electromagnetic fields

K.53	02-2000	Values of induced voltages on telecommunication installations to establish telecom and a.c. power and railway operators responsibilities
K.54	12-2004	Conducted immunity test method and level at fundamental power frequencies
K.55	08-2002	Overvoltage and overcurrent requirements for insulation displacement connectors (IDC) terminations
K.56	07-2003	Protection of radio base stations against lightning discharges
K.57	09-2003	Protection measures for radio base stations sited on power line towers
K.58	07-2003	EMC, resistibility and safety requirements and procedures for co-located telecommunication installations
K.59	07-2003	EMC, resistibility and safety requirements and procedures for connection to unbundled cables
K.60	07-2003	Emission limits and test methods for telecommunication networks
K.61	09-2003	Guidance to measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations
K.62	02-2004	System level radiated emissions compliance using mathematical modelling
K.63	02-2004	Maintaining the suitability of production telecommunications equipment to its intended electromagnetic environment
K.64	02-2004	Safe working practices for outside equipment installed in particular environments
K.65	12-2004	Overvoltage and overcurrent requirements for termination modules with contacts for test ports or SPDs
K.66	12-2004	Protection of customer premises from overvoltages

Recommendation count: 60

Series L : Construction, installation and protection of cables and other elements of outside plant

Number	*Approval Date*	*Recommendation Title*	*Status*
		Construction, installation and protection of cables and other elements of outside plant	
L.1	11-1988	Construction, installation and protection of telecommunication cables in public networks	
L.2	11-1988	Impregnation of wooden poles	
L.3	11-1988	Armouring of cables	
L.4	11-1988	Aluminium cable sheaths	
L.5	11-1988	Cable sheaths made of metals other than lead or aluminium	
L.6	11-1988	Methods of keeping cables under gas pressure	
L.7	11-1988	Application of joint cathodic protection	
L.8	11-1988	Corrosion caused by alternating current	
L.9	11-1988	Methods of terminating metallic cable conductors	
L.10	12-2002	Optical fibre cables for duct and tunnel application	
L.11	11-1988	Joint use of tunnels by pipelines and telecommunication cables, and the standardization of underground duct plans	
L.12	05-2000	Optical fibre joints	
L.13	04-2003	Performance requirements for passive optical nodes: Sealed closures for outdoor environments	
L.14	07-1992	Measurement method to determine the tensile performance of optical fibre cables under load	
L.15	03-1993	Optical local distribution networks – Factors to be considered for their construction	
L.16	03-1993	Conductive plastic material (CPM) as protective covering for metal cable sheaths	
L.17	06-1995	Implementation of connecting customers into the public switched telephone network (PSTN) via optical fibres	
L.17 Appendix I	02-1997	Examples of possible applications	
L.18	10-1996	Sheath closures for terrestrial copper telecommunication cables	
L.19	11-2003	Multi-pair copper network cable supporting shared multiple services such as POTS, ISDN and xDSL	
L.20	10-1996	Creation of a fire security code for telecommunication facilities	
L.21	10-1996	Fire detection and alarm systems, detector and sounder devices	
L.22	10-1996	Fire protection	

L.23	10-1996	Fire extinction – Classification and location of fire extinguishing installations and equipment on premises
L.24	10-1996	Classification of outside plant waste
L.25	10-1996	Optical fibre cable network maintenance
L.26	12-2002	Optical fibre cables for aerial application
L.27	10-1996	Method for estimating the concentration of hydrogen in optical fibre cables
L.28	10-2002	External additional protection for marinized terrestrial cables
L.29	01-2002	As-laid report and maintenance/repair log for marinized terrestrial cable installation
L.30	10-1996	Markers on marinized terrestrial cables
L.31	10-1996	Optical fibre attenuators
L.32	10-1998	Protection devices for through-cable penetrations of fire-sector partitions
L.33	10-1998	Periodic control of fire extinction devices in telecommunication buildings
L.34	10-1998	Installation of Optical Fibre Ground Wire (OPGW) cable
L.35	10-1998	Installation of optical fibre cables in the access network
L.36	10-1998	Single mode fibre optic connectors
L.37	10-1998	Fibre optic (non-wavelength selective) branching devices
L.38	09-1999	Use of trenchless techniques for the construction of underground infrastructures for telecommunication cable installation
L.39	05-2000	Investigation of the soil before using trenchless techniques
L.40	10-2000	Optical fibre outside plant maintenance support, monitoring and testing system
L.41	05-2000	Maintenance wavelength on fibres carrying signals
L.42	05-2003	Extending optical fibre solutions into the access network
L.43	12-2002	Optical fibre cables for buried application
L.44	10-2000	Electric power supply for equipment installed as outside plant
L.45	10-2000	Minimizing the effect on the environment from the outside plant in telecommunication networks
L.46	10-2000	Protection of telecommunication cables and plant from biological attack
L.47	10-2000	Access facilities using hybrid fibre/copper networks
L.48	03-2003	Mini-trench installation technique
L.49	03-2003	Micro-trench installation technique
L.50	11-2003	Requirements for passive optical nodes: Optical distribution frames for central office environments

L.51	04-2003	Passive node elements for fibre optic networks – General principles and definitions for characterization and performance evaluation	
L.52	05-2003	Deployment of Passive Optical Networks (PON)	
L.53	05-2003	Optical fibre maintenance criteria for access networks	
L.54	02-2004	Splice closure for marinized terrestrial cables (MTC)	
L.55	11-2003	Digital database for marine cables and pipelines	
L.56	05-2003	Installation of optical fibre cables along railways	
L.57	05-2003	Air-assisted installation of optical fibre cables	
L.58	03-2004	Optical fibre cables: Special needs for access network	
L.59	09-2004	Optical fibre cables for indoor application	Pre-published.
L.60	09-2004	Construction of optical/metallic hybrid cables	
L.61	07-2004	Optical fibre cable installation by floating technique	
L.62	09-2004	Practical aspects of unbundling services by multiple operators in copper access networks	
L.63	10-2004	Safety procedures for outdoor installations	Pre-published.

Recommendation count: 64

Series M : Telecommunication management, including TMN and network maintenance

Number	*Approval Date*	*Recommendation Title*	*Status*
		Telecommunication management, including TMN and network maintenance	
M.10	10-1992	Scope and application of Recommendations for maintenance of telecommunication networks and services	
M.15	11-1988	Maintenance considerations for new systems	
M.20	10-1992	Maintenance philosophy for telecommunication networks	
M.21	10-1992	Maintenance philosophy for telecommunication services	
M.32	11-1988	Principles for using alarm information for maintenance of international transmission systems and equipment	
M.34	11-1988	Performance monitoring on international transmission systems and equipment	
M.35	11-1988	Principles concerning line-up and maintenance limits	
M.50	11-1988	Use of telecommunication terms for maintenance	Not available, contact sales@itu.int.
M.60	03-1993	Maintenance terminology and definitions	
M.70	11-1988	Guiding principles on the general maintenance organization for telephone-type international circuits	
M.75	10-1992	Technical service	
M.80	11-1988	Control stations	
M.85	10-1992	Fault report points	
M.90	11-1988	Sub-control stations	
M.100	11-1988	Service circuits	
M.110	11-1988	Circuit testing	
M.120	11-1988	Access points for maintenance	
M.125	11-1988	Digital loopback mechanisms	
M.160	11-1988	Stability of transmission	
M.320	11-1988	Numbering of the channels in a group	
M.330	11-1988	Numbering of groups within a supergroup	
M.340	11-1988	Numbering of supergroups within a mastergroup	
M.350	11-1988	Numbering of mastergroups within a supermastergroup	
M.380	11-1988	Numbering in coaxial systems	

M.390	11-1988	Numbering in systems on symmetric pair cable
M.400	11-1988	Numbering in radio-relay links or open-wire line systems
M.410	11-1988	Numbering of digital blocks in transmission systems
M.450	11-1988	Bringing a new international transmission system into service
M.460	11-1988	Bringing international group, supergroup, etc., links into service
M.470	11-1988	Setting up and lining up analogue channels for international telecommunication services
M.475	11-1988	Setting up and lining up mixed analogue/digital channels for international telecommunication services
M.495	11-1988	Transmission restoration and transmission route diversity: Terminology and general principles
M.496	11-1988	Functional organization for automatic transmission restoration
M.500	11-1988	Routine maintenance measurements to be made on regulated line sections
M.510	11-1988	Readjustment to the nominal value of a regulated line section (on a symmetric pair line, a coaxial line or a radio-relay link)
M.520	11-1988	Routine maintenance on international group, supergroup, etc., links
M.525	11-1988	Automatic maintenance procedures for international group, supergroup, etc., links
M.530	11-1988	Readjustment to the nominal value of an international group, supergroup, etc., link
M.535	11-1988	Special maintenance procedures for multiple destination, unidirectional (MU) group and supergroup links
M.540	11-1988	Routine maintenance of carrier and pilot generating equipment
M.556	11-1988	Setting up and initial testing of digital channels on an international digital path or block
M.560	11-1988	International telephone circuits – Principles, definitions and relative transmission levels
M.562	11-1988	Types of circuit and circuit section
M.565	11-1988	Access points for international telephone circuits
M.570	11-1988	Constitution of the circuit; preliminary exchange of information
M.580	11-1988	Setting up and lining up an international circuit for public telephony
M.585	11-1988	Bringing an international digital circuit into service
M.590	11-1988	Setting up and lining up a circuit fitted with a compandor
M.600	11-1988	Organization of routine maintenance measurements on circuits
M.605	11-1988	Routine maintenance schedule for international public telephony circuits
M.610	11-1988	Periodicity of maintenance measurements on circuits

M.620	11-1988	Methods for carrying out routine measurements on circuits
M.630	11-1988	Maintenance of circuits using control chart methods
M.650	11-1988	Routine line measurements to be made on the line repeaters of audio-frequency sections or circuits
M.660	11-1988	Periodical in-station tests of echo suppressors complying with Recommendations G.161 and G.164
M.665	11-1988	Testing of echo cancellers
M.670	11-1988	Maintenance of a circuit fitted with a compandor
M.675	11-1988	Lining up and maintaining international demand assignment circuits (SPADE)
M.710	11-1988	General maintenance organization for the international automatic and semi-automatic telephone service
M.715	11-1988	Fault report point (circuit)
M.716	11-1988	Fault report point (network)
M.717	11-1988	Testing point (transmission)
M.718	11-1988	Testing point (line signalling)
M.719	11-1988	Testing point (switching and interregister signalling)
M.720	11-1988	Network analysis point
M.721	11-1988	System availability information point
M.722	11-1980	Network management point
M.723	11-1988	Circuit control station
M.724	11-1988	Circuit sub-control station
M.725	11-1988	Restoration control point
M.726	11-1988	Maintenance organization for the wholly digital international automatic and semi-automatic telephone service
M.729	11-1988	Organization of the maintenance of international public switched telephone circuits used for data transmission
M.730	11-1988	Maintenance methods
M.731	11-1988	Subjective testing
M.732	11-1988	Signalling and switching routine maintenance tests and measurements
M.733	11-1988	Transmission routine maintenance measurements on automatic and semi-automatic telephone circuits
M.734	11-1988	Exchange of information on incoming test facilities at international switching centres
M.760	11-1988	Transfer link for common channel Signalling System No. 6
M.762	11-1988	Maintenance of common channel Signalling System No. 6

M.800	11-1988	Use of circuits for voice-frequency telegraphy
M.810	11-1988	Setting up and lining up an international voice-frequency telegraph link for public telegraph circuits (for 50, 100 and 200 baud modulation rates)
M.820	11-1988	Periodicity of routine tests on international voice-frequency telegraph links
M.830	11-1988	Routine measurements to be made on international voice-frequency telegraph links
M.850	11-1988	International time division multiplex (TDM) telegraph systems
M.880	11-1988	International phototelegraph transmission
M.900	11-1988	Use of leased group and supergroup links for wide-spectrum signal transmission (data, facsimile, etc.)
M.910	11-1988	Setting up and lining up an international leased group link for wide-spectrum signal transmission
M.1010	11-1988	Constitution and nomenclature of international leased circuits
M.1012	11-1988	Circuit control station for leased and special circuits
M.1013	11-1988	Sub-control station for leased and special circuits
M.1014	11-1988	Transmission maintenance point (international line) (TMP-IL)
M.1015	11-1988	Types of transmission on leased circuits
M.1016	11-1988	Assessment of the service availability performance of international leased circuits
M.1020	03-1993	Characteristics of special quality international leased circuits with special bandwidth conditioning
M.1025	03-1993	Characteristics of special quality international leased circuits with basic bandwidth conditioning
M.1030	11-1988	Characteristics of ordinary quality international leased circuits forming part of private switched telephone networks
M.1040	11-1988	Characteristics of ordinary quality international leased circuits
M.1045	05-1996	Preliminary exchange of information for the provision of international leased circuits and international data transmission systems
M.1050	06-1998	Lining up an international point-to-point leased circuit with analogue presentation to the user
M.1055	11-1988	Lining up an international multiterminal leased circuit
M.1060	11-1988	Maintenance of international leased circuits
M.1130	10-1992	General definitions and general principles of operation/maintenance procedures to be used in satellite mobile systems
M.1140	10-1992	Maritime mobile telecommunication services via satellite
M.1150	04-1997	Maintenance aspects of maritime/land mobile telecommunication store-and-forward services (packet mode) via satellite
M.1160	04-1997	Maintenance aspects of aeronautical mobile telecommunication service via satellite

M.1170	04-1997	Maintenance aspects of mobile digital telecommunication service via satellite	
M.1230	05-1996	Method to improve the management of operations and maintenance processes in the international telephone network	
M.1235	11-1988	Use of automatically generated test calls for assessment of network performance	
M.1300	10-1997	Maintenance of international data transmission systems operating in the range 2.4 kbit/s to 140 Mbit/s	
M.1301	01-2001	General description and operational procedures for international SDH leased circuits	
M.1320	11-1988	Numbering of channels in data transmission systems	
M.1340	02-2000	Performance objectives, allocations and limits for international PDH leased circuits and supporting data transmission links and systems	
M.1340 (2000) Corrigendum 1	08-2001		Available only in PDF.
M.1350	11-1988	Setting up, lining up and characteristics of international data transmission systems operating in the range 2.4 kbit/s to 14.4 kbit/s	
M.1355	11-1988	Maintenance of international data transmission systems operating in the range 2.4 to 14.4 kbit/s	
M.1370	06-1998	Bringing-into-service of international data transmission systems	
M.1375	06-1998	Maintenance of international data transmission systems	
M.1380	02-2000	Bringing-into-service of international leased circuits that are supported by international data transmission systems	
M.1385	02-2000	Maintenance of international leased circuits that are supported by international data transmission systems	
M.1400	01-2004	Designations for interconnections among operators' networks	
M.1401	02-2004	Formalization of interconnection designations among operators’ networks	
M.1510	10-1992	Exchange of contact point information for the maintenance of international services and the international network	
M.1520	10-1992	Standardized information exchange between Administrations	
M.1530	03-1999	Network maintenance information	
M.1532	02-2000	Network maintenance service performance agreement (MSPA)	
M.1535	05-1996	Principles for maintenance information to be exchanged at customer contact point (MICC)	
M.1537	10-1997	Definition of maintenance information to be exchanged at customer contact point (MICC)	
M.1539	03-1999	Management of the grade of network maintenance services at the Maintenance Service Customer Contact Point (MSCC)	
M.1540	10-1994	Exchange of information for planned outages of transmission systems	
M.1550	10-1992	Escalation procedure	
M.1560	10-1992	Escalation procedure for international leased circuits	

M.2100	04-2003	Performance limits for bringing-into-service and maintenance of international multi-operator PDH paths and connections	
M.2101	06-2003	Performance limits for bringing-into-service and maintenance of international multi-operator SDH paths and multiplex sections	
M.2102	02-2000	Maintenance thresholds and procedures for recovery mechanisms (protection and restoration) of international SDH VC trails (paths) and multiplex sections	
M.2110	07-2002	Bringing into service international multi-operator paths, sections and transmission systems	
M.2120	07-2002	International multi-operator paths, sections and transmission systems fault detection and localization procedures	
M.2130	02-2000	Operational procedures for the maintenance of the transport network	
M.2140	02-2000	Transport network event correlation	
M.2201	03-2001	Performance objectives, allocations and limits for bringing-into-service and maintenance of international ATM virtual path and virtual channel connections	
M.2301	07-2002	Performance objectives and procedures for provisioning and maintenance of IP-based networks	
M.2401	12-2003	Error performance limits and procedures for bringing-into-service and maintenance of multi-operator international paths and sections within an optical transport network	
M.3000	02-2000	Overview of TMN Recommendations	
M.3010	02-2000	Principles for a telecommunications management network	
M.3010 (2000) Amendment 1	12-2003	TMN conformance and TMN compliance	
M.3013	02-2000	Considerations for a telecommunications management network	
M.3016	06-1998	TMN Security Overview	
M.3016.1	04-2005	Security for the management plane: Security requirements	Pre-published.
M.3016.2	04-2005	Security for the management plane: Security services	Pre-published.
M.3016.3	04-2005	Security for the management plane: Security mechanism	Pre-published.
M.3016.4	04-2005	Security for the management plane: Profile proforma	Pre-published.
M.3017	06-2003	Framework for the integrated management of hybrid circuit/packet networks	
M.3017 (2003) Amendment 1	04-2005	Additional options	Pre-published.
M.3020	02-2000	TMN Interface Specification Methodology	
M.3030	08-2002	Telecommunications Markup Language (tML) framework	
M.3031	07-2004	Guidelines for Implementation Conformance Statement proformas for tML schemas	
M.3050.0	07-2004	Enhanced Telecom Operations Map (eTOM) – Introduction	

M.3050.1	06-2004	Enhanced Telecom Operations Map (eTOM) – The business process framework	
M.3050.2	06-2004	Enhanced Telecom Operations Map (eTOM) – Process decompositions and descriptions	
M.3050.3	06-2004	Enhanced Telecom Operations Map (eTOM) – Representative process flows	
M.3050.4	06-2004	Enhanced Telecom Operations Map (eTOM) – B2B integration: Using B2B inter-enterprise integration with the eTOM	
M.3100	04-2005	Generic network information model	Not available, contact sales@itu.int.
M.3101	07-1995	Managed object conformance statements for the generic network information model	
		TMN management services for dedicated and reconfigurable circuits network	
M.3108.1	03-1999	Information model for management of leased circuit and reconfigurable services	
M.3108.1 (1999) Corrigendum 1	01-2001		
M.3108.2	02-2000	Information model for connection management of preprovisioned service link connections to form a reconfigurable leased service	
M.3108.3	01-2001	Information model for management of virtual private network service	
M.3120	10-2001	CORBA generic network and network element level information model	Available only in MS Word.
M.3120 (2001) Amendment 1	05-2002	Protection switching	
M.3120 (2001) Amendment 2	03-2003		
M.3180	10-1992	Catalogue of TMN management information	
M.3200	04-1997	TMN management services and telecommunications managed areas: overview	
M.3207.1	05-1996	TMN management service: Maintenance aspects of B-ISDN management	
		TMN management services for dedicated and reconfigurable circuits network	
M.3208.1	10-1997	Leased circuit services	
M.3208.1 (1997) Corrigendum 1	02-2000		
M.3208.2	03-1999	Connection management of pre-provisioned service link connections to form a leased circuit service	
M.3208.2 (1999) Corrigendum 1	01-2001		
M.3208.3	02-2000	Virtual private network service	

M.3210.1	01-2001	TMN management services for IMT-2000 security management
M.3211.1	05-1996	TMN management service: Fault and performance management of the ISDN access
M.3300	06-1998	TMN F interface requirements
M.3320	04-1997	Management requirements framework for the TMN X-Interface
M.3341	12-2003	Requirements for QoS/SLA management over the TMN X-interface for IP-based services
M.3350	05-2004	TMN service management requirements for information interchange across the TMN X-interface to support provisioning of Emergency Telecommunication Service (ETS)
M.3400	02-2000	TMN management functions
M.3600	10-1992	Principles for the management of ISDNs
M.3602	10-1992	Application of maintenance principles to ISDN subscriber installations
M.3603	10-1992	Application of maintenance principles to ISDN basic rate access
M.3604	10-1992	Application of maintenance principles to ISDN primary rate access
M.3605	10-1992	Application of maintenance principles to static multiplexed ISDN basic rate access
M.3610	05-1996	Principles for applying the TMN concept to the management of B-ISDN
M.3611	04-1997	Test management of the B-ISDN ATM layer using the TMN
M.3620	10-1992	Principles for the use of ISDN test calls, systems and responders
M.3621	07-1995	Integrated management of the ISDN customer access
M.3640	10-1992	Management of the D-channel – Data link layer and network layer
M.3641	10-1994	Management information model for the management of the data link and network layer of the ISDN D-channel
M.3650	04-1997	Network performance measurements of ISDN calls
M.3660	10-1992	ISDN interface management services
M.4010	10-1992	Inter-Administration agreements on common channel Signalling System No. 6
M.4030	10-1992	Transmission characteristics for setting up and lining up a transfer link for common channel Signalling System N° 6 (analogue version)
M.4100	05-1996	Maintenance of common channel Signalling System No. 7
M.4110	05-1996	Inter-Administration agreements on common channel Signalling System No. 7

Recommendation count: 203

Series N : Maintenance: international sound programme and television transmission circuits

Number	*Approval Date*	*Recommendation Title*	*Status*
		Maintenance: international sound programme and television transmission circuits	
N.1	03-1993	Definitions for application to international sound-programme and television-sound transmission	
N.2	11-1988	Different types of sound-programme circuit	
N.3	11-1988	Control circuits	
N.4	11-1988	Definition and duration of the line-up period and the preparatory period	
N.5	11-1988	Sound-programme control, sub-control and send reference stations	
N.10	03-1993	Limits for the lining-up of international sound-programme links and connections	
N.11	11-1988	Essential transmission performance objectives for international sound-programme centres (ISPC)	
N.12	11-1988	Measurements to be made during the line-up period that precedes a sound-programme transmission	
N.13	11-1988	Measurements to be made by the broadcasting organizations during the preparatory period	
N.15	11-1988	Maximum permissible power during an international sound-programme transmission	
N.16	11-1988	Identification signal	
N.17	11-1988	Monitoring the transmission	
N.18	11-1988	Monitoring for charging purposes, releasing	
N.21	11-1988	Limits and procedures for the lining-up of a sound-programme circuit	
N.23	11-1988	Maintenance measurements to be made on international sound-programme circuits	
N.51	11-1988	Definitions for application to international television transmissions	
N.52	11-1988	Multiple destination television transmissions and coordination centres	
N.54	11-1988	Definition and duration of the line-up period and the preparatory period	
N.55	03-1993	Organization, responsibilities and functions of control and sub-control international television centres and control and sub-control stations for international television connections, links, circuits and circuit sections	
N.60	03-1993	Nominal amplitude of video signals at video interconnection points	
N.61	11-1988	Measurements to be made before the line-up period that precedes a television transmission	
N.62	03-1993	Tests to be made during the line-up period that precedes a television transmission	
N.63	11-1988	Test signals to be used by the broadcasting organizations during the preparatory period	

N.64	11-1988	Quality and impairment assessment
N.67	03-1993	Monitoring television transmissions – Use of the field blanking interval
N.73	11-1988	Maintenance of permanent international television circuits, links and connections

Recommendation count: 26

Series O : Specifications of measuring equipment

Number	Approval Date	Recommendation Title	Status
		Specifications of measuring equipment	
O.1	02-2000	Scope and application of measurement equipment specifications covered in the O-series Recommendations	
O.3	10-1992	Climatic conditions and relevant tests for measuring equipment	
O.6	11-1988	1020 Hz reference test frequency	
O.9	03-1999	Measuring arrangements to assess the degree of unbalance about earth	
O.11	10-1992	Maintenance access lines	
O.22	10-1992	CCITT automatic transmission measuring and signalling testing equipment ATME No. 2	
O.27	11-1988	In-station echo canceller test equipment	
O.33	07-1995	Automatic equipment for rapidly measuring stereophonic pairs and monophonic sound-programme circuits, links and connections	
O.41	10-1994	Psophometer for use on telephone-type circuits	
O.42	11-1988	Equipment to measure non-linear distortion using the 4-tone intermodulation method	
O.61	11-1988	Simple equipment to measure interruptions on telephone-type circuits	
O.62	11-1988	Sophisticated equipment to measure interruptions on telephone-type circuits	
O.71	11-1988	Impulsive noise measuring equipment for telephone-type circuits	
O.81	11-1988	Group-delay measuring equipment for telephone-type circuits	
O.81 Appendix I	06-1998	A measuring signal (multitone test signal) for fast measurement of amplitude and phase for telephone type circuits	
O.81 Appendix I Erratum1	06-2000		
O.82	11-1988	Group-delay measuring equipment for the range 5 to 600 kHz	
O.91	11-1988	Phase jitter measuring equipment for telephone-type circuits	
O.95	11-1988	Phase and amplitude hit counters for telephone-type circuits	
O.111	11-1988	Frequency shift measuring equipment for use on carrier channels	
O.131	11-1988	Quantizing distortion measuring equipment using a pseudo-random noise test signal	
O.132	11-1988	Quantizing distortion measuring equipment using a sinusoidal test signal	
O.133	03-1993	Equipment for measuring the performance of PCM encoders and decoders	
O.150	05-1996	General requirements for instrumentation for performance measurements on digital transmission equipment	

O.150 (1996) Corrigendum 1	05-2002		
O.151	10-1992	Error performance measuring equipment operating at the primary rate and above	
O.151 (1992) Corrigendum 1	05-2002		
O.152	10-1992	Error performance measuring equipment for bit rates of 64 kbit/s and N x 64 kbit/s	
O.153	10-1992	Basic parameters for the measurement of error performance at bit rates below the primary rate	
O.161	11-1988	In-service code violation monitors for digital systems	
O.162	10-1992	Equipment to perform in-service monitoring on 2048, 8448, 34 368 and 139 264 kbit/s signals	
O.163	11-1988	Equipment to perform in-service monitoring on 1544 kbit/s signals	
O.171	04-1997	Timing jitter and wander measuring equipment for digital systems which are based on the plesiochronous digital hierarchy (PDH)	
O.172	04-2005	Jitter and wander measuring equipment for digital systems which are based on the synchronous digital hierarchy (SDH)	Pre-published.
O.173	03-2003	Jitter measuring equipment for digital systems which are based on the Optical Transport Network (ONT)	
O.181	05-2002	Equipment to assess error performance on STM-N interfaces	
O.191	02-2000	Equipment to measure the cell transfer performance of ATM connections	
O.201	07-2003	Q-factor test equipment to estimate the transmission performance of optical channels	

Recommendation count: 38

Series P : Telephone transmission quality, telephone installations, local line networks

Number	*Approval Date*	*Recommendation Title*	*Status*
		Telephone transmission quality, telephone installations, local line networks	
P.10	12-1998	Vocabulary of terms on telephone transmission quality and telephone sets	
P.10 (1998) Amendment 1	11-2003	New Annex A – List of psychoacoustic parameters	
P.11	03-1993	Effect of transmission impairments	
P.16	11-1988	Subjective effects of direct crosstalk; thresholds of audibility and intelligibility	
P.32	11-1988	Evaluation of the efficiency of telephone booths and acoustic hoods	
P.48	11-1988	Specification for an intermediate reference system	
P.50	09-1999	Artificial voices	
P.50 Erratum 1	05-2000		
P.50 Appendix I	02-1998	Test signals	
P.51	08-1996	Artificial mouth	
P.52	03-1993	Volume meters	
O.41	10-1994	Psophometer for use on telephone-type circuits	
P.54	11-1988	Sound level meters (apparatus for the objective measurement of room noise)	
P.55	11-1988	Apparatus for the measurement of impulsive noise	
P.56	03-1993	Objective measurement of active speech level	
P.57	07-2002	Artificial ears	
P.57 (2002) Corrigendum 1	01-2005		
P.58	08-1996	Head and torso simulator for telephonometry	
P.58 Erratum 1	01-2003		
P.59	03-1993	Artificial conversational speech	
P.61	11-1988	Methods for the calibration of condenser microphones	
P.64	09-1999	Determination of sensitivity/frequency characteristics of local telephone systems	
P.64 Erratum 1	05-2000		
P.75	11-1988	Standard conditioning method for handsets with carbon microphones	
P.76	11-1988	Determination of loudness ratings; fundamental principles	

P.78	02-1996	Subjective testing method for determination of loudness ratings in accordance with Recommendation P.76	
P.79	09-1999	Calculation of loudness ratings for telephone sets	
P.79 Erratum 1	05-2000		
P.79 (1999) Corrigendum 1	10-2000		
P.79 (1999) Corrigendum 2	02-2001		
P.79 (1999) Corrigendum 3	01-2005		
P.79 Annex G	11-2001	Wideband loudness rating algorithm	
P.82	11-1988	Method for evaluation of service from the standpoint of speech transmission quality	
P.85	06-1994	A method for subjective performance assessment of the quality of speech voice output devices	
P.300	11-2001	Transmission performance of group audio terminals (GATs)	
P.310	03-2003	Transmission characteristics for telephone band (300-3400 Hz) digital telephones	
P.311	02-1998	Transmission characteristics for wideband (150-7000 Hz) digital handset telephones	
P.313	05-2004	Transmission characteristics for cordless and mobile digital terminals	
P.330	03-2003	Speech processing devices for acoustic enhancement	
P.330 (2003) Amendment 1	09-2003		
P.340	05-2000	Transmission characteristics and speech quality parameters of hands-free terminals	
P.340 (2000) Corrigendum 1	03-2004		
P.341	02-1998	Transmission characteristics for wideband (150-7000 Hz) digital hands-free telephony terminals	
P.341 (1998) Corrigendum 1	09-1999		
P.342	05-2000	Transmission characteristics for telephone band (300-3400 Hz) digital loudspeaking and hands-free telephony terminals	
P.350	03-2001	Handset dimensions	
P.360	12-1998	Efficiency of devices for preventing the occurrence of excessive acoustic pressure by telephone receivers	
P.370	08-1996	Coupling hearing aids to telephone sets	
P.380	11-2003	Electro-acoustic measurements on headsets	
P.501	05-2000	Test signals for use in telephonometry	Available only in MS Word.

P.501 Erratum 1	09-2001		
P.501 (2000) Amend.1	05-2004	New annexes A and B	Not available, contact sales@itu.int.
P.502	05-2000	Objective test methods for speech communication systems using complex test signals	
P.502 Erratum 1	07-2001		
P.561	07-2002	In-service non-intrusive measurement device – Voice service measurements	
P.561 App. III	02-1998	Digital speech recordings	Not available, contact sales@itu.int.
P.562	05-2004	Analysis and interpretation of INMD voice-service measurements	
P.563	05-2004	Single-ended method for objective speech quality assessment in narrow-band telephony applications	Available only in MS Word.
P.581	05-2000	Use of head and torso simulator (HATS) for hands-free terminal testing	
P.800	08-1996	Methods for subjective determination of transmission quality	
P.800.1	03-2003	Mean Opinion Score (MOS) terminology	
P.810	02-1996	Modulated noise reference unit (MNRU)	
P.830	02-1996	Subjective performance assessment of telephone-band and wideband digital codecs	
P.831	12-1998	Subjective performance evaluation of network echo cancellers	
P.832	05-2000	Subjective performance evaluation of hands-free terminals	
P.833	02-2001	Methodology for derivation of equipment impairment factors from subjective listening-only tests	
P.834	07-2002	Methodology for the derivation of equipment impairment factors from instrumental models	Available only in MS Word.
P.834 (2002) Corrigendum 1	01-2005		
P.835	11-2003	Subjective test methodology for evaluating speech communication systems that include noise suppression algorithm	
P.840	11-2003	Subjective listening test method for evaluating circuit multiplication equipment	
P.851	11-2003	Subjective quality evaluation of telephone services based on spoken dialogue systems	
P.862	02-2001	Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs	Available only in MS Word.
P.862 (2001) Amd.1	03-2003	Revised Annex A: Source code for reference implementation and conformance tests	Available only in MS Word.

P.862.1	11-2003	Mapping function for transforming P.862 raw result scores to MOS-LQO	
P.880	05-2004	Continuous evaluation of time-varying speech quality	Pre-published.
P.910	09-1999	Subjective video quality assessment methods for multimedia applications	
P.911	12-1998	Subjective audiovisual quality assessment methods for multimedia applications	
P.911 (1998) Corrigendum 1	09-1999		
P.920	05-2000	Interactive test methods for audiovisual communications	
P.930	08-1996	Principles of a reference impairment system for video	
P.931	12-1998	Multimedia communications delay, synchronization and frame rate measurement	
P.1010	07-2004	Fundamental voice transmission objectives for VoIP terminals and gateways	
P.supp10	11-1988	Considerations relating to transmission characteristics for analogue handset telephones	
P.supp16	11-1988	Guidelines for placement of microphones and loudspeakers in telephone conference rooms and for group audio terminals (GATs)	
P.supp20	03-1993	Examples of measurements of handset receive-frequency responses: dependence on earcap leakage losses	
P.Sup23	02-1998	ITU-T coded-speech database	

Recommendation count: 86

Series Q : Switching and signalling

Number	*Approval Date*	*Recommendation Title*	*Status*
		Switching and signalling	
Q.1	11-1988	Signal receivers for manual working	
Q.2	11-1988	Signal receivers for automatic and semi-automatic working, used for manual working	
Q.4	11-1988	Automatic switching functions for use in national networks	
Q.5	11-1988	Advantages of semi-automatic service in the international telephone service	
Q.6	11-1988	Advantages of international automatic working	
Q.7	11-1988	Signalling systems to be used for international automatic and semi-automatic telephone working	
Q.8	11-1988	Signalling systems to be used for international manual and automatic working on analogue leased circuits	
Q.9	11-1988	Vocabulary of switching and signalling terms	
E.164	02-2005	The international public telecommunication numbering plan	Pre-published.
E.164 Supplement 1	03-1998	Alternatives for carrier selection and network identification	
E.164 Supplement 2	11-1998	Number Portability	
E.164 Supplement 3	05-2004	Operational and administrative issues associated with national implementations of the ENUM functions	
E.164 Supplement 4	05-2004	Operational and administrative issues associated with the implementation of ENUM for non-geographic country codes	
Q.12	11-1988	Overflow – alternative routing – rerouting – automatic repeat attempt	
Q.14	11-1988	Means to control the number of satellite links in an international telephone connection	
Q.20	11-1988	Comparative advantages of "in-band" and "out-band" systems	
Q.21	11-1988	Systems recommended for out-band signalling	
Q.22	11-1988	Frequencies to be used for in-band signalling	
Q.23	11-1988	Technical features of push-button telephone sets	
Q.24	11-1988	Multifrequency push-button signal reception	
Q.25	11-1988	Splitting arrangements and signal recognition times in "in-band" signalling systems	
Q.26	11-1988	Direct access to the international network from the national network	
Q.27	11-1988	Transmission of the answer signal	

Q.28	11-1988	Determination of the moment of the called subscriber's answer in the automatic service
Q.29	11-1988	Causes of noise and ways of reducing noise in telephone exchanges
Q.30	11-1988	Improving the reliability of contacts in speech circuits
Q.31	11-1988	Noise in a national 4-wire automatic exchange
Q.32	11-1988	Reduction of the risk of instability by switching means
Q.33	11-1988	Protection against the effects of faulty transmission on groups of circuits
E.180/Q.35	03-1998	Technical characteristics of tones for the telephone service
Q.44	11-1988	Attenuation distortion
Q.45	10-1984	Transmission characteristics of an analogue international exchange
Q.45bis	11-1988	Transmission characteristics of an analogue international exchange
Q.48	11-1988	Demand assignment signalling systems
O.22	10-1992	CCITT automatic transmission measuring and signalling testing equipment ATME No. 2
Q.50	07-2001	Signalling between Circuit Multiplication Equipment (CME) and International Switching Centres (ISC)
Q.50.1	07-2001	Signalling between International Switching Centres (ISC) and Digital Circuit Multiplication Equipment (DCME) including the control of compression/decompression
Q.50.2	12-2002	Signalling between International Switching Centres (ISC) and Digital Circuit Multiplication Equipment (DCME) including the control of compression/decompression over an IP network
Q.52	03-2001	Signaling between international switching centers and stand-alone echo control devices
Q.55	12-1999	Signalling between signal processing network equipments (SPNE) and international switching centres (ISC)
Q.56	05-2001	Signalling between signal processing network equipment (SPNE) and international switching centres (ISC) over an IP network
Q.65	06-2000	The unified functional methodology for the characterization of services and network capabilities including alternative object oriented techniques
Q.68	03-1993	Overview of methodology for developing management services
Q.71	03-1993	ISDN circuit mode switched bearer services
Q.72	03-1993	Stage 2 description for packet mode services
Q.76	02-1995	Service procedures for Universal Personal Telecommunication – Functional modelling and information flows
Q.80	11-1988	Introduction to stage 2 service descriptions for supplementary services
		Stage 2 description for number identification supplementary services
Q.81.1	11-1988	Direct dialling-in

Q.81.2	02-1992	Multiple subscriber number	
Q.81.3	09-1991	Calling line identification presentation (CLIP) and calling line identification restriction (CLIR)	
Q.81.5	09-1991	Connected line identification, presentation and restriction (COLP) and (COLR)	
Q.81.7	06-1997	Malicious call identification (MCID)	
Q.81.8	02-1992	Sub-addressing (SUB)	
		Stage 2 description for call offering supplementary services	
Q.82.1	11-1988	Call transfer	Not available, contact sales@itu.int.
Q.82.2	03-1993	call forwarding	
Q.82.3	03-1993	Call deflection	
Q.82.4	11-1988	Line hunting	
Q.82.7	07-1996	Explicit call transfer	
		Stage 2 description for call completion supplementary services	
Q.83.1	09-1991	Call waiting (CW)	
Q.83.2	02-1992	Call hold	
Q.83.3	11-1988	Completion of call to busy subscriber	Available only in PDF.
Q.83.4	09-1991	Terminal portability	Not available, contact sales@itu.int.
		Stage 2 description for multiparty supplementary services	
Q.84.1	03-1993	Conference calling (CONF)	
Q.84.2	10-1995	Three-party service	
		Stage 2 description for community of interest supplementary services	
Q.85.1	02-1992	Closed user group	
Q.85.3	02-1992	Multi-level precedence and preemption (MLPP)	
Q.85.6	02-1995	Global Virtual Network Service (GVNS)	
Q.85.6 Annex A	07-1996	Service procedures and information flows based on intelligent network CS-1 capabilities	
		Stage 2 description for charging supplementary services	

Q.86.1	11-1988	Credit card call	Not available, contact sales@itu.int.
Q.86.2	10-1995	Advice of charge (AOC)	
Q.86.3	03-1993	Reverse charging (REV)	
Q.86.4	06-1997	International Freephone Service (IFS)	
Q.86.7	10-1995	International Telecommunication Charge Card (ITCC)	
		Stage 2 description for additional information transfer supplementary services	
Q.87.1	03-1993	User-to-user signalling (UUS)	
Q.87.2	11-1988	User signalling bearer services	Not available, contact sales@itu.int.
Q.101	11-1988	Facilities provided in international semi-automatic working	
Q.102	11-1988	Facilities provided in international automatic working	
Q.103	11-1988	Numbering used	
Q.104	11-1988	Language digit or discriminating digit	
Q.105	11-1988	National (significant) number	
Q.106	11-1988	The sending-finished signal	
Q.107	11-1988	Standard sending sequence of forward address information	
Q.107bis	03-1993	Analysis of forward address information for routing	
Q.108	11-1988	One-way or both-way operation of international circuits	
Q.109	11-1988	Transmission of the answer signal in international exchanges	
Q.110	11-1988	General aspects of the utilization of standardized CCITT signalling systems on PCM links	
Q.112	11-1988	Signal levels and signal receiver sensitivity	
Q.113	11-1988	Connection of signal receivers in the circuit	
Q.114	11-1988	Typical transmission requirements for signal senders and receivers	
Q.115.0	12-2002	Protocols for the control of signal processing network elements and functions	
Q.115.0 Erratum 1	09-2003		
Q.115.1	12-2002	Logic for the control of echo control devices and functions	
Q.116	11-1988	Indication given to the outgoing operator or calling subscriber in case of an abnormal condition	

Q.117	11-1988	Alarms for technical staff and arrangements in case of faults
Q.118	09-1997	Abnormal conditions – Special release arrangements
Q.118bis	11-1988	Indication of congestion conditions at transit exchanges
Q.120-Q.139	11-1988	Specifications of Signalling system No. 4
Q.140-Q.180	11-1988	Specifications of Signalling System No. 5
Q.251-Q.300	11-1988	Specifications of Signalling System No. 6
Q.310-Q.332	11-1988	Specifications of Signalling System R1
Q.400-Q.490	11-1988	Specifications of Signalling System R2
Q.500	11-1988	Digital local, combined, transit and international exchanges – Introduction and field of application
Q.511	11-1988	Exchange interfaces towards other exchanges
Q.512	02-1995	Digital exchange interfaces for subscriber access
Q.513	03-1993	Digital exchange interfaces for operations, administration and maintenance
Q.521	03-1993	Digital exchange functions
Q.522	11-1988	Digital exchange connections, signalling and ancillary functions
Q.541	03-1993	Digital exchange design objectives – General
Q.542	03-1993	Digital exchange design objectives – Operations and maintenance
Q.543	03-1993	Digital exchange performance design objectives
Q.544	11-1988	Digital exchange measurements
Q.551	01-2002	Transmission characteristics of digital exchanges
Q.552	11-2001	Transmission characteristics at 2-wire analogue interfaces of digital exchanges
Q.553	11-2001	Transmission characteristics at 4-wire analogue interfaces of digital exchanges
Q.554	11-1996	Transmission characteristics at digital interfaces of digital exchanges
Q.601	03-1993	Interworking of signalling systems – General
Q.602	03-1993	Interworking of signalling systems – Introduction
Q.603	11-1988	Events
Q.604	03-1993	Interworking of signalling systems – Information analysis tables
Q.605	11-1988	Drawing conventions
Q.606	11-1988	Logic procedures
Q.607	11-1988	Interworking requirements for new signalling systems

Q.608	11-1988	Miscellaneous interworking aspects
Q.611	11-1988	Logic procedures for incoming signalling system No. 4
Q.612	11-1988	Logic procedures for incoming signalling system No. 5
Q.613	11-1988	Logic procedures for incoming signalling system No. 6
Q.614	03-1993	Logic procedures for incoming Signalling System No. 7 (TUP)
Q.615	11-1988	Logic procedures for incoming signalling system R1
Q.616	11-1988	Logic procedures for incoming signalling system R2
Q.617	03-1993	Logic procedures for incoming signalling system No. 7 (ISUP)
Q.621	11-1988	Logic procedures for outgoing signalling system No. 4
Q.622	11-1988	Logic procedures for outgoing signalling system No. 5
Q.623	11-1988	Logic procedures for outgoing signalling system No. 6
Q.624	03-1993	Logic procedures for outgoing Signalling System No. 7 (TUP)
Q.625	11-1988	Logic procedures for outgoing signalling system R1
Q.626	11-1988	Logic procedures for outgoing signalling system R2
Q.627	03-1993	Logic procedures for outgoing Signalling System No. 7 (ISUP)
Q.634	11-1988	Logic procedures for interworking of signalling system No. 4 to R2
Q.642	11-1988	Logic procedures for interworking of signalling system No. 5 to No. 6
Q.643	11-1988	Logic procedures for interworking of signalling system No. 5 to No. 7 (TUP)
Q.644	11-1988	Logic procedures for interworking of signalling system No. 5 to R1
Q.645	11-1988	Logic procedures for interworking of signalling system No. 5 to R2
Q.646	03-1993	Logic procedures for interworking of Signalling System No. 5 to Signalling System No. 7 (ISUP)
Q.652	11-1988	Logic procedures for interworking of signalling system No. 6 to No. 5
Q.653	11-1988	Logic procedures for interworking of signalling system No. 6 to No. 7 (TUP)
Q.654	11-1988	Logic procedures for interworking of signalling system No. 6 to R1
Q.655	11-1988	Logic procedures for interworking of signalling system No. 6 to R2
Q.656	03-1993	Logic procedures for interworking of Signalling System No. 6 to Signalling System No. 7 (ISUP)
Q.662	11-1988	Logic procedures for interworking of signalling system No. 7 (TUP) to No. 5
Q.663	11-1988	Logic procedures for interworking of signalling system No. 7 (TUP) to No. 6

Q.664	11-1988	Logic procedures for interworking of signalling system No. 7 (TUP) to No. 7 (TUP)
Q.665	11-1988	Logic procedures for interworking of signalling system No. 7 (TUP) to R1
Q.666	11-1988	Logic procedures for interworking of signalling system No. 7 (TUP) to R2
Q.667	03-1993	Logic procedures for interworking of Signalling System No. 7 (TUP) to Signalling System No. 7 (ISUP)
Q.671	11-1988	Logic procedures for interworking of signalling system R1 to No. 5
Q.672	11-1988	Logic procedures for interworking of signalling system R1 to No. 6
Q.673	11-1988	Logic procedures for interworking of signalling system R1 to No. 7 (TUP)
Q.674	11-1988	Logic procedures for interworking of signalling system R1 to R2
Q.675	03-1993	Logic procedures for interworking of Signalling System R1 to Signalling System No. 7 (ISUP)
Q.681	11-1988	Logic procedures for interworking of signalling system R2 to No. 4
Q.682	11-1988	Logic procedures for interworking of signalling system R2 to No. 5
Q.683	11-1988	Logic procedures for interworking of signalling system R2 to No. 6
Q.684	11-1988	Logic procedures for interworking of signalling system R2 to No. 7 (TUP)
Q.685	11-1988	Logic procedures for interworking of signalling system R2 to R1
Q.686	03-1993	Logic procedures for interworking of Signalling System R2 to Signalling System No. 7 (ISUP)
Q.690	03-1993	Logic procedures for interworking of Signalling System No. 7 (ISUP) to No. 5
Q.691	03-1993	Logic procedures for interworking of Signalling System No. 7 (ISUP) to No. 6
Q.692	03-1993	Logic procedures for interworking of Signalling System No. 7 (ISUP) to No. 7 (TUP)
Q.694	03-1993	Logic procedures for interworking of signalling system No. 7 (ISUP) to R1
Q.695	03-1993	Logic procedures for interworking of Signalling System No. 7 (ISUP) to R2
Q.696	06-1997	Interworking between the Signalling System No. 7 ISDN User Part (ISUP) and Signalling Systems No. 5, R2 and Signalling System No. 7 TUP
Q.698	03-1993	Interworking of Signalling System No. 7 ISUP, TUP and Signalling System No. 6 using arrow diagrams
Q.699	09-1997	Interworking between ISDN access and non-ISDN access over ISDN User Part of Signalling System No. 7
Q.699 Addendum 1	12-1999	DSS1-SS7 interworking for call completion on no reply
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Q.2111 (1999) Amendment 2 Erratum 1	03-2004	
Q.2111 Amendment 3 Erratum 1	07-2004	
Q.2119	07-1996	B-ISDN ATM adaptation layer – Convergence function for SSCOP above the frame relay core service
Q.2120	02-1995	B-ISDN meta-signalling protocol
Q.2130	07-1994	B-ISDN signalling ATM adaptation layer – Service specific coordination function for support of signalling at the user-network interface (SSCF at UNI)
Q.2140	02-1995	B-ISDN ATM adaptation layer – Service specific coordination function for signalling at the network node interface (SSCF at NNI)
Q.2140 (1995) Erratum 1	03-2004	
Q.2144	10-1995	B-ISDN signalling ATM adaptation layer – Layer management for the SAAL at the network node interface
Q.2150.0	05-2001	Generic signalling transport service
Q.2150.1	05-2001	Signalling transport converter on MTP3 and MTP3b
Q.2150.2	05-2001	Signalling transport converter on SSCOP and SSCOPMCE
Q.2150.3	12-2002	Signalling transport converter on SCTP
Q.2210	07-1996	Message transfer part level 3 functions and messages using the services of ITU-T Recommendation Q.2140
Q.2220	12-2002	Transport-Independent Signalling Connection Control Part (TI-SCCP)
Q.2610	12-1999	Usage of cause and location in B-ISDN user part and DSS2
Q.2630.1	12-1999	AAL type 2 signalling protocol – Capability Set 1

Q.2630.1 Annex B	03-2001	SDL definition of the AAL type 2 signalling protocol CS-1
Q.2630.2	12-2000	AAL type 2 signalling protocol – Capability Set 2
Q.2630.2 Annex D	04-2002	SDL definition of the AAL type 2 signalling protocol CS-2
Q.2630.3	10-2003	AAL type 2 signalling protocol – Capability Set 3
Q.2631.1	10-2003	IP connection control signalling protocol - Capability Set 1
Q.2632.1	10-2003	Interworking between AAL type 2 signalling protocol Capability Set 2 and IP connection control signalling protocol Capability Set 1
Q.2650	12-1999	Interworking between signalling system No. 7 broadband ISDN User Part (B-ISUP) and digital subscriber signalling system No. 2 (DSS2)
Q.2660	12-1999	Interworking between signalling system No. 7 broadband ISDN user part (B-ISUP) and narrow-band ISDN user part (N-ISUP)
Q.2722.1	07-1996	B-ISDN user part – Network node interface specification for point-to-multipoint call/connection control
Q.2722.1 (1996) Amendment 1	06-2000	
Q.2724.1	07-1996	B-ISDN user part – Look-ahead without state change for the network node interface
Q.2726.2	07-1996	B-ISDN user part – Call priority
Q.2726.3	07-1996	B-ISDN user part – Network generated session identifier
Q.2726.4	06-2000	Extensions to the B-ISDN User Part – Application generated identifiers
Q.2730	12-1999	Signalling system No. 7 B-ISDN user part (B-ISUP) – Supplementary services
		Stage 3 description for community of interest supplementary services for B-ISDN using SS No. 7
Q.2735.1	06-1997	Closed User Group (CUG)
Q.2751.1	09-1997	Extension of Q.751.1 for SAAL signalling links
Q.2761	12-1999	Functional description of the B-ISDN user part (B-ISUP) of signalling system No. 7
Q.2761 (1999) Amendment 1	12-2002	Support for the International Emergency Preference Scheme
Q.2762	12-1999	General functions of messages and signals of the B-ISDN User Part (B-ISUP) of Signalling System No. 7
Q.2762 (1999) Amendment 1	12-2002	Support for the International Emergency Preference Scheme
Q.2763	12-1999	Signalling System No. 7 B-ISDN User Part (B-ISUP) – Formats and codes
Q.2763 (1999) Amendment 1	12-2002	Support for the International Emergency Preference Scheme
Q.2764	12-1999	Signalling System No. 7 B-ISDN User Part (B-ISUP) – Basic call procedures

Q.2764 (1999) Amendment 1	12-2002	Support for the International Emergency Preference Scheme
Q.2765	12-1999	Signalling System No. 7 B-ISDN User Part (B-ISUP) – Application transport mechanism (APM)
Q.2766.1	05-1998	Switched virtual path capability
Q.2766.1 (1998) Amendment 1	06-2000	
Q.2767.1	06-2000	Soft PVC capability
Q.2769.1	06-2000	Support of number portability information across B-ISUP
Q.2920	12-2003	Broadband integrated services digital network (B-ISDN) – Digital Subscriber Signalling System No. 2 (DSS 2): Call/connection control for the support of ATM-MPLS network interworking
Q.2931	02-1995	Digital Subscriber Signalling System No. 2 – User-Network Interface (UNI) layer 3 specification for basic call/connection control
Q.2931 (1995) Amendment 1	06-1997	
Q.2931 (1995) Amendment 2	03-1999	
Q.2931 (1995) Amendment 3	03-1999	
Q.2931 (1995) Amendment 4	12-1999	
Q.2931 (1995) Amendment 2 Corrigendum 1	06-2000	
Q.2931B	12-2000	Broadband integrated services digital network (B-ISDN) – Digital subscriber signalling system No. 2 (DSS2) – User-network interface (UNI) layer 3 specification for basic call/connection control: Protocol implementation conformance statement (PICS) proform
Q.2931C	12-2000	Broadband integrated services digital network (B-ISDN) – Digital subscriber signalling system No. 2 (DSS2) – User-network interface (UNI) layer 3 specification for basic call/connection control: Test suite structure and test purposes (TSS & TP) for the us
Q.2931D	12-2000	Broadband integrated services digital network (B-ISDN) – Digital subscriber signalling system No. 2 (DSS2) – User-network interface (UNI) layer 3 specification for basic call/connection control: Abstract Test Suite (ATS) and partial Protocol Implementatio
Q.2931E	12-2000	Broadband integrated services digital network (B-ISDN) – Digital subscriber signalling system No. 2 (DSS2) – User-network interface (UNI) layer 3 specification for basic call/connection control: Test suite structure and test purposes (TSS & TP) for the ne
Q.2931F	12-2000	Broadband integrated services digital network (B-ISDN) – Digital subscriber signalling system No. 2 (DSS2) – User-network interface (UNI) layer 3 specification for basic call/connection control: Abstract Test Suite (ATS) and partial Protocol Implementatio
		Digital subscriber signalling system No. 2 – Generic functional protocol
Q.2932.1	07-1996	Core functions

Q.2933	07-1996	Digital subscriber signalling system No. 2 – Signalling specification for frame relay service
Q.2934	05-1998	Digital subscriber signalling system No. 2 – Switched virtual path capability
Q.2939.1	09-1997	Digital Subscriber Signalling System No. 2 – Application of DSS2 service-related information elements by equipment supporting B-ISDN services
Q.2941.1	09-1997	Digital Subscriber Signalling System No. 2 – Generic identifier transport
Q.2941.2	12-1999	Digital Subscriber Signalling System No. 2 – Generic identifier transport extensions
Q.2941.3	06-2000	Digital Subscriber Signalling System No. 2 – Generic identifier transport extension for support of bearer independent call control
		Stage 3 description for number identification supplementary services using B-ISDN digital subscriber signalling system No. 2 (DSS2) – Basic Call
Q.2951.1-8	02-1995	Direct-Dialling-In (DDI)
Q.2951.1-8 (1995) Corrigendum 1	05-1998	
Q.2951.1-8	02-1995	Multiple Subscriber Number (MSN)
Q.2951.1-8	02-1995	Calling Line Identification Presentation (CLIP)
Q.2951.1-8	02-1995	Calling Line Identification Restriction (CLIR)
Q.2951.1-8	02-1995	Connected Line Identification Presentation (COLP)
Q.2951.1-8	02-1995	Connected Line Identification Restriction (COLR)
Q.2951.1-8	02-1995	Sub-addressing (SUB)
Q.2951.9	12-1999	Support of ATM end system addressing format by Number identification supplementary services
		Stage 3 description for community of interest supplementary services using B-ISDN digital subscriber signalling system No. 2 (DSS2)
Q.2955.1	06-1997	Closed User Group (CUG)
		Stage 3 description for additional information transfer supplementary services using B-ISDN digital subscriber signalling system No. 2 (DSS2) – Basic call
Q.2957.1	02-1995	User-to-user signalling (UUS)
Q.2957.1 (1995) Amendment 1	12-1999	
Q.2959	07-1996	Digital subscriber signalling system No. 2 – Call priority
		Digital subscriber signalling system No. 2 – Additional traffic parameters
Q.2961B	12-2000	Digital subscriber signalling system No. 2 (DSS2) – Additional traffic parameters: Protocol implementation conformance statement (PICS) proforma

Q.2961C	12-2000	Digital subscriber signalling system No. 2 (DSS2) – Additional traffic parameters: Test suite structure and test purposes (TSS & TP) for the user
Q.2961D	12-2000	Digital subscriber signalling system No. 2 (DSS2) – Additional traffic parameters: Abstract test suite (ATS) and partial protocol implementation extra information for testing (PIXIT) proforma for the user
Q.2961E	12-2000	Digital subscriber signalling system No. 2 (DSS2) – Additional traffic parameters: Test suite structure and test purposes (TSS & TP) for the network
Q.2961F	12-2000	Digital subscriber signalling system No. 2 (DSS2) – Additional traffic parameters: Abstract test suite (ATS) and partial protocol implementation extra information for testing (PIXIT) proforma for the Network
Q.2961.1	10-1995	Additional signalling capabilities to support traffic parameters for the tagging option and the sustainable cell rate parameter set
Q.2961.2	06-1997	Support of ATM Transfer capability in the broadband bearer capability information element
Q.2961.2 (1997) Corrigendum 1	03-1999	
Q.2961.3	09-1997	Signalling capabilities to support traffic parameters for the available bit rate (ABR) ATM transfer capability
Q.2961.4	09-1997	Signalling capabilities to support traffic parameters for the ATM Block Transfer (ABT) ATM transfer capability
Q.2961.5	03-1999	Additional traffic parameters for cell delay variation tolerance indication
Q.2961.6	05-1998	Additional signalling procedures for the support of the SBR2 and SBR3 ATM transfer capabilities
Q.2962	05-1998	Digital subscriber signalling system No. 2 – Connection characteristics negotiation during call/connection establishment phase
Q.2962B	12-2000	Digital subscriber signalling system No. 2 – Connection characteristics negotiation during call/connection establishment phase: Protocol Implementation Conformance Statement (PICS) proforma
Q.2962C	12-2000	Digital subscriber signalling system No. 2 – Connection characteristics negotiation during call/connection establishment phase: Test suite structure and test purposes (TSS & TP) for the user
Q.2962D	12-2000	Digital subscriber signalling system No. 2 – Connection characteristics negotiation during call/connection establishment phase: Abstract test suite (ATS) and partial protocol implementation extra information for testing (PIXIT) proforma for the user
Q.2962E	12-2000	Digital subscriber signalling system No. 2 – Connection characteristics negotiation during call/connection establishment phase: Test suite structure and test purposes (TSS & TP) for the network
Q.2962F	12-2000	Digital subscriber signalling system No. 2 – Connection characteristics negotiation during call/connection establishment phase: Abstract test suite (ATS) and partial protocol Implementation extra information for testing (PIXIT) proforma for the network
		Digital subscriber signalling system No. 2 – Connection modification
Q.2963.1	12-1999	Peak cell rate modification by the connection owner
Q.2963.1B	12-2000	Peak cell rate modification by the connection owner: Protocol implementation conformance statement (PICS) proforma

Q.2963.1C	12-2000	Peak cell rate modification by the connection owner: Test suite structure and test purposes (TSS & TP) for the user
Q.2963.1D	12-2000	Peak cell rate modification by the connection owner: Abstract test suite (ATS) and partial protocol implementation extra information for testing (PIXIT) proforma for the user
Q.2963.1E	12-2000	Peak cell rate modification by the connection owner: Test suite structure and test purposes (TSS & TP) for the network
Q.2963.1F	12-2000	Peak cell rate modification by the connection owner: Abstract test suite (ATS) and partial protocol implementation extra information for testing (PIXIT) proforma for the network
Q.2963.2	09-1997	Modification procedures for sustainable cell rate parameters
Q.2963.3	05-1998	ATM traffic descriptor modification with negotiation by the connection owner
Q.2964.1	07-1996	Digital subscriber signalling system No. 2 – Basic look-ahead
Q.2965.1	03-1999	Digital subscriber signalling system No. 2 – Support of Quality of Service classes
Q.2965.1 (1999) Amendment 1	06-2000	
Q.2965.1B	12-2000	Digital subscriber signalling system No. 2 – Support of Quality of Service classes: Protocol Implementation Conformance Statement (PICS) proforma
Q.2965.2	12-1999	Digital subscriber signalling system No. 2 – Signalling of individual Quality of Service parameters
Q.2965.2B	12-2000	Digital subscriber signalling system No. 2 – Signalling of individual Quality of Service parameters: Protocol Implementation Conformance Statement (PICS) proforma
Q.2971	10-1995	Digital subscriber signalling system No. 2 – User-network interface layer 3 specification for point-to-multipoint call/connection control
Q.2971 (1999) Corrigendum 1	12-1999	
Q.2971C	12-1999	Digital subscriber signalling system No. 2 – User-network interface layer 3 specification for point-to-multipoint call/connection control: Test Suite Structure and Test Purposes (TSS & TP) for the user
Q.2971D	12-1999	Digital subscriber signalling system No. 2 – User-network interface layer 3 specification for point-to-multipoint call/connection control: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra information for testing (PIXIT) proforma for the
Q.2971E	12-1999	Digital subscriber signalling system No. 2 – User-network interface layer 3 specification for point-to-multipoint call/connection control: Test Suite Structure and Test Purposes (TSS & TP) for the network
Q.2971F	12-1999	Digital subscriber signalling system No. 2 – User-network interface layer 3 specification for point-to-multipoint call/connection control: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma for the
Q.2981	12-1999	Broadband integrated services digital network (B-ISDN) and broadband private integrated services network (B-PISN) – Call control protocol
Q.2982	12-1999	Broadband integrated services sigital network (B-ISDN) – Digital subscriber signalling system No. 2 (DSS2) – Q.2931-based separated call control protocol

Q.2983	12-1999	Broadband integrated services digital network (B-ISDN) – Digital subscriber signalling system No. 2 (DSS2) – Bearer control protocol	
Q.2984	12-1999	Broadband integrated services digital network (B-ISDN) and broadband private integrated services network (B-PISN) – Prenegotiation	
		Abstract test suite for the network integration testing for B-ISDN and B-ISDN/N-ISDN	
Q.2991.1	12-1999	TSS & TP	
Q.2991.2	12-1999	ICS & IXIT and ATS	
Q-500 series Suppl. 1	11-1988	Definition of relative levels, transmission loss and attenuation/frequency distortion for digital exchanges with complex impedances at Z interfaces	Not available, contact sales@itu.int.
Q-500 series Suppl. 2	11-1988	Impedance strategy for telephone instruments and digital local exchanges in the British Telecom Network	Not available, contact sales@itu.int.
Q.Sup1	10-1995	Signalling System No. 7 testing and planning tools	
Q.Sup2	09-1997	Intelligent network user's guide: Supplement for IN CS-1	
Q.Sup3	05-1998	Number portability – Scope and capability set 1 architecture	
Q.Sup4	05-1998	Number portability – Capability set 1 requirements for service provider portability (All call query and Onward routing)	
Q.Sup5	03-1999	Number portability – Capability set 2 requirements for service provider portabilty (Query on release and Dropback)	
Q.Sup7	03-1999	Technical Report TRQ.2001: General aspects for the development of unified signalling requirements	
Q.Sup8	03-1999	Technical Report TRQ.2400: Transport control signalling requirements – Signalling requirements for AAL Type 2 link control capability set 1	
Q.Sup9	03-2004	Technical Report TRQ.2000: Roadmap for the TRQ.2xxx-series Technical Reports	
Q.Sup10	12-1999	Technical Report TRQ.2002: Information flow elements	
Q.Sup11	12-1999	Technical Report TRQ.2010: B-ISDN signalling interworking requirements	
Q.Sup12	12-1999	Technical Report TRQ.2100: Coordinated call control and bearer control signalling requirements – Root-party coordinated call and bearer control	
Q.Sup13	12-1999	Technical Report TRQ.2110: Coordinated call control and bearer control signalling requirements – Leaf-party coordinated call and bearer control	
Q.Sup14	12-1999	Technical Report TRQ.2120: Coordinated call control and bearer control signalling requirements – Third-party coordinated call and bearer control	
Q.Sup15	12-1999	Technical Report TRQ.2130: Coordinated call control and bearer control signalling requirements for leaf initiated join service	
Q.Sup16	12-1999	Technical Report TRQ.2140: Signalling requirements for the support of narrowband services via broadband transport technologies	
Q.Sup17	12-1999	Technical Report TRQ.2200: Call control signalling requirements – Party call control	

Q.Sup18	12-1999	Technical Report TRQ.2230: Call control signalling requirements – Join call service
Q.Sup19	12-1999	Technical Report TRQ.2300: Bearer control signalling requirements – Root-party bearer control
Q.Sup20	12-1999	Technical Report TRQ.2310: Bearer control signalling requirements – Leaf-party bearer control
Q.Sup21	12-1999	Technical Report TRQ.2320: Bearer control signalling requirements – Third-party bearer control
Q.Sup22	12-1999	Technical Report TRQ.3000: Operation of the bearer independant call control (BICC) protocol with digital subscriber signalling system No. 2 (DSS2)
Q.Sup23	12-1999	Supplement to ITU-T Q.1901 Recommendation – Technical Report TRQ.3010: Operation of the bearer independant call control (BICC) protocol with AAL type 2 signalling protocol (CS-1)
Q.Sup24	12-1999	Technical Report TRQ.3020: Operation of the bearer independant call control (BICC) protocol with broadband integrated services digital network user part (B-ISUP) for AAL Type 1 adaptation
Q.Sup25	12-1999	Supplement to ITU-T Q.2900 series Recommendations: Broadband integrated services digital network (B-ISDN) – Digital subscriber signalling system No. 2 (DSS2) – User-network interface layer 3 – Overview of B-ISDN DSS2 signalling capabilities
Q.Sup26	12-1999	Broadband integrated services digital network (B-ISDN) – Digital subscriber signalling system No. 2 (DSS2) and signalling system No. 7 (B-ISUP) – Support of services over IP-based networks
Q.Sup27	12-1999	Technical Report – Overview of Signalling and Protocol Framework for an Emerging Environment (SPFEE)
Q.Sup28	12-1999	Technical Report: Signalling and protocol framework for an emerging environment (SPFEE) – Specifications for service access
Q.Sup29	12-1999	Service Modelling: Evolution to the use of object oriented techniques
Q.Sup30	12-2000	Supplement to ITU-T Recommendation Q.1701 – Roadmap to IMT-2000 Recommendations, Standards and Technical Specifications
Q.Sup31	12-2000	Technical Report TRQ.2141.0: Signalling requirements for the support of narrow-band services over broadband transport technologies – Capability set 2 (CS-2)
Q.Sup32	11-2002	Technical Report TRQ.2141.1: Signalling requirements for the support of narrowband services via broadband transport technologies – CS-2 signalling flows
Q.Sup33	12-2000	Technical Report TRQ.2401: Transport control signalling requirements – Signalling requirements for AAL type 2 link control capability set 2
Q.Sup34	12-2000	Technical Report TRQ.2410: Signalling Requirements Capability Set 1 for the support of IP Bearer Control in BICC networks
Q.Sup35	12-2000	Technical Report TRQ.2500: Signalling Requirements for the support of the call bearer control interface (CS-1)
Q.Sup36	12-2000	Technical Report TRQ.3030: Operation of the bearer independent call control (BICC) protocol (CS-2) with IP bearer control protocol (IPBCP)
Q.Sup37	12-2000	DSS1 and DSS2 Messages and information element identifiers
Q.Sup38	05-2001	Technical Report TRQ.2600: BICC signalling transport requirements – Capability set 1

Q.Sup39	03-2002	Technical Report TRQ.2700: Requirements for signalling in access networks that support BICC
Q.Sup40	11-2002	Technical Report: Reference document on API/object interface between network control and application layer
Q.Sup41	11-2002	Technical Report TRQ.2003: Roadmap to the BICC protocol Recommendations, BICC interworking Recommendations, and BICC requirement Supplements
Q.Sup42	09-2003	Technical Report TRQ.2402: Transport control signalling requirements – Signalling requirements for AAL type 2 link control Capability Set 3
Q.Sup43	09-2003	Technical Report TRQ.2415: Transport control signalling requirements – Signalling requirements for IP connection control in radio access networks Capability Set 1
Q.Sup44	09-2003	Technical Report TRQ.2800: Transport control signalling requirements – Signalling requirements for AAL type 2 to IP interworking Capability Set 1
Q.Sup45	09-2003	Technical Report TRQ.2815: Requirements for interworking BICC/ISUP network with originating/destination networks based on Session Initiation Protocol and Session Description Protocol
Q.Sup46	09-2003	Technical Report TRQ.2830: ATM-MPLS network interworking signalling requirements
Q.Sup47	11-2003	Emergency services for IMT-2000 networks – Requirements for harmonization and convergence
Q.Sup48	03-2004	Guideline document for specifying API/object interface between network control and application layer
Q.Sup49	03-2004	Technical Report TRQ.2840: Signalling requirements to support IP telephony
Q.Sup50	03-2004	Technical Report TRQ.2145: Requirements for a Narrow-band Signalling Syntax (NSS)

Recommendation count: 705

Series R : Telegraph transmission

Number	*Approval Date*	*Recommendation Title*	*Status*
		Telegraph transmission	
R.2	11-1988	Element error rate	
R.4	11-1988	Methods for the separate measurements of the degrees of various types of telegraph distortion	
R.5	03-1993	Observation conditions recommended for routine distortion measurements on international telegraph circuits	
R.9	03-1993	How the laws governing distribution of distortion should be arrived at	
R.11	03-1993	Calculation of the degree of distortion of a telegraph circuit in terms of the degrees of distortion of the component links	
R.20	11-1988	Telegraph modem for subscriber lines	
R.21	08-1996	9600 bit/s modem standardized for use in the telegraph TDM system	
R.22	08-1996	Data over voice 19 200 bit/s modem standardized for use on telephone network subscriber lines	
R.30	11-1988	Transmission characteristic for international VFT links	
R.31	11-1988	Standardization of AMVFT systems for a modulation rate of 50 bauds	
R.35	11-1988	Standardization of FMVFT systems for a modulation rate of 50 bauds	
R.35bis	11-1988	50-baud wideband VFT systems	
R.36	11-1988	Coexistence of 50-baud/120-Hz channels, 100-baud/240-Hz channels, 200-baud/360-Hz or 480-Hz channels on the same voice-frequency telegraph system	
R.37	11-1988	Standardization of FMVFT systems for a modulation rate of 100 bauds	
R.38 A	11-1988	Standardization of FMVFT system for a modulation rate of 200 bauds with channels spaced at 480 Hz	
R.38B	11-1988	Standardization of FMVFT systems for a modulation rate of 200 bauds with channels spaced at 360 Hz usable on long intercontinental bearer circuits generally used with a 3-kHz spacing	
R.39	11-1988	Voice-frequency telegraphy on radio circuits	
R.40	11-1988	Coexistence in the same cable of telephony and super-telephone telegraphy	
R.43	11-1988	Simultaneous communication by telephone and telegraph on a telephone-type circuit	
R.44	11-1988	6-unit synchronous time-division 2-3-channel multiplex telegraph system for use over FMVFT channels spaced at 120 Hz for connection to standardized teleprinter networks	
R.49	11-1988	Interband telegraphy over open-wire 3-channel carrier systems	
R.50	11-1988	Tolerable limits for the degree of isochronous distortion of code-independent 50-baud telegraph circuits	

R.51	11-1988	Standardized text for distortion testing of the code-independent elements of a complete circuit
R.51bis	11-1988	Standardized text for testing the elements of a complete circuit
R.52	11-1988	Standardization of international texts for the measurement of the margin of start-stop equipment
R.53	11-1988	Permissible limits for the degree of distortion on an international 50-baud/120-Hz VFT channel (frequency and amplitude modulation)
R.54	03-1993	Conventional degree of distortion tolerable for standardized start-stop 50-baud systems
R.55	03-1993	Conventional degree of distortion
R.56	03-1993	Telegraph distortion limits to be quoted in Recommendations for equipment and transmission plans
R.57	11-1988	Standard limits of transmission quality for planning code-independent international point-to-point telegraph communications and switched networks using 50-baud start-stop equipment
R.58	11-1988	Standard limits of transmission quality for the gentex and telex networks
R.58bis	11-1988	Limits on signal transfer delay for telegraph, telex and gentex networks
R.59	11-1988	Interface requirements for 50-baud start-stop telegraph transmission in the maritime mobile satellite service
R.60	11-1988	Conditions to be fulfilled by regenerative repeaters for start-stop signals of International Telegraph Alphabet No. 2
R.62	11-1988	Siting of regenerative repeaters in international telex circuits
R.70	11-1988	Designation of international telegraph circuits
R.70bis	11-1988	Numbering of international VFT channels
R.71	11-1988	Organization of the maintenance of international telegraph circuits
R.72	11-1988	Periodicity of maintenance measurements to be carried out on the channels of international VFT systems
R.73	11-1988	Maintenance measurements to be carried out on VFT systems
R.74	11-1988	Choice of type of telegraph distortion-measuring equipment
R.75	11-1988	Maintenance measurements on code-independent international sections of international telegraph circuits
R.75bis	11-1988	Maintenance measurements of character error rate on international sections of international telegraph circuits
R.76	11-1988	Reserve channels for maintenance measurements on channels of international VFT systems
R.77	11-1988	Use of bearer circuits for voice-frequency telegraphy
R.78	11-1988	Pilot channel for AMVFT systems
R.79	11-1988	Automatic tests of transmission quality on telegraph circuits between switching centres
R.80	11-1988	Causes of disturbances to signals in VFT channels and their effect on telegraph distortion

R.81	11-1988	Maximum acceptable limit for the duration of interruption of telegraph channels arising from failure of the normal power supplies
R.82	11-1988	Appearance of false calling and clearing signals in circuits operated by switched teleprinter services
R.83	11-1988	Changes of level and interruptions in VFT channels
R.90	11-1988	Organization for locating and clearing faults in international telegraph switched networks
R.91	11-1988	General maintenance aspects for the maritime satellite telex service
R.100	03-1993	Transmission characteristics of international TDM links
R.101	03-1993	Code and speed dependent TDM system for anisochronous telegraph and data transmission using bit interleaving
R.102	03-1993	4800 bit/s code and speed dependent and hybrid TDM systems for anisochronous telegraph and data transmission using bit interleaving
R.103	11-1988	Code and speed-dependent TDM 600 bit/s system for use in point-to-point or branch-line muldex configurations
R.105	03-1993	Duplex muldex concentrator, connecting a group of gentex and telex subscribers to a telegraph exchange by assigning virtual channels to time slots of a bit-interleaved TDM system
R.106	08-1995	Muldex unit for telegraph and low speed data transmission using TDM bit interleaving with an aggregate bit rate higher than 4800 bit/s
R.111	03-1993	Code and speed independent TDM system for anisochronous telegraph and data transmission
R.112	03-1993	TDM hybrid system for anisochronous telegraph and data transmission using bit interleaving
R.113	03-1993	Combined muldex for telegraphy and synchronous data transmission
R.114	03-1993	Numbering of international TDM channels
R.115	03-1993	Maintenance loops for TDM-systems
R.116	11-1988	Maintenance tests to be carried out on international TDM systems
R.117	03-1993	End-to-end error performance for telegraph, telex and gentex connections involving regenerative equipment
R.118	03-1993	Performance and availability monitoring in regenerative TDM
R.120	11-1988	Tolerable limits for the degree of isochronous distortion of code-independent telegraph circuits operating at modulation rates of 75, 100 and 200 bauds
R.121	11-1988	Standard limits of transmission quality for start-stop user classes of service 1 and 2 on anisochronous data networks
R.122	11-1988	Summary of transmission plans for rates up to 300 bauds
R.140	11-1988	Definitions of essential technical terms in the field of telegraph transmission
R.150	11-1988	Automatic protection switching of dual diversity bearers

Recommendation count: ***72***

Series S : Telegraph services terminal equipment

Number	Approval Date	Recommendation Title	Status
		Telegraph services terminal equipment	
S.1	03-1993	International Telegraph Alphabet No. 2	
S.2	11-1988	Coding scheme using International Telegraph Alphabet No. 2 (ITA2) to allow the transmission of capital and small letters	
S.3	11-1988	Transmission characteristics of the local end with its termination (ITA2)	
S.4	03-1993	Special use of certain characters of the International Telegraph Alphabet No. 2	
S.5	11-1988	Standardization of page-printing start-stop equipment and cooperation between page-printing and tape-printing start-stop equipment (ITA2)	
S.6	11-1988	Characteristics of answerback units (ITA2)	
S.7	11-1988	Control of teleprinter motors	
S.8	03-1993	Intercontinental standardization of the modulation rate of start-stop apparatus and of the use of combination No. 4 in figure-shift	
S.9	11-1988	Switching equipment of start-stop apparatus	
S.10	11-1988	Transmission at reduced character transfer rate over a standardized 50-baud telegraph channel	
S.11	11-1988	Use of start-stop reperforating equipment for perforated tape retransmission	
S.12	11-1988	Conditions that must be satisfied by synchronous systems operating in connection with standard 50-baud teleprinter circuits	
S.13	11-1988	Use on radio circuits of 7-unit synchronous systems giving error correction by automatic repetition	
S.14	11-1988	Suppression of unwanted reception in radiotelegraph multi-destination teleprinter systems	
S.15	11-1988	Use of the telex network for data transmission at 50 bauds	
S.16	03-1993	Connection to the telex network of an automatic terminal using a V.24 DCE/DTE interface	
S.17	11-1988	Answer-back unit simulators	
S.18	11-1988	Conversion between International Telegraph Alphabet No. 2 and International Alphabet No. 5	
S.19	11-1988	Calling and answering in the telex network with automatic terminal equipment	
S.20	03-1993	Automatic clearing procedure for a telex terminal	
S.21	03-1993	Use of display screens in telex machines	
S.22	03-1993	"Conversation impossible" and or pre-recorded message in response to J/BELL signals from a telex terminal	

S.23	03-1993	Automatic request of the answerback of the terminal of the calling party, by the telex terminal of the called party or by the international network
S.30	11-1988	Standardization of basic model page-printing machine using International Alphabet No. 5
S.31	11-1988	Transmission characteristics for start-stop data terminal equipment using International Alphabet No. 5
S.32	11-1988	Answer-back units for 200- and 300-baud start-stop machines in accordance with Recommendation S.30
S.33	03-1993	Alphabets and presentation characteristics for the intex service
S.34	03-1993	Intex terminals – Requirements to effect interworking with the international telex service
S.35	03-1993	Answerback coding for the Intex service
S.36	07-1996	Intex and similar services – Terminal requirements to effect interworking between terminals operating at different speeds
S.140	11-1988	Definitions of essential technical terms relating to apparatus for alphabetic telegraphy
S.supp1	11-1988	Minimal specifications for the bilingual (arabic/latin) teleprinter

Recommendation count: 32

Series T : Terminals for telematic services

Number	*Approval Date*	*Recommendation Title*	*Status*
		Terminals for telematic services	
T.0	07-1996	Classification of facsimile terminals for document transmission over the public networks	
T.1	11-1988	Standardization of phototelegraph apparatus	
T.4	07-2003	Standardization of Group 3 facsimile terminals for document transmission	
G.511	02-1998	Test methodology for Group 3 facsimile processing equipment in the Public Switched Telephone Network	
T.6	11-1988	Facsimile coding schemes and coding control functions for Group 4 facsimile apparatus	
T.10	11-1988	Document facsimile transmissions on leased telephone-type circuits	
T.10bis	11-1988	Document facsimile transmissions in the general switched telephone network	
T.22	03-1993	Standardized test charts for document facsimile transmissions	
T.23	04-1994	Standardized colour test chart for document facsimile transmissions	
T.24	06-1998	Standardized digitized image set	Available only in PDF.
T.24 (1998) Amend.1	02-2000		Not available, contact sales@itu.int.
T.30	07-2003	Procedures for document facsimile transmission in the general switched telephone network	
T.30 (2003) Erratum 1	04-2004		
T.31	08-1995	Asynchronous facsimile DCE control – Service Class 1	
T.31 (1995) Amendment 1	07-1996	Annex B: Procedure for Service Class 1 support of V.34 modems	
T.32	08-1995	Asynchronous facsimile DCE control – Service Class 2	
T.32 (1995) Amendment 1	07-1996		
T.33	07-1996	Facsimile routing utilizing the subaddress	
T.35	02-2000	Procedure for the allocation of ITU-T defined codes for non-standard facilities	
T.36	07-1997	Security capabilities for use with Group 3 facsimile terminals	
T.36 (1997) Amendment 1	04-1999		

T.37	06-1998	Procedures for the transfer of facsimile data via store-and-forward on the Internet	
T.37 (1998) Amendment 1	09-1999	Full Mode	
T.37 (1998) Amendment 2	03-2001	Replacement of reference RFC 2531 by RFC 2879	
T.37 (1998) Amendment 3	11-2002	Support of image/tiff and image/tiff-fx MIME content-types	
T.38	04-2004	Procedures for real-time Group 3 facsimile communication over IP networks	
T.38 (2004) Amendment 1	01-2005	Addition of vendor information in SIP/SDP call setup, corrections to Annex C and Annex D, and enhanced implementation guidelines	Pre-published.
T.39	10-1997	Application profiles for simultaneous voice and facsimile terminals	
T.42	07-2003	Continuous-tone colour representation method for facsimile	
T.42 (2003) Corrigendum 1	03-2004		
T.43	07-1997	Colour and gray-scale image representations using lossless coding scheme for facsimile	
T.43 (1997) Amendment 1	02-2000	Accommodation of new and future Resolutions	
T.44	01-2005	Mixed Raster Content (MRC)	Pre-published.
T.45	02-2000	Run-length Colour Encoding	
T.50	09-1992	International Reference Alphabet (IRA) (Formerly International Alphabet No. 5 or IA5) – Information technology – 7-bit coded character set for information interchange	
T.51	09-1992	Latin based coded character sets for telematic services	
T.51 (1992) Amendment 1	08-1995		
T.52	03-1993	Non-latin coded character sets for telematic services	
T.52 (1993) Amendment 1	10-1996		
T.53	04-1994	Character coded control functions for telematic services	
T.62	03-1993	Control procedures for teletex and Group 4 facsimile services	
T.62bis	03-1993	Control procedures for teletex and G4 facsimile services based on Recommendations X.215 and X.225	
T.66	03-2002	Facsimile code points for use with Recommendations V.8 and V.8 bis	
T.70	03-1993	Network-independent basic transport service for the telematic services	
T.71	11-1988	Link access protocol balanced (LAPB) extended for half-duplex physical level facility	
T.80	09-1992	Common components for image compression and communication – Basic principles	

T.81	09-1992	Information technology – Digital compression and coding of continuous-tone still images – Requirements and guidelines
T.81 (1992) Corrigendum 1	01-2004	Patent information update
T.82	03-1993	Information technology – Coded representation of picture and audio information – Progressive bi-level image compression
T.82 (1993) Technical Cor.1	03-1995	
T.82 (1993) Technical Cor.2	03-2001	
T.83	11-1994	Information technology – Digital compression and coding of continuous-tone still images: Compliance testing
T.84	07-1996	Information technology – Digital compression and coding of continuous-tone still images: Extensions
T.84 (1996) Amendment 1	04-1999	Provisions to allow registration of new compression types and versions in the SPIFF header
T.85	08-1995	Application profile for Recommendation T.82 – Progressive bi-level image compression (JBIG coding scheme) for facsimile apparatus
T.85 (1995) Amendment 1	10-1996	
T.85 (1995) Corrigendum 1	02-1997	
T.85 (1995) Amendment 2	10-1997	
T.86	06-1998	Information technology – Digital compression and coding of continuous-tone still images: Registration of JPEG Profiles, SPIFF Profiles, SPIFF Tags, SPIFF colour Spaces, APPn Markers, SPIFF Compression types and Registration authorities (REGAUT)
T.87	06-1998	Information technology – Lossless and near-lossless compression of continuous-tone still images – Baseline
T.88	02-2000	Information technology – Lossy/lossless coding of bi-level images
T.88 (2000) Amendment 1	06-2003	Encoder
T.88 (2000) Amendment 2	06-2003	Extension of adaptive templates for halftone coding
T.88 Amendment 1 Erratum 1	12-2004	
T.89	09-2001	Application profiles for Recommendation T.88 – Lossy/lossless coding of bi-level images (JBIG2) for facsimile
T.90	02-1992	Characteristics and protocols for terminals for telematic services in ISDN
T.90 (1992) Amendment 1	11-1994	
T.90 (1992) Amendment 2	07-1996	
T.90 (1992) Amendment 3	06-1998	Cause value for a G4 fax fallback

T.100	11-1988	International information exchange for interactive Videotex
T.101	11-1994	International interworking for Videotex services
T.102	03-1993	Syntax-based Videotex end-to-end protocols for the circuit mode ISDN
T.103	03-1993	Syntax-based Videotex end-to-end protocols for the packet mode ISDN
T.104	03-1993	Packet mode access for syntax-based Videotex via PSTN
T.105	11-1994	Syntax-based Videotex application layer protocol
T.106	03-1993	Framework of videotex terminal protocols
T.107	08-1995	Enhanced man machine interface for videotex and other retrieval services (VEMMI)
T.120	07-1996	Data protocols for multimedia conferencing
T.120 Annex C	02-1998	Lightweight profiles for the T.120 architecture
T.121	07-1996	Generic application template
T.122	02-1998	Multipoint communication service – Service definition
T.123	05-1999	Network-specific data protocol stacks for multimedia conferencing
T.124	02-1998	Generic Conference Control
T.125	02-1998	Multipoint communication service protocol specification
T.126	07-1997	Multipoint still image and annotation protocol
T.127	08-1995	Multipoint binary file transfer protocol
T.128	02-1998	Multipoint application sharing
T.134	02-1998	Text chat application entity
T.135	02-1998	User-to-reservation system transactions within T.120 conferences
T.136	05-1999	Remote device control application protocol
T.137	02-2000	Virtual meeting room management for multimedia conferencing audio-visual control
T.140	02-1998	Protocol for multimedia application text conversation
T.140 Addendum 1	02-2000	
T.150	11-1988	Telewriting terminal equipment
T.170	02-1998	Framework of the T.170-Series of Recommendations
T.171	10-1996	Protocols for interactive audiovisual services: Coded representation of multimedia and hypermedia objects
T.172	02-1998	MHEG-5 – Support for base-level interactive applications
T.173	07-1997	MHEG-3 script interchange representation

T.174	10-1996	Application programming interface (API) for MHEG-1
T.175	02-1998	Application programming interface (API) for MHEG-5
T.176	02-1998	Application programming interface (API) for digital storage media command and control (DSM-CC)
T.180	06-1998	Homogeneous access mechanism to communication services
T.190	08-1995	Cooperative Document Handling (CDH) – Framework and basic services
T.191	07-1996	Cooperative document handling (CDH) – Joint synchronous editing (point-to-point)
T.192	06-1998	Cooperative document handling – Complex services: Joint synchronous editing and joint document presentation/viewing
T.300	11-1988	General principles of telematic interworking
T.330	11-1988	Telematic access to interpersonal messaging system
T.351	11-1988	Imaging process of character information on facsimile apparatus
T.390	11-1988	Teletex requirements for interworking with the telex service
T.411	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Introduction and general principles
T.411 (1993) Technical Cor. 1	10-1997	
T.412	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Document structures
T.412 (1993) Technical Cor. 1	10-1997	
T.412 (1993) Technical Cor. 2	10-1997	
T.413	11-1994	Information technology – Open Document Architecture (ODA) and interchange format: Abstract interface for the manipulation of ODA documents
T.414	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Document profile
T.414 (1993) Technical Cor. 1	10-1997	
T.414 (1993) Technical Cor. 2	10-1997	
T.415	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Open document interchange format (ODIF)
T.415 (1993) Technical Cor. 1	10-1997	
T.415 (1993) Technical Cor. 2	10-1997	
T.416	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Character content architectures
T.416 (1993) Technical Cor. 1	10-1997	

T.417	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Raster graphics content architectures
T.417 (1993) Technical Cor. 1	10-1997	
T.417 (1993) Amendment 1	10-1997	
T.417 (1993) Amendment 2	02-2000	
T.418	03-1993	Information technology – Open Document Architecture (ODA) and interchange format: Geometric graphics content architecture
T.419	08-1995	Information technology – Open Document Architecture (ODA) and interchange format: Audio content architectures
T.421	11-1994	Information technology – Open Document Architecture (ODA) and interchange format: Tabular structures and tabular layout
T.422	08-1995	Information technology – Open Document Architecture (ODA) and interchange format: Identification of document fragments
T.424	07-1996	Information technology – Open Document Architecture (ODA) and interchange format: Temporal relationships and non-linear structures
T.431	09-1992	Document Transfer And Manipulation (DTAM) – Services and protocols – Introduction and general principles
T.432	09-1992	Document Transfer And Manipulation (DTAM) – Services and protocols – Service definition
T.432 (1992) Amendment 1	08-1995	Revisions of T.432 to support G4 colour and file transfer
T.433	09-1992	Document Transfer And Manipulation (DTAM) – Services and protocols – Protocol specification
T.433 (1992) Amendment 1	08-1995	Revisions of T.433 to support G4 colour and file transfer
T.434	04-1999	Binary file transfer format for the telematic services
T.435	08-1995	Document Transfer And Manipulation (DTAM) – Services and protocols – Abstract service definition and procedures for confirmed document manipulation
T.436	08-1995	Document Transfer and Manipulation (DTAM) – Services and protocols – Protocol specifications for confirmed document manipulation
T.441	11-1988	Document Transfer And Manipulation (DTAM) – Operational structure
T.501	03-1993	Document application profile MM for the interchange of formatted mixed mode documents
T.502	11-1994	Document application profile PM-11 for the interchange of simple structure, character content documents in processable and formatted forms
T.503	02-2000	Document application profile for the interchange of Group 4 facsimile documents
T.504	03-1993	Document application profile for videotex interworking
T.505	11-1994	Document application profile PM-26 for the interchange of enhanced structure, mixed content documents in processable and formatted forms

T.506	08-1993	Document application profile PM-36 for the interchange of extended document structures and mixed content documents in processable and formatted forms	
T.510	03-1993	General overview of the T.510-Series Recommendations	
T.521	11-1994	Communication application profile BT0 for document bulk transfer based on the session service	
T.521 (1994) Amendment 1	08-1995		
T.522	09-1992	Communication application profile BT1 for document bulk transfer	
T.523	03-1993	Communication application profile DM-1 for videotex interworking	
T.541	03-1993	Operational application profile for videotex interworking	
T.561	11-1988	Terminal characteristics for mixed mode of operation MM	
T.562	11-1988	Terminal characteristics for teletex processable mode PM.1	
T.563	10-1996	Terminal characteristics for Group 4 facsimile apparatus	
T.563 (1996) Amendment 1	07-1997		
T.563 (1996) Amendment 2	10-1997	Annex C – T.30 frames for G4 facsimile	
T.563 (1996) Corrigendum 1	06-1998		
T.563 (1996) Amendment 3	04-1999		
T.564	03-1993	Gateway characteristics for videotex interworking	
T.571	09-1992	Terminal characteristics for the telematic file transfer within the teletex service	
T.611	11-1994	Programming Communication Interface (PCI) APPLI/COM for facsimile Group 3, facsimile Group 4, teletex, telex, E-mail and file transfer services	
T.800	08-2002	Information technology – JPEG 2000 image coding system: Core coding system	
T.801	08-2002	Information technology – JPEG 2000 image coding system: Extensions	
T.801 (2002) Corrigendum 3	01-2005		
T.802	01-2005	Information technology – JPEG 2000 image coding system: Motion JPEG 2000	Pre-published.
T.803	11-2002	Information technology – JPEG 2000 image coding system: Conformance testing	Available only in MS Word.
T.804	08-2002	Information technology – JPEG 2000 image coding system: Reference software	Available only in MS Word.
T.808	01-2005	Information technology – JPEG 2000 image coding system: Interactivity tools, APIs and protocols	Pre-published.
T.870	03-2002	Information technology – Lossless and near-lossless compression of continuous-tone still images: Extensions	Available only in MS Word.

Recommendation count: ***171***

Series U : Telegraph switching

Number	*Approval Date*	*Recommendation Title*	*Status*
		Telegraph switching	
U.1	03-1993	Signalling conditions to be applied in the international telex service	
U.2	11-1988	Standardization of dials and dial pulse generators for the international telex service	
U.3	11-1988	Arrangements in switching equipment to minimize the effects of false calling signals	
U.4	11-1988	Exchange of information regarding signals destined to be used over international circuits concerned with switched teleprinter networks	
U.5	11-1988	Requirements to be met by regenerative repeaters in international connections	
U.6	11-1988	Prevention of fraudulent transit traffic in the fully automatic international telex service	
U.7	03-1993	Numbering schemes for automatic switching networks	
U.8	11-1988	Hypothetical reference connections for telex and gentex networks	
U.10	03-1993	Equipment of an international telex position	
U.11	03-1993	Telex and gentex signalling on intercontinental circuits used for intercontinental automatic transit traffic (type C signalling)	
U.12	03-1993	Terminal and transit control signalling system for telex and similar services on international circuits (type D signalling)	
U.15	03-1993	Interworking rules for international signalling systems according to Recommendations U.1, U.11 and U.12	
U.20	11-1988	Telex and gentex signalling on radio channels (synchronous 7-unit systems affording error correction by automatic repetition)	
U.21	11-1988	Operator recall on a telex call set up on a radiotelegraph circuit	
U.22	11-1988	Signals indicating delay in transmission on calls set up by means of synchronous systems with automatic error correction by repetition	
U.23	11-1988	Use of radiotelegraph circuits with ARQ equipment for fully automatic telex calls charged on the basis of elapsed time	
U.24	11-1988	Requirements for telex and gentex operation to be met by synchronous multiplex equipment described in Recommendation R.44	
U.25	11-1988	Requirements for telex and gentex operation to be met by code- and speed-dependent TDM systems conforming to Recommendation R.101	
U.30	11-1988	Signalling conditions for use in the international gentex network	
U.31	11-1988	Prevention of connection to faulty stations and/or station lines in the gentex service	
U.40	03-1993	Reactions by automatic terminals connected to the telex network in the event of ineffective call attempts or signalling incidents	
U.41	11-1988	Changed address interception and call redirection in the telex service	

U.43	11-1988	Follow-on calls
U.44	11-1988	Multi-address calls in real time for broadcast purposes in the international telex service
U.45	03-1993	Response to the not-ready condition of the telex terminal
U.46	03-1993	Interruption of automatic transmission and flow control in the international telex service
U.60	11-1988	General requirements to be met in interfacing the international telex network with maritime satellite systems
U.61	03-1993	Detailed requirements to be met in interfacing the international telex network with maritime satellite systems
U.62	03-1993	General requirements to be met in interfacing the international telex network with the fully automated maritime VHF/UHF radio system
U.63	11-1988	General requirements to be met in interfacing the international telex network with the maritime "direct printing" system
U.70	11-1988	Telex service signals for telex to teletex interworking
U.74	11-1988	Extraction of telex selection information from a calling telex answerback
U.75	03-1993	Automatic called telex answerback check
U.80	03-1993	International telex store and forward access from a telex subscriber
U.81	10-1996	International telex store-and-forward – Delivery to a telex subscriber
U.101	03-1993	Signalling systems for the Intex service (types E and F signalling)
U.102	07-1996	Intex and similar services – Network requirements to effect interworking between terminals operating at different speeds
U.140	11-1988	Definitions of essential technical terms relating to telegraph switching and signalling
U.200	03-1993	The international telex service – General technical requirements for interworking
U.201	03-1993	Interworking between the teletex service and the international telex service
U.202	03-1993	Technical requirements to be met in providing the international telex service within an integrated services digital network
U.203	03-1993	Technical requirements to be met when providing real-time bothway communications between terminals of the international telex service and data terminal equipments on a PSPDN or via the PSTN
U.204	03-1993	Interworking between the international telex service and the public interpersonal messaging service
U.205	03-1993	Store-and-retrieve facility for the delivery of messages from a terminal of the international telex service to a data terminal equipment which connects to a packet-switched public data network over the public switched telephone network
U.206	03-1993	Technical requirements for interworking between the international telex service and the videotex service
U.207	03-1993	Technical requirements to be met for the transfer of messages between terminals of the international telex service and Group 3 facsimile terminals connected to the PSTN

U.208	10-1996	The international telex service – Interworking with the INMARSAT C system using one-stage selection
U.210	03-1993	Intex service network requirements to effect interworking with the international telex service
U.220	03-1993	The international telex service – Technical requirements for a status enquiry function in an interworking scenario

Recommendation count: 49

Series V : Data communication over the telephone network

Number	*Approval Date*	*Recommendation Title*	*Status*
		Data communication over the telephone network	
V.1	11-1988	Equivalence between binary notation symbols and the significant conditions of a two-condition code	
V.2	11-1988	Power levels for data transmission over telephone lines	
V.4	11-1988	General structure of signals of International Alphabet No. 5 code for character oriented data transmission over public telephone networks	
V.7	11-1988	Definitions of terms concerning data communication over the telephone network	
V.8	11-2000	Procedures for starting sessions of data transmission over the public switched telephone network	
V.8bis	11-2000	Procedures for the identification and selection of common modes of operation between data circuit-terminating equipments (DCEs) and between data terminal equipments (DTEs) over the public switched telephone network and on leased point-to-point telephone-t	
V.10	03-1993	Electrical characteristics for unbalanced double-current interchange circuits operating at data signalling rates nominally up to 100 kbit/s	
V.11	10-1996	Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s	
V.12	08-1995	Electrical characteristics for balanced double-current interchange circuits for interfaces with data signalling rates up to 52 Mbit/s	
V.13	03-1993	Simulated carrier control	
V.14	03-1993	Transmission of start-stop characters over synchronous bearer channels	
V.14 (1993) Corrigendum 1	09-1998		
V.15	11-1988	Use of acoustic coupling for data transmission	
V.16	11-1988	Medical analogue data transmission modems	
V.17	02-1991	A 2-wire modem for facsimile applications with rates up to 14 400 bit/s	
V.17 (1991) Corrigendum 1	09-1998		
V.18	11-2000	Operational and interworking requirements for DCEs operating in the text telephone mode	
V.18 (2000) Amendment 1	11-2002	Harmonization with ANSI TIA/EIA-825 (2000) text phones	
V.19	11-1988	Modems for parallel data transmission using telephone signalling frequencies	
V.21	11-1988	300 bits per second duplex modem standardized for use in the general switched telephone network	
V.22	11-1988	1200 bits per second duplex modem standardized for use in the general switched telephone network and on point-to-point 2-wire leased telephone-type circuits	

V.22bis	11-1988	2400 bits per second duplex modem using the frequency division technique standardized for use on the general switched telephone network and on point-to-point 2-wire leased telephone-type circuits
V.23	11-1988	600/1200-baud modem standardized for use in the general switched telephone network
V.24	02-2000	List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)
V.25	10-1996	Automatic answering equipment and general procedures for automatic calling equipment on the general switched telephone network including procedures for disabling of echo control devices for both manually and automatically established calls
V.25 (1996) Corrigendum 1	07-2001	
V.25bis	10-1996	Synchronous and asynchronous automatic dialling procedures on switched networks
V.26	11-1988	2400 bits per second modem standardized for use on 4-wire leased telephone-type circuits
V.26bis	11-1988	2400/1200 bits per second modem standardized for use in the general switched telephone network
V.26ter	11-1988	2400 bits per second duplex modem using the echo cancellation technique standardized for use on the general switched telephone network and on point-to-point 2-wire leased telephone-type circuits
V.27	11-1988	4800 bits per second modem with manual equalizer standardized for use on leased telephone-type circuits
V.27bis	11-1988	4800/2400 bits per second modem with automatic equalizer standardized for use on leased telephone-type circuits
V.27ter	11-1988	4800/2400 bits per second modem standardized for use in the general switched telephone network
V.28	03-1993	Electrical characteristics for unbalanced double-current interchange circuits
V.29	11-1988	9600 bits per second modem standardized for use on point-to-point 4-wire leased telephone-type circuits
V.31	11-1988	Electrical characteristics for single-current interchange circuits controlled by contact closure
V.31bis	11-1988	Electrical characteristics for single-current interchange circuits using optocouplers
V.32	03-1993	A family of 2-wire, duplex modems operating at data signalling rates of up to 9600 bit/s for use on the general switched telephone network and on leased telephone-type circuits
V.32bis	02-1991	A duplex modem operating at data signalling rates of up to 14 400 bit/s for use on the general switched telephone network and on leased point-to-point 2-wire telephone-type circuits
V.33	11-1988	14 400 bits per second modem standardized for use on point-to-point 4-wire leased telephone-type circuits
V.34	02-1998	A modem operating at data signalling rates of up to 33 600 bit/s for use on the general switched telephone network and on leased point-to-point 2-wire telephone-type circuits
V.36	11-1988	Modems for synchronous data transmission using 60-108 kHz group band circuits

V.37	11-1988	Synchronous data transmission at a data signalling rate higher than 72 kbit/s using 60-108 kHz group band circuits	
V.38	10-1996	A 48/56/64 kbit/s data circuit-terminating equipment standardized for use on digital point-to-point leased circuits	
V.41	11-1988	Code-independent error-control system	
V.42	03-2002	Error-correcting procedures for DCEs using asynchronous-to-synchronous conversion	
V.42 (2002) Corrigendum 1	07-2003		
V.42bis	01-1990	Data compression procedures for data circuit-terminating equipment (DCE) using error correction procedures	
V.43	02-1998	Data flow control	
V.44	11-2000	Data compression procedures	
V.44 (2000) Corrigendum 1	03-2002		
V.50	11-1988	Standard limits for transmission quality of data transmission	
M.729	11-1988	Organization of the maintenance of international public switched telephone circuits used for data transmission	
V.53	11-1988	Limits for the maintenance of telephone-type circuits used for data transmission	
V.54	11-1988	Loop test devices for modems	
O.71	11-1988	Impulsive noise measuring equipment for telephone-type circuits	
V.56	11-1988	Comparative tests of modems for use over telephone-type circuits	
V.56bis	08-1995	Network transmission model for evaluating modem performance over 2-wire voice grade connections	
V.56ter	08-1996	Test procedure for evaluation of 2-wire 4 kHz voiceband duplex modems	
V.58	09-1994	Management information model for V-Series DCEs	
V.59	11-2000	Managed objects for diagnostic information of public switched telephone network connected V-series modem DCEs	
V.59 (2000) Corrigendum 1	07-2001		
V.59 (2000) Corrigendum 2	03-2002		
V.61	08-1996	A simultaneous voice plus data modem, operating at a voice plus data signalling rate of 4800 bit/s, with optional automatic switching to data-only signalling rates of up to 14400 bit/s, for use on the General Switched Telephone Network and on leased point	
V.61 (1996) Corrigendum 1	01-2005		Pre-published.
V.70	08-1996	Procedures for the simultaneous transmission of data and digitally encoded voice signals over the GSTN, or over 2-wire leased point-to-point telephone type circuits	

V.70 (1996) Corrigendum 1	01-2005		Pre-published.
V.75	08-1996	DSVD terminal control procedures	
V.75 (1996) Corrigendum 1	01-2005		Pre-published.
V.75 Appendix II	02-1998	Session establishment using V.75/H.245 procedures	
V.76	08-1996	Generic multiplexer using V.42 LAPM-based procedures	
V.76 (1996) Corrigendum 1	01-2005		Pre-published.
V.80	08-1996	In-band DCE control and synchronous data modes for asynchronous DTE	
V.80 (1996) Amendment 1	07-2001	Additional data signalling rate codes in support of cellular systems	
V.90	09-1998	A digital modem and analogue modem pair for use on the Public Switched Telephone Network (PSTN) at data signalling rates of up to 56 000 bit/s downstream and up to 33 600 bit/s upstream	
V.91	05-1999	A digital modem operating at data signalling rates of up to 64 000 bit/s for use on a 4-wire circuit switched connection and on leased point-to-point 4-wire digital circuits	
V.91 (1999) Corrigendum 1	07-2001		
V.92	11-2000	Enhancements to Recommendation V.90	
V.92 (2000) Amendment 1	07-2001	Update of Tables 18, 19, 31, 32, Figure 20 and Clauses 8.6.6, 8.7.6, 9.10.1, and 9.11	
V.92 (2000) Amendment 2	03-2002	New interaction facilities for error-correcting procedures	
V.92 (2000) Corrigendum 1	07-2003		
V.100	11-1988	Interconnection between public data networks (PDNs) and the public switched telephone networks (PSTN)	
V.110	02-2000	Support by an ISDN of data terminal equipments with V-series type interfaces	
V.120	10-1996	Support by an ISDN of data terminal equipment with V-series type interfaces with provision for statistical multiplexing	
V.120 (1996) Corrigendum 1	05-1999		
V.130	08-1995	ISDN terminal adaptor framework	
V.140	01-2005	Procedures for establishing communication between two multiprotocol audiovisual terminals using digital channels at a multiple of 64 or 56 kbit/s	Pre-published.
V.150.0	01-2003	Modem-over-IP networks: Foundation	
V.150.1	01-2003	Modem-over-IP networks: Procedures for the end-to-end connection of V-series DCEs	
V.150.1 (2003) Corrigendum 1	07-2003		Pre-published.

V.150.1 (2003) Corrigendum 2	03-2004		Pre-published.
V.150.1 (2003) Amendment 1	01-2005	Modification to SSE reason identifier codes to support voice band data and text relay	Pre-published.
V.152	01-2005	Procedures for supporting voice-band data over IP networks	Pre-published.
V.230	11-1988	General data communications interface layer 1 specification	
V.250	07-2003	Serial asynchronous automatic dialling and control	
V.250 Supplement 1	06-2001	Various extensions to V.250 basic command set	
V.251	08-1996	Procedure for DTE-controlled call negotiation	
V.251 (1996) Erratum 1	10-2003		
V.252	02-1998	Procedure for control of V.70 and H.324 terminals by a DTE	
V.253	02-1998	Control of voice-related functions in a DCE by an asynchronous DTE	
V.300	07-1999	A 128 (144) kbit/s data circuit-terminating equipment standardized for use on digital point-to-point leased circuits	

Recommendation count: 101

Series X : Data networks, open system communications and security

Number	*Approval Date*	*Recommendation Title*	*Status*
		Data networks, open system communications and security	
X.1	03-2000	International user classes of service in, and categories of access to, public data networks and Integrated Services Digital Networks (ISDNs)	
X.2	03-2000	International data transmission services and optional user facilities in public data networks and ISDNs	
X.3	03-2000	Packet Assembly/Disassembly facility (PAD) in a public data network	
X.4	11-1988	General structure of signals of International Alphabet No. 5 code for character oriented data transmission over public data networks	
X.5	10-1996	Facsimile Packet Assembly/Disassembly facility (FPAD) in a public data network	
X.6	08-1997	Multicast service definition	
X.6 (1997) Amendment 1	03-2000	Frame relay PVC multicast service definition	
X.7	04-2004	Technical characteristics of data transmission services	
X.8	07-1994	Multi-aspect PAD (MAP) framework and service definition	
X.20	11-1988	Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for start-stop transmission services on public data networks	
X.20bis	11-1988	Use on public data networks of Data Terminal Equipment (DTE) which is designed for interfacing to asynchronous duplex V-Series modems	
X.21	09-1992	Interface between Data Terminal Equipment and Data Circuit-terminating Equipment for synchronous operation on public data networks	
X.21bis	11-1988	Use on public data networks of Data Terminal Equipment (DTE) which is designed for interfacing to synchronous V-Series modems	
X.22	11-1988	Multiplex DTE/DCE interface for user classes 3-6	
X.24	11-1988	List of definitions for interchange circuits between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) on public data networks	
X.25	10-1996	Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit	
X.25 (1996) Corrigendum 1	09-1998		
V.10	03-1993	Electrical characteristics for unbalanced double-current interchange circuits operating at data signalling rates nominally up to 100 kbit/s	
V.11	10-1996	Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s	
X.28	12-1997	DTE/DCE interface for a start-stop mode Data Terminal Equipment accessing the Packet Assembly/Disassembly facility (PAD) in a public data network situated in the same country	

X.28 (1997) Amendment 1	03-2000	Extensions of PAD parameter settings and PAD service signals
X.29	12-1997	Procedures for the exchange of control information and user data between a Packet Assembly/Disassembly (PAD) facility and a packet mode DTE or another PAD
X.30	03-1993	Support of X.21, X.21 bis and X.20 bis based Data Terminal Equipments (DTEs) by an Integrated Services Digital Network (ISDN)
X.31	11-1995	Support of packet mode terminal equipment by an ISDN
X.32	10-1996	Interface between Data terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and accessing a Packet-Switched Public Data Network through a public switched telephone network or an Integrated Servic
X.33	10-1996	Access to packet-switched data transmission services via frame relaying data transmission services
X.34	10-1996	Access to packet-switched data transmission services via B-ISDN
X.34 (1996) Corrigendum 1	03-2000	
X.35	11-1993	Interface between a PSPDN and a private PSDN which is based on X.25 procedures and enhancements to define a gateway function that is provided in the PSPDN
X.36	02-2003	Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for public data networks providing frame relay data transmission service by dedicated circuit
X.37	04-1995	Encapsulation in X.25 packets of various protocols including frame relay
X.38	10-1996	G3 facsimile equipment/DCE interface for G3 facsimile equipment accessing the Facsimile Packet Assembly/Disassembly facility (FPAD) in a public data network situated in the same country
X.39	10-1996	Procedures for the exchange of control information and user data between a Facsimile Packet Assembly/Disassembly (FPAD) facility and a packet mode Data Terminal Equipment (DTE) or another FPAD
X.42	10-2003	Procedures and methods for accessing a public data network from a DTE operating under control of a generalized polling protocol
X.45	10-1996	Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks, designed for efficiency at higher speeds
X.46	09-1998	Access to FRDTS via B-ISDN
X.48	10-1996	Procedures for the provision of a basic multicast service for data terminal equipments (DTEs) using Recommendation X.25
X.49	10-1996	Procedures for the provision of an extended multicast service for data terminal equipments (DTEs) using Recommendation X.25
X.50	11-1988	Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks
X.50bis	11-1988	Fundamental parameters of a 48-kbit/s user data signalling rate transmission scheme for the international interface between synchronous data networks

X.51	11-1988	Fundamental parameters of a multiplexing scheme for the international interface between synchronous data networks using 10-bit envelope structure
X.51bis	11-1988	Fundamental parameters of a 48-kbit/s user data signalling rate transmission scheme for the international interface between synchronous data networks using 10-bit envelope structure
X.52	11-1988	Method of encoding anisochronous signals into a synchronous user bearer
X.53	03-1993	Numbering of channels on international multiplex links at 64 kbit/s
X.54	11-1988	Allocation of channels on international multiplex links at 64 kbit/s
X.55	11-1988	Interface between synchronous data networks using a 6 + 2 envelope structure and single channel per carrier (SCPC) satellite channels
X.56	11-1988	Interface between synchronous data networks using an 8 + 2 envelope structure and single channel per carrier (SCPC) satellite channels
X.57	11-1988	Method of transmitting a single lower speed data channel on a 64 kbit/s data stream
X.58	11-1988	Fundamental parameters of a multiplexing scheme for the international interface between synchronous non-switched data networks using no envelope structure
X.60	11-1988	Common channel signalling for circuit-switched data applications
X.70	11-1988	Terminal and transit control signalling system for start-stop services on international circuits between anisochronous data networks
X.71	11-1988	Decentralized terminal and transit control signalling system on international circuits between synchronous data networks
X.75	10-1996	Packet-switched signalling system between public networks providing data transmission services
X.75 (1996) Corrigendum 1	09-1998	
X.76	02-2003	Network-to-network interface between public networks providing PVC and/or SVC frame relay data transmission service
X.77	08-1997	Interworking between PSPDNs via B-ISDN
X.77 (1997) Corrigendum 1	03-2000	
X.78	06-1999	Interworking procedures between networks providing frame relay data transmission services via B-ISDN
X.78 (1999) Corrigendum 1	03-2000	
X.80	11-1988	Interworking of interexchange signalling systems for circuit-switched data services
X.81	11-1988	Interworking between an ISDN circuit-switched and a circuit-switched public data network (CSPDN)
X.82	11-1988	Detailed arrangements for interworking between CSPDNs and PSPDNs based on Recommendation T.70
X.84	03-2004	Support of frame relay services over MPLS core networks

X.85/Y.1321	03-2001	IP over SDH using LAPS	
X.85/Y.1321 (2001) Amendment 1	04-2004	Bit-oriented method for LAPS	
X.86/Y.1323	02-2001	Ethernet over LAPS	
X.86/Y.1323 (2001) Amendment 1	04-2002	Using Ethernet flow control as rate limiting	
X.87/Y.1324	10-2003	Multiple services ring based on RPR	Pre-published.
X.92	11-1988	Hypothetical reference connections for public synchronous data networks	
X.96	03-2000	Call progress signals in public data networks	
X.110	04-2002	International routing principles and routing plan for Public Data Networks	
X.111	02-2003	Principles for the routing of international frame relay traffic	
X.115	04-1995	Definition of address translation capability in public data networks	
X.115 (1995) Amendment 1	10-1996	Refinements	
X.116	10-1996	Address translation registration and resolution protocol	
X.121	10-2000	International numbering plan for public data networks	
E.166/X.122	03-1998	Numbering plan interworking for the E.164 and X.121 numbering plans	
X.123	10-1996	Mapping between escape codes and TOA/NPI for E.164/X.121 numbering plan interworking during the transition period	
X.124	06-1999	Arrangements for the interworking of the E.164 and X.121 numbering plans for frame relay and ATM networks	
X.125	09-1998	Procedure for the notification of the assignment of international network identification codes for public frame relay data networks and ATM networks numbered under the E.164 numbering plan	
X.130	11-1988	Call processing delays in public data networks when providing international synchronous circuit-switched data services	
X.131	11-1988	Call blocking in public data networks when providing international synchronous circuit-switched data services	
X.134	08-1997	Portion boundaries and packet-layer reference events: basis for defining packet-switched performance parameters	
X.135	08-1997	Speed of service (delay and throughput) performance values for public data networks when providing international packet-switched services	
X.135 Suppl. 1	08-1997	Some test results from specific national and international portions	Not available, contact sales@itu.int.
X.136	08-1997	Accuracy and dependability performance values for public data networks when providing international packet-switched services	
X.137	08-1997	Availability performance values for public data networks when providing international packet-switched services	

X.138	08-1997	Measurement of performance values for public data networks when providing international packet-switched services
X.139	08-1997	Echo, drop, generator and test DTEs for measurement of performance values in public data networks when providing international packet-switched services
X.140	09-1992	General quality of service parameters for communication via public data networks
X.141	11-1988	General principles for the detection and correction of errors in public data networks
X.142	10-2003	Quality of service metrics for characterizing Frame Relay/ATM service interworking performance
X.144	10-2003	User information transfer performance parameters for public frame relay data networks
X.145	10-2003	Connection establishment and disengagement performance parameters for public Frame Relay data networks providing SVC services
X.146	10-2000	Performance objectives and quality of service classes applicable to frame relay
X.147	10-2003	Frame Relay network availability
X.147 (2003) Amendment 1	04-2004	Specification of availability objective values
X.148	02-2003	Procedures for the measurement of the performance of public data networks providing the international frame relay service
X.149	10-2003	Performance of IP networks when supported by public Frame Relay data networks
X.150	11-1988	Principles of maintenance testing for public data networks using Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) test loops
X.151	10-2003	Frame Relay operations and maintenance – Principles and functions
X.151 (2003) Erratum 1	03-2004	
X.160	10-1996	Architecture for customer network management service for public data networks
X.161	08-1997	Definition of customer network management services for public data networks
X.162	03-2000	Definition of management information for customer network management service for public data networks to be used with the CNMc interface
X.163	04-1995	Definition of management information for customer network management service for public data networks to be used with the CNMe interface
X.170	06-1999	Network-network management architecture for data networks
X.171	03-2000	Network-network management services for data networks
X.180	11-1988	Administrative arrangements for international closed user groups (CUGs)
X.181	11-1988	Administrative arrangements for the provision of international permanent virtual circuits (PVCs)
X.200	07-1994	Information technology – Open Systems Interconnection – Basic Reference Model: The basic model

X.207	11-1993	Information technology – Open Systems Interconnection – Application layer structure
X.210	11-1993	Information technology – Open Systems Interconnection – Basic Reference Model: Conventions for the definition of OSI services
X.211	11-1995	Information technology – Open Systems Interconnection – Physical service definition
X.212	11-1995	Information technology – Open Systems Interconnection – Data Link service definition
X.213	10-2001	Information technology – Open Systems Interconnection – Network service definition
X.214	11-1995	Information technology – Open Systems Interconnection -Transport service definition
X.215	11-1995	Information technology – Open Systems Interconnection – Session service definition
X.215 (1995) Amendment 1	08-1997	Efficiency enhancements
X.215 (1995) Amendment 2	12-1997	Nested connections functional unit
X.215 (1995) Technical Cor. 1	03-2000	
X.216	07-1994	Information technology – Open Systems Interconnection – Presentation service definition
X.216 (1994) Amendment 1	08-1997	Efficiency enhancements
X.216 (1994) Amendment 2	12-1997	Nested connections functional unit
X.217	04-1995	Information technology – Open Systems Interconnection – Service definition for the Association Control Service Element
X.217 (1995) Amendment 1	10-1996	Support of authentication mechanisms for the connectionless mode
X.217 (1995) Amendment 2	08-1997	Fast-associate mechanism
X.217bis	09-1998	Information technology – Open Systems Interconnection – Service definition for the Application Service Object Association Control Service Element
X.218	03-1993	Reliable Transfer: Model and service definition
X.219	11-1988	Remote Operations: Model, notation and service definition
X.220	03-1993	Use of X.200-Series protocols in CCITT applications
X.222	04-1995	Use of X.25 LAPB-compatible Data Link procedures to provide the OSI connection-mode Data Link service
X.222 (1995) Amendment 1	10-1996	Frame relay mapping
X.223	11-1993	Use of X.25 to provide the OSI connection-mode Network service for ITU-T applications

X.223 (1993) Amendment 1	10-1996	Transit delay and other refinements
X.224	11-1995	Information technology – Open Systems Interconnection – Protocol for providing the connection-mode transport service
X.224 (1995) Amendment 1	08-1997	Relaxation of class conformance requirements and expedited data service feature negotiation
X.225	11-1995	Information technology – Open Systems Interconnection – Connection-oriented Session protocol: Protocol specification
X.225 (1995) Amendment 1	08-1997	Efficiency enhancements
X.225 (1995) Amendment 2	12-1997	Nested connections functional unit
X.225 (1995) Technical Cor. 1	03-2000	
X.226	07-1994	Information technology – Open Systems Interconnection – Connection-oriented Presentation protocol: Protocol specification
X.226 (1994) Amendment 1	08-1997	Efficiency enhancements
X.226 (1994) Amendment 2	12-1997	Nested connections functional unit
X.227	04-1995	Information technology – Open Systems Interconnection – Connection-oriented protocol for the Association Control Service Element: Protocol specification
X.227 (1995) Amendment 1	10-1996	Incorporation of extensibility markers
X.227 (1995) Amendment 2	08-1997	Fast-associate mechanism
X.227bis	09-1998	Information technology – Open Systems Interconnection – Connection-mode protocol for the Application Service Object Association Control Service Element
X.228	11-1988	Reliable Transfer: Protocol specification
X.228 (1988) Corrigendum 1	03-2000	
X.229	11-1988	Remote Operations: Protocol specification
X.233	08-1997	Information technology – Protocol for providing the connectionless-mode network service: Protocol specification
X.234	07-1994	Information technology – Protocol for providing the OSI connectionless-mode transport service
X.234 (1994) Amendment 1	11-1995	Addition of connectionless-mode multicast capability
X.235	04-1995	Information technology – Open Systems Interconnection – Connectionless Session protocol: Protocol specification
X.235 (1995) Amendment 1	06-1999	Efficiency enhancements
X.236	04-1995	Information technology – Open Systems Interconnection – Connectionless Presentation protocol: Protocol specification

X.236 (1995) Amendment 1	06-1999	Efficency enhancements
X.237	04-1995	Information technology – Open Systems Interconnection – Connectionless protocol for the Association Control Service Element: Protocol specification
X.237 (1995) Amendment 1	10-1996	Incorporation of extensibility markers and authentication parameters
X.237 Amd1 (10/96) Technical Cor.1	06-1999	
X.237bis	09-1998	Information technology – Open Systems Interconnection – Connectionless protocol for the Application Service Object Association Control Service Element
X.245	04-1995	Information technology – Open Systems Interconnection – Connection-oriented Session protocol: Protocol Implementation Conformance Statement (PICS) proforma
X.246	10-1996	Information technology – Open Systems Interconnection – Connection-oriented Presentation protocol: Protocol Implementation Conformance Statement (PICS) proforma
X.247	10-1996	Information technology – Open Systems Interconnection – Protocol specification for the Association Control Service Element: Protocol Implementation Conformance Statement (PICS) proforma
X.248	11-1995	Information technology – Open Systems Interconnection – Reliable Transfer: Protocol Implementation Conformance Statement (PICS) proforma
X.249	11-1995	Information technology – Open Systems Interconnection – Remote Operations: Protocol Implementation Conformance Statement (PICS) proforma
X.255	04-1995	Information technology – Open Systems Interconnection – Connectionless Session protocol: Protocol Implementation Conformance Statement (PICS) proforma
X.256	04-1995	Information technology – Open Systems Interconnection – Connectionless Presentation protocol: Protocol Implementation Conformance Statement (PICS) proforma
X.257	04-1995	Information technology – Open Systems Interconnection – Connectionless protocol for the Association Control Service Element: Protocol Implementation Conformance Statement (PICS) proforma
X.257 (1995) Amendment 1	10-1996	Support of authentication parameters
X.260	10-1996	Information technology – Framework for protocol identification and encapsulation
X.263	09-1998	Information technology – Protocol identification in the Network Layer
X.264	11-1993	Transport protocol identification mechanism
X.272	03-2000	Data compression and privacy over frame relay networks
X.273	07-1994	Information technology – Open Systems Interconnection – Network layer security protocol
X.274	07-1994	Information technology – Telecommunication and information exchange between systems – Transport layer security protocol

X.281	06-1999	Information technology – Elements of management information related to the OSI Physical Layer
X.282	06-1999	Elements of management information related to the OSI Data Link layer
X.283	12-1997	Information technology – Elements of management information related to the OSI Network layer
X.284	12-1997	Information technology – Elements of management information related to the OSI Transport layer
X.287	03-1999	Information technology – Open Systems Interconnection – Structure of management information: Managed objects for supporting upper layers
X.290	04-1995	OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – General concepts
X.291	04-1995	OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – Abstract test suite specification
X.292	05-2002	OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – The Tree and Tabular Combined Notation (TTCN)
X.293	04-1995	OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – Test realization
X.294	04-1995	OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – Requirements on test laboratories and clients for the conformance assessment process
X.295	04-1995	OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – Protocol profile test specification
X.296	11-1995	OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – Implementation conformance statements
X.300	10-1996	General principles for interworking between public networks and between public networks and other networks for the provision of data transmission services
X.301	10-1996	Description of the general arrangements for call control within a subnetwork and between subnetworks for the provision of data transmission services
X.302	11-1988	Description of the general arrangements for internal network utilities within a subnetwork and intermediate utilities between subnetworks for the provision of data transmission services
X.305	11-1988	Functionalities of subnetworks relating to the support of the OSI connection-mode network service
X.320	10-1996	General arrangements for interworking between Integrated Services Digital Networks (ISDNs) for the provision of data transmission services
X.321	10-1996	General arrangements for interworking between Circuit-Switched Public Data Networks (CSPDNs) and Integrated Services Digital Networks (ISDNs) for the provision of data transmission services
X.322	11-1988	General arrangements for interworking between Packet-Switched Public Data Networks (PSPDNs) and Circuit-Switched Public Data Networks (CSPDNs) for the provision of data transmission services
X.323	11-1988	General arrangements for interworking between Packet-Switched Public Data Networks (PSPDNs)

X.324	11-1988	General arrangements for interworking between Packet-Switched Public Data Networks (PSPDNs) and public mobile systems for the provision of data transmission services
X.325	10-1996	General arrangements for interworking between Packet-Switched Public Data Networks (PSPDNs) and Integrated Services Digital Networks (ISDNs) for the provision of data transmission services
X.326	11-1988	General arrangements for interworking between Packet-Switched Public Data Networks (PSPDNs) and Common Channel Signalling Network (CCSN)
X.327	11-1993	General arrangements for interworking between Packet-Switched Public Data Networks (PSPDNs) and private data networks for the provision of data transmission services
X.328	10-1996	General arrangements for interworking between Public Data Networks providing frame relay data transmission services and Integrated Services Digital Networks (ISDNs) for the provision of data transmission services
X.329	03-2000	General arrangements for interworking between networks providing frame relay data transmission services and B-ISDN
X.340	03-1993	General arrangements for interworking between a Packet-Switched Public Data Network (PSPDN) and the international telex network
X.350	12-1997	General interworking requirements to be met for data transmission in international public mobile satellite systems
X.351	11-1988	Special requirements to be met for Packet Assembly/Disassembly facilities (PADs) located at or in association with coast earth stations in the public mobile satellite service
X.352	11-1988	Interworking between Packet-Switched Public Data Networks and public maritime mobile satellite data transmission systems
X.353	11-1988	Routing principles for interconnecting public maritime mobile satellite data transmission systems with public data networks
X.361	10-1996	Connection of VSAT systems with Packet-Switched Public Data Networks based on X.25 procedures
X.371/Y.1402	02-2001	General arrangements for interworking between Public Data Networks and the Internet
F.400/X.400	06-1999	Message handling system and service overview
X.402	06-1999	Information technology – Message Handling Systems (MHS): Overall architecture
X.404	06-1999	Information technology – Message Handling Systems (MHS): MHS routing – Guide for messaging systems managers
X.408	11-1988	Message handling systems: Encoded information type conversion rules
X.411	06-1999	Information technology – Message Handling Systems (MHS): Message Transfer System: Abstract Service Definition and Procedures
X.412	06-1999	Information technology – Message Handling Systems (MHS): MHS routing
X.413	06-1999	Information technology – Message Handling Systems (MHS): Message store – Abstract service definition
X.419	06-1999	Information technology – Message Handling Systems (MHS): Protocol Specifications

X.420	06-1999	Information technology – Message Handling Systems (MHS): Interpersonal Messaging System
X.421	06-1999	Message handling systems: COMFAX use of MHS
X.435	06-1999	Information technology – Message Handling Systems (MHS): Electronic data interchange messaging system
X.440	06-1999	Message handling systems: Voice messaging system
X.445	04-1995	Asynchronous protocol specification – Provision of OSI connection mode network service over the telephone network
X.446	08-1997	Common messaging call API
X.460	04-1995	Information technology – Message Handling Systems (MHS) Management: Model and architecture
X.462	10-1996	Information technology – Message Handling Systems (MHS) Management: Logging information
X.467	10-1996	Information technology – Message Handling Systems (MHS) Management: Message Transfer Agent management
X.481	06-1999	Message handling systems – P2 protocol PICS proforma
X.482	06-1999	Message handling systems – P1 Protocol PICS proforma
X.483	06-1999	Message handling systems – P3 Protocol PICS proforma
X.484	06-1999	Message handling systems – P7 protocol PICS proforma
X.485	09-1992	Message handling systems: Voice messaging system Protocol Implementation Conformance Statement (PICS) proforma
X.486	06-1999	Message handling systems – Pedi protocol PICS proforma
X.487	06-1999	Message handling systems – IPM-MS attributes PICS proforma
X.488	06-1999	Message handling systems – EDI-MS attributes PICS proforma
X.500	02-2001	Information technology – Open Systems Interconnection – The Directory: Overview of concepts, models and services
X.501	02-2001	Information technology – Open Systems Interconnection – The Directory: Models
X.509	03-2000	Information technology – Open Systems Interconnection – The Directory: Public-key and attribute certificate frameworks
X.509 (2000) Technical Cor.1	10-2001	
X.509 (2000) Technical Cor.2	04-2002	
X.509 (2000) Corrigendum 3	04-2004	
X.511	02-2001	Information technology – Open Systems Interconnection – The Directory: Abstract service definition
X.518	02-2001	Information technology – Open Systems Interconnection – The Directory: Procedures for distributed operation

X.519	02-2001	Information technology – Open Systems Interconnection – The Directory: Protocol specifications
X.520	02-2001	Information technology – Open Systems Interconnection – The Directory: Selected attribute types
X.520 (2001) Technical Cor.1	04-2002	
X.521	02-2001	Information technology – Open Systems Interconnection – The Directory: Selected object classes
X.525	02-2001	Information technology – Open Systems Interconnection – The Directory: Replication
X.530	02-2001	Information technology – Open Systems Interconnection – The Directory: Use of systems management for administration of the Directory
X.583	12-1997	Information technology – Open Systems Interconnection – The Directory: Protocol Implementation Conformance Statement (PICS) Proforma for the Directory Access Protocol
X.584	12-1997	Information technology – Open Systems Interconnection – The Directory: Protocol Implementation Conformance Statement (PICS) Proforma for the Directory System Protocol
X.585	12-1997	Information technology – Open Systems Interconnection – The Directory: Protocol Implementation Conformance Statement (PICS) Proforma for the Directory Operational Binding Management Protocol
X.586	12-1997	Information technology – Open Systems Interconnection – The Directory: Protocol Implementation Conformance Statement (PICS) Proforma for the Directory Information Shadowing Protocol
X.601	03-2000	Multi-peer communications framework
X.602	04-2004	Information technology – Group management protocol
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X.605	09-1998	Information technology – Enhanced Communications Transport Service definition
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X.614	09-1992	Information technology – Use of X.25 Packet Layer Protocol to provide the OSI connection-mode Network service over the telephone network
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X.623	07-1994	Information technology – Protocol for providing the connectionless-mode Network service: Provision of the underlying service by a subnetwork that provides the OSI Data Link service	
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X.633 Addendum 1	09-1998	SDL specifications	
X.634	10-1996	Information technology – Open Systems Interconnection – Transport Fast Byte Protocol	
X.634 Addendum 1	09-1998	SDL specifications	
X.637	10-1996	Basic connection-oriented common upper layer requirements	
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X.639	10-1996	Basic connection-oriented requirements for ROSE-based profiles	
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X.691 (2002) Amendment 1	10-2003	Support for EXTENDED-XER	
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X.711 (1997) Technical Cor. 1	03-1999		Available only in PDF.
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X.722	01-1992	Information technology – Open Systems Interconnection – Structure of management information: Guidelines for the definition of managed objects	
X.722 (1992) Amendment 1	11-1995	Set by create and component registration	
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X.722 (1992) Amendment 2	08-1997	Addition of the NO-MODIFY syntax element and guidelines extension	
X.722 (1992) Amendment 3	08-1997	Guidelines for the use of Z in formalizing the behaviour of managed objects	

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X.730	01-1992	Information technology – Open Systems Interconnection – Systems Management: Object management function
X.730 (1992) Amendment 1	04-1995	Implementation Conformance Statement proformas
X.730 (1992) Am1Technical Cor.1	10-1996	
X.731	01-1992	Information technology – Open Systems Interconnection – Systems management: State management function
X.731 (1992) Technical Cor. 1	04-1995	
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X.731 (1992) Am1Technical Cor.1	10-1996	
X.731 (1992) Technical Cor. 2	01-2001	Clarification of state change event
X.731 (1992) Amendment 2	01-2001	Amendment to support LIFECYCLE state
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X.732 (1992) Am1Technical Cor.1	10-1996	
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X.733 (1992) Amendment 1	04-1995	Implementation Conformance Statement proformas
X.733 (1992) Am1Technical Cor.1	10-1996	
X.733 (1992) Technical Cor. 2	03-1999	
X.734	09-1992	Information technology – Open Systems Interconnection – Systems Management: Event report management function
X.734 (1992) Technical Cor. 1	02-1994	
X.734 (1992) Amendment 1	04-1995	Implementation Conformance Statement proformas
X.734 (1992) Am1Technical Cor.1	10-1996	
X.734 (1992) Technical Cor. 2	03-1999	
X.735	09-1992	Information technology – Open Systems Interconnection – Systems Management: Log control function
X.735 (1992) Amendment 1	04-1995	Implementation Conformance Statement proformas
X.735 (1992) Am1Technical Cor.1	10-1996	
X.735 (1992) Technical Cor.1	03-2001	
X.736	01-1992	Information technology – Open Systems Interconnection – Systems Management: Security alarm reporting function
X.736 (1992) Amendment 1	04-1995	Implementation Conformance Statement proformas
X.736 (1992) Amd.1Technical Cor.1	10-1996	
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X.737 (1995) Technical Cor. 1	06-1998	

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X.737 (1995) Technical Cor.3	03-2001	
X.738	11-1993	Information technology – Open Systems Interconnection – Systems management: Summarization function
X.738 (1993) Amendment 1	10-1996	Implementation conformance statement proformas
X.738 (1993) Technical Cor. 1	06-1998	
X.738 (1993) Technical Cor.2	02-2000	Revision to include ASN.1:1997
X.739	11-1993	Information technology – Open Systems Interconnection – Systems Management: Metric objects and attributes
X.739 (1993) Amendment 1	08-1997	Implementation conformance statement proformas
X.739 (1993) Technical Cor. 1	06-1998	
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X.740 (1992) Technical Cor. 1	04-1995	
X.740 (1992) Technical Cor. 2	10-1996	
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X.742 (1995) Technical Cor. 1	06-1998	
X.742 (1995) Technical Cor.2	02-2000	
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X.743 (1998) Technical Cor.1	03-2001	

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X.744 (1996) Technical Cor. 1	06-1998	
X.744 (1996) Technical Cor.2	02-2000	Revision to include ASN.1:1997
X.744 (1996) Technical Cor.3	03-2001	
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X.745 (1993) Technical Cor. 1	08-1997	
X.745 (1993) Technical Cor. 2	06-1998	
X.745 (1993) Technical Cor.3	02-2000	
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X.750 (1996) Technical Cor.1	02-2000	Revision to include ASN.1:1997
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Recommendation count: 484

Series Y : Global information infrastructure, Internet protocol aspects and next-generation networks

Number	*Approval Date*	*Recommendation Title*	*Status*
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Y.1241	03-2001	Support of IP-based services using IP transfer capabilities	
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G.7041/Y.1303 (2003) Amendment 2	06-2004		
G.7041/Y.1303 (2003) Amendment 1	10-2004		
G.7041/Y.1303 (2003) Corrigendum 1	01-2005		
G.7041/Y.1303 (2003) Amendment 3	01-2005		
G.8080/Y.1304	11-2001	Architecture for the automatically switched optical network (ASON)	
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X.85/Y.1321 (2001) Amendment 1	04-2004	Bit-oriented method for LAPS	

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G.707/Y.1322 (2003) Corrigendum 1	06-2004		
G.707/Y.1322 Amendment 1	08-2004		
X.86/Y.1323	02-2001	Ethernet over LAPS	
X.86/Y.1323 (2001) Amendment 1	04-2002	Using Ethernet flow control as rate limiting	
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G.709/Y.1331 (2003) Amendment 1	12-2003		Pre-published.
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G.8040/Y.1340 (2004) Corrigendum 1	01-2005		
G.8040/Y.1340 (2004) Amendment 1	01-2005		
G.8021/Y.1341	08-2004	Characteristics of Ethernet transport network equipment functional blocks	
G.7043/Y.1343	07-2004	Virtual concatenation of plesiochronous digital hierarchy (PDH) signals	
G.7043/Y.1343 (2004) Amendment 1	01-2005		
G.780/Y.1351	07-2004	Terms and definitions for synchronous digital hierarchy (SDH) networks	
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Y.1415	02-2005	Ethernet-MPLS network interworking – User plane interworking	

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Y.1540 (2002) Amendment 1	08-2003	New Appendix VIII: Background on IP service availability	
Y.1541	05-2002	Network performance objectives for IP-based services	
Y.1541 (2002) Amendment 1	08-2003	Revised Appendix VI: Applicability of the Y.1221 transfer capabilities and IETF differentiated services to IP QoS classes	
Y.1541 (2002) Amendment 2	02-2004	New Appendix XI – Concatenating QoS values	
Y.1541 Appendix X	11-2002	Speech quality calculations for Y.1541 hypothetical reference paths	
Y.1560	09-2003	Parameters for TCP connection performance in the presence of middleboxes	
Y.1561	05-2004	Performance and availability parameters for MPLS networks	
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G.7712/Y.1703	03-2003	Architecture and specification of data communication network	
G.7713/Y.1704	12-2001	Distributed Call and Connection Management (DCM)	
G.7713/Y.1704 (2001) Amendment 1	06-2004		
G.7713.1/Y.1704.1	03-2003	Distributed Call and Connection Management (DCM) based on PNNI	
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G.7713.3/Y.1704.3	03-2003	Distributed Call and Connection Management: Signalling mechanism using GMPLS CR-LDP	
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G.7718/Y.1709	02-2005	Framework for ASON management	Pre-published.
Y.1710	11-2002	Requirements for Operation & Maintenance functionality in MPLS networks	
Y.1711	02-2004	Operation & Maintenance mechanism for MPLS networks	

Y.1711 (2004) Corrigendum 1	02-2005	
Y.1712	01-2004	OAM functionality for ATM-MPLS interworking
Y.1713	03-2004	Misbranching detection for MPLS networks
Y.1720	09-2003	Protection switching for MPLS networks
Y.1720 (09/2003) Erratum 1	04-2004	
Y.1730	01-2004	Requirements for OAM functions in Ethernet-based networks and Ethernet services
Y.2001	12-2004	General overview of NGN
Y.2011	10-2004	General principles and general reference model for Next Generation Networks

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Number	*Approval Date*	*Recommendation Title*	*Status*
		Languages and general software aspects for telecommunication systems	
Z.100	08-2002	Specification and Description Language (SDL)	
Z.100 (2002) Amendment 1	10-2003	Backwards compatibility and compliance	
Z.100 (2002) Corrigendum 1	08-2004		
Z.100 Annex F1	11-2000	SDL formal definition: General overview	
Z.100 Annex F2	11-2000	SDL formal definition: Static semantics	Available only in PDF.
Z.100 Annex F3	11-2000	SDL formal definition: Dynamic semantics	
Z.100 Supplement 1	05-1997	SDL+ methodology: use of MSC and SDL (with ASN.1)	
Z.104	10-2004	Encoding of SDL data	
Z.105	07-2003	SDL combined with ASN.1 modules (SDL/ASN.1)	
Z.106	08-2002	Common interchange format for SDL	
Z.107	11-1999	SDL with embedded ASN.1	
Z.109	11-1999	SDL combined with UML	
Z.110	11-2000	Criteria for use of formal description techniques by ITU-T	
Z.120	04-2004	Message sequence chart (MSC)	Pre-published.
Z.120 Annex B	04-1998	Formal semantics of message sequence charts	Available only in PDF.
Z.121	02-2003	Specification and Description Language (SDL) data binding to Message Sequence Charts (MSC)	
Z.130	07-2003	Extended Object Definition Language (eODL): Techniques for distributed software component development – Conceptual foundation, notations and technology mappings	Pre-published.
Z.140	04-2003	Testing and Test Control Notation version 3 (TTCN-3): Core language	
Z.141	02-2003	Testing and Test Control Notation version 3 (TTCN-3): Tabular presentation format	
Z.142	02-2003	Testing and Test Control Notation version 3 (TTCN-3): Graphical presentation format	
Z.150	02-2003	User Requirements Notation (URN) - Language requirements and framework	
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Z.302	11-1988	The meta-language for describing MML syntax and dialogue procedures	
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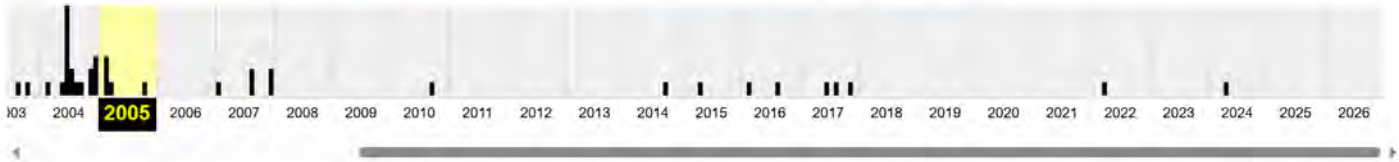
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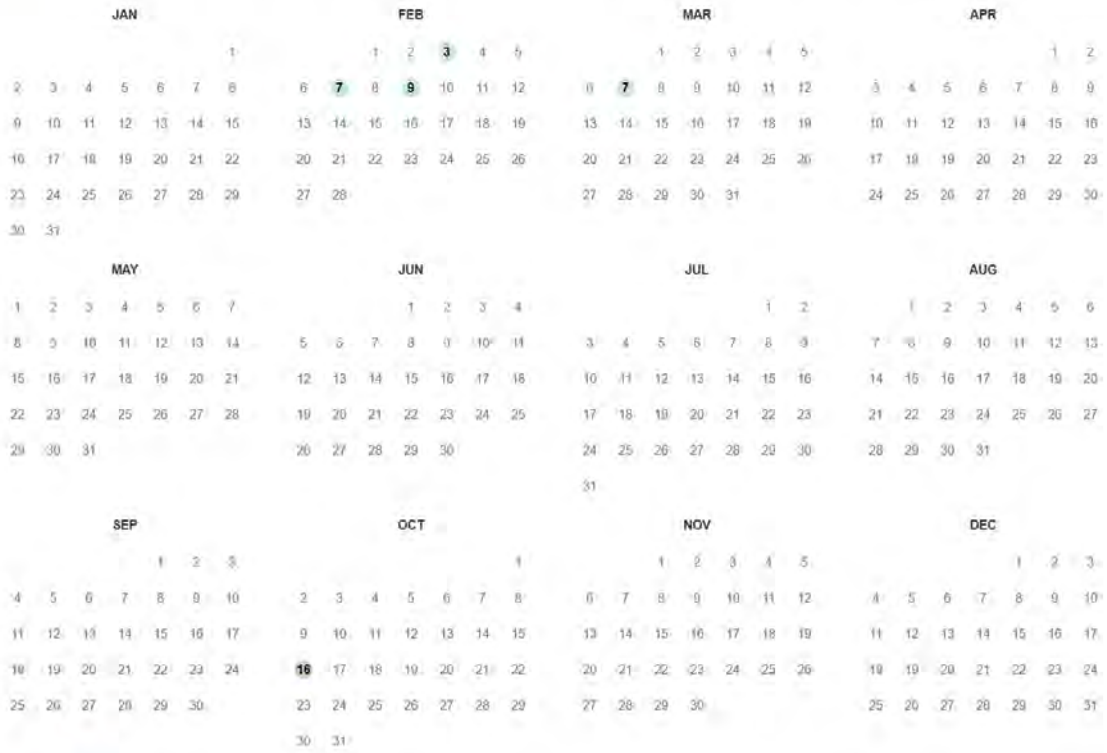
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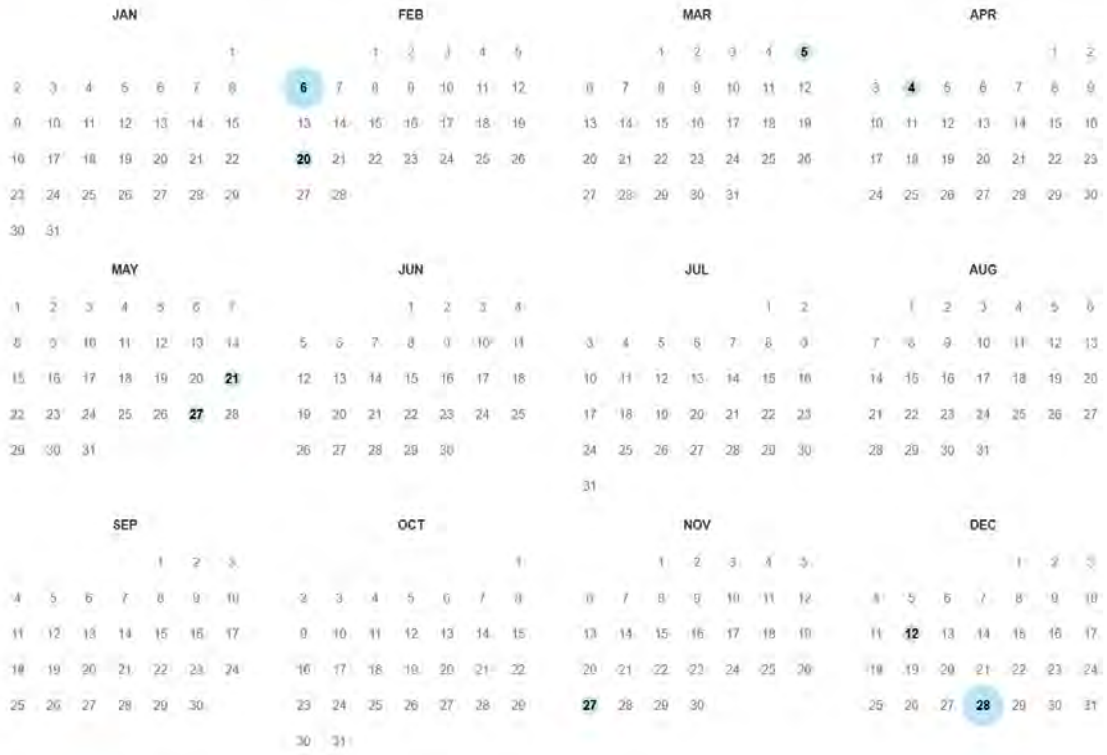
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