UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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ADOBE INC.

Petitioner

v.

JONATHAN E. JAFFE
Patent Owner

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U.S. Patent No. 6,757,828

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DECLARATION OF KENNETH PARULSKI IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 6,757,828

I, Kenneth Parulski, declare as follows:

1. I make this declaration based upon my own personal knowledge and, if called upon to testify, would testify competently to the matters stated herein.

2. I am the Chief Scientist and Managing Member at aKAP Innovations, LLC. A copy of my curriculum vitae is attached as Exhibit A to this declaration.

3. I received a Master of Science degree in Electrical Engineering and a Bachelor of Science degree in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology in May 1980. I joined the Kodak Research Labs division of Eastman Kodak Company in August 1980, where I began developing and implementing image processing algorithms. From approximately 1990 until my retirement from Kodak in 2012, I was involved in the research and development of Kodak's consumer digital cameras. Beginning in 1992, I served as architect of Kodak's first generation of consumer-oriented digital still cameras.

4. As part of my Kodak job responsibilities, starting in 1994 I worked with the key technical experts in Japan who were responsible for standardizing image formats for digital still cameras through an organization called the Japan Electronic Industry Development Association (JEIDA). These experts included Mikio Watanabe, the chairman of the JEIDA Exif sub working group who is now known as the "father of Exif"; Masaki Izumi, who represented Eastman Kodak

Japan Ltd. at meetings of the JEIDA Exif sub working group; and Motokazu Ohkawa, the chairman of the JEIDA Digital Still Camera Technical Committee.

5. The first Exif standard (version 1.0) was published by JEIDA in October 1995. I note that some later versions of Exif incorrectly list October 1996 as the Exif 1.0 publication date. More recent versions correctly identify October 1995, which is also the date listed on the copy of Exif 1.0 that I have in my files. Version 1.1 of the Exif standard was published by JEIDA in May 1997.

6. Version 2.0 of the Exif standard was published by JEIDA in November 1997. I received a hardcopy of the Exif version 2.0 standard document, entitled "Digital Still Camera Image File Format Standard (Exchangeable image file format for Digital Still Camera: Exif) Version 2.0," shortly after it was published and certainly before the end of 1997. I have maintained that hardcopy document in my files ever since. Exhibit B attached to this declaration is a true and correct copy of the Exif version 2.0 standard document that I have maintained in my files since 1997. On pdf-page 175 of Exhibit B, Mikio Watanabe is listed as the chairman of the JEIDA Exif sub working group and Masaki Izumi is listed as a member. On pdf-page 4 of Exhibit B, it states: "First Printing, November 1997."

7. People working in the camera industry, or otherwise interested in digital images and image processing, could easily obtain a copy of the Exif version 2.0 standard after it was released in 1997. The Exif standard was publicly

available and simple to obtain. One could contact JEIDA and request a copy for a fee, and the organization would provide a copy. Kodak used the Exif image format in its consumer digital cameras beginning in 1997. I recall telling others at Kodak how to obtain a copy of the Exif standard, and that they were able to do so. Throughout the 1990s, JEIDA was trying to get camera manufacturers and others to use the Exif standard in their products, and as part of that effort they made the standard available to anyone who asked so long as they paid the required fee.

8. Version 2.1 of the Exif standard was released in June 1998. Exhibit C attached to this declaration is a true and correct copy of a document I received by July 1998 and have maintained in my files ever since. It shows the differences between the newly released version 2.1 and the earlier version 2.0 of the Exif standard. On pdf-page 16 of Exhibit C, Mikio Watanabe is listed as the chairman of the JEIDA Exif sub working group and Masaki Izumi is listed as a member. On pdf-page 2 of Exhibit B, it states: "First Printing, June 1998."

9. Exhibit D attached to this declaration is a true and correct copy of version 2.1 of the Exif standard entitled "Digital Still Camera Image File Format Standard (Exchangeable image file format for Digital Still Cameras: Exif) Version 2.1." This document was publicly available from JEIDA by December 1998. It applied the changes made in Exif version 2.1 (shown in Exhibit C) to the Exif version 2.0 document (shown in Exhibit B) to make a single document, which was

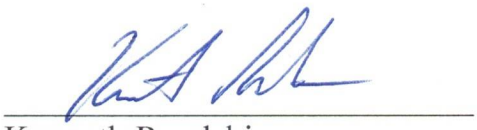
more convenient for users of the Exif 2.1 standard. Like the earlier version 2.0, version 2.1 of the Exif standard was publicly available and easy to obtain simply by contacting JEIDA and paying a fee. I recall telling others at Kodak how to obtain a copy of this version of the Exif standard, and that they were able to do so. As I mentioned above, JEIDA was trying to get camera manufacturers and others to use the Exif standard in their products, and as part of that effort they made the standard available to anyone who asked for it so long as they paid the required fee.

10. I have reviewed a declaration provided by Rachel Watters identified as Exhibit 1007. Her declaration shows that a paper entitled "Digital Image Recording for Court-Related Purposes" was published in the proceedings of an IEEE conference called the 1999 IEEE International Carnahan Conference on Security Technology, held October 5-7, 1999 in Madrid, Spain. I am familiar with the type of conference proceedings discussed in Ms. Watters' declaration. I joined IEEE (the Institute of Electrical and Electronics Engineers) as a student member in 1978, and I am now a Life Senior member of IEEE. I attended many IEEE conferences from 1982 through 2000, and I presented papers at several of those conferences. In addition, I served on the program committee for the IEEE 1983 Custom Integrated Circuits Conference and the IEEE 1984 Custom Integrated Circuits Conference. I also served on the program committee for the 1987 IEEE International Conference on Consumer Electronics and the 1988 IEEE

International Conference on Consumer Electronics. Program committee members were responsible for reviewing and selecting papers to be presented at the conference, and for organizing the conference sessions and introducing the speakers. Authors presented their papers at these IEEE conferences, and attendees could obtain a compilation of the papers in the conference proceedings which were distributed at the conference. In addition, libraries and others who did not attend the conference could purchase the conference proceedings from the IEEE shortly afterward. I can confirm that people working and researching in the areas of electrical engineering, computer science, and similar fields would have known that such conference proceedings were publicly available and could be a source of papers such as "Digital Image Recording for Court-Related Purposes."

Acknowledgement of Oath

I 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 with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1101 of Title 18 of the United States Code.



Kenneth Parulski

Dated: August 26, 2024

Exhibit A

KENNETH A. PARULSKI
225 IMPERIAL CIRCLE, ROCHESTER, NY 14617
KAPARULSKI@GMAIL.COM 585-338-1839

PROFILE

- Widely recognized digital photography pioneer and inventor, with over 225 issued U.S. patents. Many have been broadly licensed, providing earnings of over $2 billion dollars from 2005 to 2010.
- Extensive experience in digital imaging research, product development, and intellectual property strategy development, licensing & litigation.
- Proven ability to work with a wide range of disciplines, and across companies and cultures, to develop new technologies, products, systems, industry standards & business partnerships.

Chief Scientist and Managing Member, **aKAP Innovation, LLC, Rochester, NY** (June 2012 – Present)

- Served as an expert consultant to more than fifteen U.S. and international imaging companies.
- Co-founder of Tour Blend, which provides geo-located content to mobile devices.
- Invited speaker for academic and industry seminars in the U.S., Europe, and Asia.

Chairman, IT10 Technical Committee for Digital Photography Standards (1994 – Present)

- Chair of group which provides the U.S. position on international standards for digital cameras.
- Project leader for ISO standards on image formats and metadata (ISO 12234 series), resolution measurements (ISO 12233), ISO speed and sensitivity (ISO 12232) and RIMM RGB extended color encoding (ISO 22028-3).
- Chair of U.S. Technical Advisory Group to ISO/TC42 since June 2013.

Chairman, ISO Technical Committee 42 – Photography (March 2007 – February 2013)

- Leader of ISO/TC42, with more than 100 experts from 12 participating countries. TC42 developed more than 170 ISO standards for digital and conventional photography.
- Built consensus on standards goals and priorities, and chaired international plenary meetings.
- Lead the effort to move the sponsorship of ISO TC42 from the I3A trade association to the IS&T imaging society in 2010, which greatly improved the efficiency while reducing costs.

PAST EMPLOYMENT - Eastman Kodak Company, Rochester, New York (Retired June 2012)

Research Fellow and Chief Scientist, Digital Cameras and Devices (Jan. 2010 to May 2012)

- Responsibilities included inventing and prototyping new digital photography technologies and systems, setting the intellectual property strategy and filing priorities for a $1 Billion business, and supporting corporate patent licensing and litigation efforts.
- Led a cross-organizational team which rapidly developed, prototyped, and patented new personalized, interactive digital imaging systems using cloud processing and printing.

Research Fellow and Director, IP & Standards, Consumer Digital Group (2001 to 2009)

- Technical leader of Kodak's digital camera IP licensing program. Worked with Kodak lawyers and outside licensing agents to create an extremely successful licensing business.
- Developed new features for digital cameras and digital photography systems, including personalized and dual-lens cameras, on-line sharing systems, and dock printers.
- Managed an $8 Million R&D collaboration with ITRI in Taiwan. Projects included components such as compact zoom lenses and optical films, and systems such as media players and 3D cameras.

Chief Architect, Kodak Digital Cameras, Digital & Applied Imaging Division (1995 to 2001)

- Inventor of key patents related to preview, processing, and wireless sharing of digital images.
- Developed new digital camera and digital system architectures and formats, including panoramic camera systems and retail, wholesale, and on-line systems for printing digital camera images.
- Managed all IP issues for the divestiture of a $50 million industrial camera subsidiary.

Platform Leader, Electronic Imaging Platform Center (1992 to 1995)

- Architect of Kodak's first generation consumer digital still cameras, including the Apple QuickTake 100 and QuickTake 150 cameras and the Kodak Digital Science DC40 camera.
- Headed projects to develop novel digital video cameras for commercial and medical applications.
- Kodak representative to the Advanced Television Research Program at MIT, which developed the source adaptive compression technologies used worldwide in digital TV systems. Co-inventor of a TV decoding patent which has been widely licensed by MIT.

Group Leader, Electronic Photography Laboratory, Kodak Research Laboratories (1985 to 1991)

- Led Kodak R&D project which built the world's first color megapixel digital camera prototype, producing prints for Kodak's first public digital photography display in 1986 at Photokina.
- Developed an image processing VLSI chipset for digital video cameras. Designed high performance cameras for industrial and government applications using these Kodak ICs.
- Lead a major research study which developed and documented methods for comparing the image quality of megapixel CCD and 35mm film-based photographic systems.
- Key inventor of Kodak's CD based photo storage and TV display system.

Research Scientist, Image Science Laboratory, Kodak Research Laboratories (1980 to 1984)

- Developed color image processing algorithms and hardware.
- Key member of the team which developed a CCD scanner for displaying consumer film on TV, using a Kodak color sensor. This film video player was a highlight of Kodak's 1982 Photokina exhibit.

PUBLICATIONS AND PRESENTATIONS

- Over 70 external publications and presentations, including numerous invited talks on digital cameras and digital imaging systems in the US, Europe, and Japan.
- Author of the "Digital Photography" chapter in the *Consumer Digital Electronics Handbook* by MacGraw-Hill 1997; the "Color Image Processing for Digital Cameras" chapter in the *Digital Color Imaging Handbook*; CRC Press 2003; and the "Digital Camera Image Storage Formats" chapter in *Single-Sensor Imaging: Methods and Applications for Digital Cameras*, CRC Press 2008.
- Author of "Source Adaptive Encoding Options for HDTV and NTSC", which received the SMPTE Journal award in 1992.
- Created and taught Kodak courses on video technology and digital photography from 1983 to 2002.

AWARDS

- Life Fellow, Society of Motion Picture and Television Engineers – 2022.
- International Imaging Industries Association (I3A) Achievement Award, for "significant contributions to the advancement and growth of the imaging industry" – 2008.
- Photo-imaging Manufacturing & Distributors Association Technical Achievement Award for "pioneering work in the development of digital imaging technology" – 2002.
- Eastman Award (Kodak's top technical honor) for the development of digital cameras – 2001.
- Emmy Award (presented to Kodak) for developing the 24P HDTV standard – 2001.
- Kodak 'Team Achievement Awards' for VLSI chipset (1989) and PhotoCD System (1990).

EDUCATION

Massachusetts Institute of Technology – Cambridge, MA

- Master of Science in Electrical Engineering – May 1980
- Bachelor of Science in Electrical Engineering and Computer Science, minor in Political Science
- Student Employment
    - Motorola Corporate Research Labs - Developed a wireless mobile digital image transmission system for Master's thesis, supervised by Prof. William Schreiber.
    - U.S. Senate, Washington D.C., Fall 1976 - Legislative Intern to Senator William Proxmire.

ADOBE - Exhibit 1010, page 10

Kenneth A. Parulski – Publications and Presentations

1. K. A. Parulski, "Color Filters Patterns for Single-Chip Cameras", *International Electronc Imaging Exposition and Conference* Proceedings, pp. 24-39, Boston, MA, Sept. 1984.

2. K. A. Parulski, "Color Filters and Processing Alternatives for One-chip Cameras," *IEEE Trans. Electron Devices*, Vol. ED-32, No. 8, pp. 1381-1389, Aug. 1985.

3. G. Kennel, K. A. Parulski, et. al. "Determination of an Exposure Index for Electronic Cameras", *1985 SMPTE Conference*, October 1985.

4. M. Kriss, K. A. Parulski, et. al., "Critical Technologies for Electronic Still Imaging Systems, Proc SPIE, vol. 1082, *Applications of Electronic Imaging* (1989), pp 157-184.

5. L. J. D'Luna, K. A. Parulski, et al., "A Digital Video Signal Processor for Color Image Sensors," *ISSCC '89 Technical Digest*, pp. 158-159, Feb. 1989.

6. L. J. D'Luna, K. A. Parulski, et al., "A Digital Video Signal Post-Processor for Color Image Sensors," *CICC '89 Technical Digest*, pp. 24.2.1-24.2.4, May 1989.

7. K. A. Parulski, et al. "A Digital Color CCD Imaging System Using Custom VLSI Circuits," *IEEE Int. Conference on Consumer Electronics Digest of Technical Papers*, pp. 182-183, June 1989.

8. K. A. Parulski, et al. "A Digital Color CCD Imaging System Using Custom VLSI Circuits," *IEEE Trans. on Consumer Electronics*, Vol. 35, No. 3, pp. 382-389, Aug. 1989.

9. W. A. Cook, K. A. Parulski, et al., "A Digital Signal Processor for Linear Sensors", IEEE Custom Integrated Circuits Conference, 1990, pp. 7.5.1-7.5.4.

10. K. A. Parulski, et. al, "A High-performance Digital Color Video Camera", SPIE Vol.1448, *Camera and Input Scanner Systems* (1991), pp. 45-58, Feb. 1991.

11. L. J. D'Luna and K. A. Parulski, "A Systems Approach to Custom VLSI for a Digital Color Imaging System," *IEEE J. Solid State Circuits,* Vol. 26., pp. 727-737, May 1991.

12. L. J. D'Luna and K. A. Parulski, "A VLSI Digital Signal Processing Chipset for Color Imaging Systems," *Research Magazine,* pp. 4-7, Spring 1991.

13. K. A. Parulski, et. al. "Source Adaptive Encoding Options for Current and Future TV Systems, 1991 SMPTE Conference, Los Angeles, Oct. 1991.

14. K. A. Parulski, et al. "High-Performance Digital Color Video Camera," *Journal of Electronic Imaging,* Vol. 1, pp. 35-45, Jan. 1992.

15. K. A. Parulski, et. al., "Source Adaptive Encoding Options for HDTV and NTSC", NAB 1992 HDTV World Proceedings, Las Vegas.

16. K. A. Parulski "HDTV Transmission using Source Adaptive Encoding, ITEC '92: ITE Annual Convention Proceedings, July, 1992, Sapporo, Japan, pp. 261-262.

17. K. A. Parulski, et. al., "Image Sensors and Signal Processing for High Definition Digital Electronic Photography", *ITEC '92: ITE Annual Conv. Proc*., July, 1992, Sapporo, Japan, pp. 557-558.

18. K. A. Parulski, et. al. "Source Adaptive Encoding Options for HDTV and NTSC", SMPTE Journal, Vol. 101, Oct. 1992, pp. 674-683. (Winner of Journal Award).

19. K. A. Parulski, et. al., "Electronic Photography in the 1990s", *Proceedings of the International Symposium on Electronic Photography*, Koln, Germany, Sept. 1992, pp 1-7.

20. K. A. Parulski, et. al., "Technology for Non-NTSC Digital Cameras", *Electronic Imaging International Conference,* Boston, Oct.. 1992.

21. K. A. Parulski, "HDTV Transmission using Source Adaptive Encoding", Presentation to Boston Chapter of IS&T, Nov 4, 1992.

22. K. A. Parulski, "Electronic Photography in the 90s", *IEEE Joint Chapters Meeting,* Rochester, NY, March 17, 1993.

23. K. A. Parulski, et. al., "Digital, Still-Optimized Architecture for Electronic Photography", IS&T's 47th Annual Conference Proceedings, Vol. 2, May 1994, pp. 665-667.

24. G. E Lathrop and K. A. Parulski, "Advantages of Tag-Based Formats for Electronic Still Photography", IS&T's 47th Annual Conference Proceedings, Vol. 2, May 1994, pp. 630-633.

25. W. Hintz, K. A. Parulski, et. al., "Automatic Misregistration Correction for a Color Sequential Digital Still Camera", IS&T's 47th Annual Conference Proc., Vol. 2, May 1994, pp. 655-657.

26. T. J. Tredwell, K. A. Parulski, et. al., "Electronic Photography Applications of a 6.4 Megapixel Image Sensor", IS&T's 47th Annual Conference Proceedings, Vol. 2, May 1994, pp. 660-664.

27. R. Bouvy, K. A. Parulski, et. al., "A Progressive Scan 30-Frame Per Second Camera", SPIE Proceedings, Vol. 2416, Feb 1995.

28. K.A. Parulski and G. Lathrop, "TIFF/EP, A Flexible Image Format for Electronic Still Cameras, IS&T 48th Annual Conference, May 1995.

29. K.A. Parulski, et. al, "High-Performance Digital Cameras using Still Optimized Sensors" 70th Anniversary Fine Imaging Symposium, Japan, Oct. 1995

30. K.A. Parulski, "High-Performance Digital Cameras using Still Optimized Sensors" Boston Chapter, IS&T, Oct. 1995

31. K.A. Parulski and P. Jameson, "Enabling Technologies for a Family of Digital Cameras", Invited paper, IS&T/SPIE Proceedings Vol. 2654, Feb. 1996

32. K.A. Parulski, et. al, "A Family of Digital Cameras using Still Optimized Sensors" Anniversary Issue, Journal of the Society of Photographic Science and Technology of Japan", 1996

33. S. Noble and K. Parulski, "Design and Applications of a Family of 6.3 Megapixel Digital Cameras", ISEP '96, 3rd International Symposium on Electronic Photography, Koln, Germany, Sept. 1996.

34. R. Bouvy, J. Vincent, K. Parulski, K. Balch, G. Erickson and M Menadier, "The Fox Movietone News Preservation Project: The Progressive Scan CCD Camera", Vol 105, pp. 551-554, Sept. 1996.

35. K. Parulski, "Architectures and Applications for Digital Cameras", Invited paper, Joint OSA and Optics & Imaging in the Information Age Symposium, Rochester NY, Oct 1996.

36. S. Noble and K. Parulski, "Design of High Resolution Digital Cameras for Pre-press Applications", TAGA Conference, May 1997, Quebec City.

37. D. M. Lewis and K. A. Parulski, "Consumer Digital Photography: The Big Picture", Invited paper, IS&T's 50th Annual Conference, May 1997.

38. E. Higgins, A. Juenger, and K. Parulski, "Computation of ISO Draft Standard Spatial Frequency Response", IS&T's 50th Annual Conference, May 1997.

39. K. A. Parulski, "Digital Photography", Chapter 21 in "Digital Consumer Electronics Handbook", MacGraw-Hill, 1997.

40. E. Edwards, K. Parulski, and J. Holm, "Setting Standards: Developing Standards in Digital Photography", PEI, February 1998, pp. 48-53.

41. M. Rabbani and K. Parulski, "Digital Cameras", IEEE Signal Processing Magazine, March 1998, pg 28.

42. J. Adams, K. Parulski, and K. Spaulding, "Color Processing in Digital Cameras", IEEE Micro, Vol. 18, Nov. / Dec. 1998, pp. 20-31.

43. K. Parulski, "Digital Print Order Format", 1999 Kodak Developer Conference, Boston MA, January 1999.

44. J. Milch and K. Parulski, "Using Metadata to Simplify Digital Photography", IS&T PICS conference, April 1999.

45. K. Parulski and P. Gilman, “Digital Photography for Fun and Business” Imaging ’99 Short Course, June 1999, Rochester NY.

46. K. Parulski, “Why Standards Matter”, Kodak Technical Conference, Beijing, China, Sept. 1999.

47. S. Noble and K. Parulski, “Digital Camera Architectures and CCD Technology”, Kodak Technical Conference, Melbourne, Australia, Sept. 1999

48. K. Parulski, “Digital Camera Interface Standards”, 2000 Kodak Developer Conference, San Jose, CA, Jan. 2000

49. K. Parulski, “Digital Photography: From Light to Bytes”, Invited Lecture, George Eastman House, Rochester NY, Feb 2000.

50. K. Parulski and M. Rabbani, “The Continuing Evolution of Digital Cameras and Digital Photography Systems” (Invited paper), IEEE International Symposium on Circuits and Systems, May 2000, Geneva, Switzerland

51. J. Holm, E. Edwards, and K. Parulski, “Extended Colour Encoding Requirements for Photographic Applications”, Proc. of the CIE Color Experts Meeting, Scottsdale, Arizona, Nov. 2000.

52. M. Guidash and K. Parulski, “Digital Capture”, Industrial Physics Forum on Color Documents in the Internet Era, Rochester, NY, October 2001.

53. K. Parulski and Jack Holm, “Exif Print – An Industry Standard, Backward Compatible Image Format for Digital Photography”, I3A Technical Conference, PMA Feb. 24, 2002

54. P. Burns, S. Houchin, K. Parulski and M. Rabbani, “Using JPEG 2000 in Future Digital Cameras: Advantages and Challenges”, Proc. Int. Congress of Imaging Science 2002, Tokyo, SPSTJ, pp. 371-372, 2002

55. K. Parulski and Jack Holm, “Setting Standards for Digital Photography”, I3A Technical Conference, Nov. 2002

56. K. Spaulding and K. Parulski, “Color Image Processing for Digital Cameras”, Chapter in “Digital Color Imaging Handbook”, CRC Press 2003.

57. K. Parulski, “From Megapixels to Memories: The Challenges of Consumer Digital Photography”, Keynote address, IS&T PICS Conference, May 2003.

58.T. Looney, K. Parulski, and E Steinberg, “What is Picture Transfer Protocol? A Platform and Transport Independent Protocol / API for Communicating with Digital Still Cameras”, I3A Technical Conference, Nov. 2003.

59. R. Reisch, K. Miller-Mullins, K. Parulski and J. Holm "Metadata You Can Trust", I3A Technical Conference, Nov. 2003.

60. K. Parulski and R. Reisch "Digital Camera Image Storage Formats" Chapter in "Single-Sensor Imaging: Methods and Applications for Digital Cameras", Rastislav Lukac, CRC Press, 2009.

61. K. Parulski, "3D Image Capture: History, Technologies and Opportunities" presented at the ITRI International Workshop for 3D & Medical Image Technology, Industrial Technology Research Institute, Taiwan, Nov. 2012.

62. K. Parulski, "User Experiences in Digital Photography", presented at the Rochester Institute of Technology, Rochester NY, Jan. 2013 and Feb. 2014.

63. K. Parulski, "An Inventor's Dilemma: The gap between disruptive ideas and employer resources", presented at European Forum Alpbach, Tirol, Austria, Aug. 2014.

64. K. Parulski, "Intellectual Property Basics", presented at the Rochester Institute of Technology, Rochester NY, Nov. 2014.

65. K. Parulski, "Digital Photography - Technology and History", presented at the George Eastman House, Rochester NY, Sept. 18, 2015 and Nov. 4, 2016.

66. S. Farnand and K. Parulski, "Color Calibration of Unmanned Aerial System Digital Still Cameras", IS&T International Symposium on Electronic Imaging 2018, Image Quality and System Performance XV, Feb 2018.

67. P. Dillon, A. Brault and K. Parulski, "Inventing Color Image Sensors", presented at the George Eastman Museum, Rochester NY, Dec 7, 2019.

68. K. Parulski, "Who Invented Digital Cameras? The evolution of a dominant design", Webinar presentation to the MIT Clubs of Rochester and Western NY, Sept. 8, 2020.

69. K. Parulski, "The Development of Integral Color Image Sensors and Cameras", Invited Plenary Talk, IS&T International Symposium on Electronic Imaging 2021, Jan. 21, 2021.

70. K. Parulski, "The History of Integral Color Image Sensors and Cameras", Invited Talk, Eclipse Optics Seminar (Sweden), April 21, 2021.

71. K. Parulski, D. Wueller, P. Burns and H Yoshida "Creation and Evolution of ISO 12233, the International Standard for Measuring Digital Camera Resolution", Electronic Imaging 2022, Image Quality and System Performance XIX pp. 347-1-347-7, January 2022.

72. P. Burns, K. Masaoka, K. Parulski and D. Wueller, "Updated Camera Spatial Frequency Response for ISO 12233", IS&T International Symposium on Electronic Imaging 2022 IQSP-347, Image Quality and System Performance XIX, pp. 357-1-357-6, January 2022.

#	Patent No.	Published	Priority	Title	Inventor(s)
	20240223894	7/4/2024	12/30/2022	Event capture mode device method software and system	Parulski
230	10929463	2/23/2021	2/16/2015	Arranging location based content for mobile devices	Colosky, Parulski, O'Keefe, Moore
229	10817563	10/27/2020	2/16/2015	Providing location based content to mobile devices	Colosky, Parulski, O'Keefe, Moore
228	10289273	5/14/2019	8/29/2011	Display device providing feedback based on image classification	Liao, Parulski, Nichols
227	10142795	11/27/2018	2/16/2015	Providing digital content for multiple venues	Colosky, Parulski, O'Keefe, Moore
226	10136260	11/20/2018	3/22/2013	Selectively providing mobile experiences at multiple locations	Parulski, O'Keefe, Moore
225	9979683	5/22/2018	6/26/2001	System and method for managing images over a communication network	McIntyre, Parulski
224	9686469	6/20/2017	7/26/2010	Automatic digital camera photography mode selection	Razavi, Pillman, Parulski
223	9497333	11/15/2016	6/2/1999	System and method for providing customized product configuration and service plan options for a camera device	Wolcott, McIntyre, Parulski
222	9462181	10/4/2016	3/3/2010	Imaging device for capturing self-portrait images	Fredlund, Parulski, Guidash, Spaulding, Razavi
221	9454280	10/27/2016	9/29/2011	Display device providing feedback based on image classification	Liao, Parulski, Nichols
220	9270882	2/23/2016	7/26/2010	System and method for contextual digital photography mode selection	Razavi, Pillman, Parulski
219	9247306	1/26/2016	5/21/2012	Forming a multimedia product using video chat	O'Keefe, Parulski
218	9082046	7/14/2015	12/26/2001	Method for creating and using affective information in a digital imaging system	Matraszek, Fedorovskaya, Endrikhovski, Parulski
217	9055276	6/9/2015	7/29/2011	Camera having processing customized for identified persons	Parulski
216	9049388	6/2/2015	7/11/2005	Methods and systems for annotating images based on special events	Gallagher, Fryer, Loui, Oliver, Eckhaus, Parulski
215	8970720	3/3/2015	6/26/2010	Automatic digital camera photography mode selection	Razavi, Pillman, Parulski
214	8957981	2/17/2015	3/3/2010	Imaging device for capturing self-portrait images	Fredlund, Parulski, Guidash, Spaulding, Razavi
213	8934043	1/13/2015	6/17/2001	Revised recapture camera and method	Parulski, Desormeaux
212	8866930	10/21/2014	2/20/1997	Digital camera with communications interface for selectively transmitting images over a cellular phone network and a wireless LAN network to a destination	Ward, Parulski, Allen
211	8780180	7/15/2014	5/13/2011	Stereoscopic camera using anaglyphic display during capture	Parulski
210	8750674	6/10/2014	9/26/2011	Remotely controllable digital video camera system	Cornell, Parulski
209	8736694	5/27/2014	4/24/1995	Transmitting digital images to a plurality of selected receivers over a radio frequency link	Parulski, Schueckler
208	8717461	5/6/2014	7/11/2005	Identifying collection images with special events	Gallagher, Fryer, Loui, Oliver, Eckhaus, Parulski
207	8688764	4/1/2014	4/22/2001	System, method and software product for ordering image products using images stored on a digital storage device from a plurality of order terminals	Chauvin, Bussey, Dobbs, Parulski, Thompson, Foster, Gotham
206	8675112	3/18/2014	6/24/2011	Imaging device providing capture location guidance	Arujunan, Nichols, Parulski, Murray, O'Keefe
205	8630496	1/14/2014	12/26/2001	Method for creating and using affective information in a digital imaging system	Matraszek, Fedorovskaya, Endrikhovski, Parulski
204	8621047	12/31/2013	6/26/2001	System and method for managing images over a communication network	McIntyre, Parulski
203	8612308	12/17/2013	3/24/2000	System and method for providing a configured camera, image products, and services	Wolcott, McIntyre, Parulski
202	8589241	11/19/2013	5/19/2000	System and method for facilitating imaging services using a service identification number stored in an image capture device	Wolcott, McIntyre, Parulski
201	8508623	8/13/2013	4/15/1997	Image file for storing digital images and ancillary data values using multiple encoding methods	Parulski, Ward, Lathrop, Houchin, Jennings, Vansprewenburg
200	8405740	3/26/2013	6/24/2011	Guidance for image capture at different locations	Nichols, Parulski, Arujunan, Murray, O'Keefe
199	8358358	1/22/2013	7/11/2005	Identifying collection images with special events	Gallagher, Fryer, Loui, Oliver, Eckhaus, Parulski
198	8320025	11/27/2012	12/6/2000	Providing multiple payment schedules for storing images and utilizing the stored images	Jackson, Parulski
197	8184916	5/22/2012	12/26/2001	Method for creating and using affective information in a digital imaging system	Matraszek, Fedorovskaya, Endrikhovski, Parulski
196	8139126	3/20/2012	3/19/2004	Digital video system for assembling video sequences	Manico, Fredlund, Parulski, Telek, McCoy
195	8046270	10/25/2011	5/19/2000	System and method for providing image products and/or services	Wolcott, McIntyre, Parulski
194	8036467	10/11/2011	12/26/2001	Method for creating and using affective information in a digital imaging system	Matraszek, Fedorovskaya, Endrikhovski, Parulski
193	8035747	10/11/2011	3/12/2007	Image digital processing based on edit status	Fredlund, Deever, Bryant, Parulski, Parada
192	7999860	8/16/2011	4/15/1997	Image file for storing digital images and ancillary data values using multiple encoding methods	Parulski, Ward, Lathrop, Houchin, Jennings, Vansprewenburg

191	7978239	7/12/2011	3/1/2007	Digital camera using multiple image sensors to provide improved temporal sampling	Deever, Parulski, Fredlund, Rabbani, Kurtz, Manico
190	7965310	6/21/2011	5/11/2000	System and camera for transferring digital images to a service provider	Endsley, Bryant, Fredlund, Parulski
189	7952616	5/31/2011	4/24/1995	Transmitting digital images to a plurality of selected receivers over a radio frequency link	Parulski, Schueckler
188	RE42337	5/10/2011	2/20/1997	Network configuration file for automatically transmitting images from an electronic still camera	Ward, Parulski, Allen
187	7936391	5/3/2011	2/20/1997	Digital camera with communications interface for selectively transmitting images over a cellular phone network and a wireless LAN network to a destination	Ward, Parulski, Allen
186	7933474	4/26/2011	12/26/2001	Method for creating and using affective information in a digital imaging system	Matraszek, Fedorovskaya, Endrikhovski, Parulski
185	7893963	2/22/2011	5/19/2005	Digital camera which estimates and corrects small camera rotations	Gallagher, Parulski
184	7859588	12/28/2010	3/9/2007	Method and apparatus for operating a dual lens camera to augment an image	Parulski, Janson, Border, Fredlund, Manico, Parada
183	7840634	11/23/2010	6/26/2001	System and method for managing images over a communication network	McIntyre, Parulski
182	7782372	8/24/2010	2/24/1998	Image file for storing digital images and ancillary data values using multiple encoding methods	Parulski, Ward, Lathrop, Houchin, Jennings, Vansprewenburg
181	RE41542	8/17/2010	4/24/1995	Cellular telephone and electronic camera system with programmable transmission capability	Parulski, Schueckler
180	RE41524	8/17/2010	12/20/1995	Electronic still camera for capturing and categorizing images	Paurulski, Napoli, Lewis
179	7755662	7/13/2010	4/4/1997	Digital camera providing image processing for an attachable printer	Parulski, Small, Couwenhoven, VanBlargan, Wess
178	7743110	6/22/2010	1/18/2002	System, method and software product for ordering image products over a communication network from a plurality of different providers having various business relationships, using images stored on a digital storage device	Chauvin, Bussey, Dobbs, Parulski, Thompson, Foster, Gotham
177	7742084	6/22/2010	2/20/1997	Network configuration file for automatically transmitting images from an electronic still camera	Ward, Parulski, Allen
176	7729602	6/1/2010	3/9/2007	Camera using multiple lenses and image sensors operable in a default imaging mode	Janson, Parulski
175	7701490	4/20/2010	2/20/1997	Automatically transmitting images from an electronic camera to a service provider using a network configuration file	Ward, Parulski, Allen
174	7676146	3/9/2010	3/9/2007	Camera using multiple lenses and image sensors to provide improved focusing capability	Border, Palum, Janson, Parulski, Jacoby
173	7675556	3/9/2010	8/7/2002	Cameras, other imaging devices, and methods having non-uniform image remapping using a small data-set of distortion vectors	Smith, Parulski
172	7643704	1/5/2010	2/4/2005	Cropping a digital image and preserving reserves	Jackson, Parulski,McGarvey
171	7620270	11/17/2009	12/26/2001	Method for creating and using affective information in a digital imaging system	Matraszek, Fedorovskaya, Endrikhovski, Parulski
170	7616248	11/10/2009	7/17/2001	Revised recapture camera and method	Parulski, Malloy-Desormeaux
169	7587337	9/8/2009	3/24/2000	Leasing configured camera system	Parulski, Kenneth A.
168	7586532	9/8/2009	6/2/1999	Customizing a digital camera using firmware components provided by a service provider over a network	Prabhu, Miller, Akyuz, Wasula, Tintera, Parulski
167	7561191	7/14/2009	2/18/2005	Camera phone using multiple lenses and image sensors to provide an extended zoom range	May, Ludington, Parulski, Janson
166	7525680	4/28/2009	10/18/2000	Effective transfer of images captured by a digital camera to a remote location	Berarducci, Parulski, Fredlund
165	7509668	3/24/2009	3/24/2000	Leasing a configured camera system	Parulski, Kenneth A.
164	7495697	2/24/2009	2/20/1997	Network configuration file for automatically transmitting images from an electronic still camera	Ward, Parulski, Allen
163	7492389	2/17/2009	2/20/1997	Electronic camera having an interface for selecting users permitted to view transferred images	Parulski, Ward, Hopwood
162	7466336	12/16/2008	9/5/2002	Camera and method for composing multi-perspective images	Regan, Parulski
161	7453605	11/18/2008	7/1/2005	Capturing digital images to be transferred to an e-mail address	Parulski, Ward, Hopwood
160	7453498	11/18/2008	12/8/2005	Electronic image capture device and image file format providing raw and processed image data	Prentice, Yamagata, Parulski
159	7443418	10/28/2008	4/11/2003	Method for producing electronic job pages	Bryant, Parulski, Lyon, Wolf
158	7418116	8/26/2008	4/30/2007	Imaging method and system	Fedorovskaya, Endrikhovski, Matraszek, Parulski, Zacks, Taxier, Telek, Marino, Harel
157	7408582	8/5/2008	5/20/2004	Methods for configuring a digital camera and for display digital images	Prabhu, Miller, Akyuz, Wasula, Tintera, Parulski
156	7369164	5/6/2008	4/11/2003	Using favorite digital images to organize and identify electronic albums	Bryant, Parulski, Lyon, Wolf
155	7349010	3/25/2008	4/11/2003	Digital camera including an on-line sales mode	Bryant, Parulski, Lyon, Wolf
154	7327505	2/5/2008	2/19/2002	Method for providing affective information in an imaging system	Fedoroyskaya, Endrikhorski, Matrasszek, Parulski, Mir
153	7319780	1/15/2008	11/25/2002	Imaging method and system for health monitoring and personal security	Fedoroyskaya, Endrikhorski, Parulski, Zacks, Taxier, Telek, Manico, Harel

152	7307636	12/11/2007	12/26/2001	An image format including affective information	Matraszek, Fedorovskaya, Endrikhovski, Parulski
151	7305180	12/4/2007	2/18/2005	Digital camera using multiple lenses and image sensors to provide an extended zoom range	Labaziewicz, Janson, Parulski
150	7304677	12/4/2007	6/2/1999	Customizing a digital camera based on demographic factors	Keelan, Wheeler, Parulski, Prabhu
149	7301568	11/27/2007	8/7/2002	Cameras, other imaging devices, and methods having non-uniform image remapping using a small data set of distortion vectors	Smith, Parulski
148	7295244	11/13/2007	3/26/2002	System for capturing and archiving motion video segments	Manico, Fredlund, Parulski
147	7292267	11/6/2007	9/12/1996	Dual mode digital imaging and camera system	Prentice, Berarducci, Parulski
146	7289663	10/30/2007	7/24/2002	Producing an extended color gamut luminance-chrominance digital image from a captured image	Spaulding, Parulski, Prentice
145	7275044	9/25/2007	8/22/2001	System, method and software product for ordering image products over a communication network from a plurality of different providers having various business relationships	Chauvin, Bussey, Dobbs, Parulski, Thompson, Foster, Gotham
144	7271832	9/18/2007	4/15/1997	JPEG compatible image file format using multiple application segments	Parulski, Ward, Lathrrop, Houchin, Jennings, Vansprewenburg
143	7271809	9/18/2007	2/19/2002	Method for using viewing time to determine affective information in an imaging system	Fedorovskaya, Endikhovski, Matraszek, Parulski, Mir
142	7260546	8/21/2007	3/24/2000	Method for providing image goods and / or services to a customer	McIntyre, Willand, Brumlow, White, Parulski
141	7256944	8/14/2007	2/18/2005	Compact image capture assembly using multiple lenses and image sensors to provide an extended zoom	Labaziewicz, Parulski, Janson
140	7256823	8/14/2007	2/20/1997	Network configuration file for automatically transmitting images	Ward, Parulski, Allen
139	7236306	6/26/2007	2/18/2005	Digital camera using an express zooming mode to provide expedited operation over an extended zoom range	Janson, Parulski
138	7233684	6/19/2007	11/25/2002	Imaging method and system using affective information.	Fedorovskaya, Endikhovski, Matraszek, Parulski, Zacks, Taxier, Telek, Marino, Harel
137	7231359	6/12/2007	12/17/2004	Configuring image storage devices to enable imaging services	Parulski
136	7212229	5/1/2007	3/6/2001	Digital camera providing image processing for an attachable printer	Parulski, Small, Couwenhoven, VanBlargan, Wess
135	7210161	4/24/2007	2/20/1997	Automatically transmitting images from an electronic camera to a service provider using a network configuration	Ward, Parulski, Allen
134	7206136	4/17/2007	2/18/2005	Digital camera using multiple lenses and image sensors to provide an extended zoom range	Parulski, Janson, Labaziewicz
133	7171113	1/30/2007	11/22/2000	Digital camera for capturing images and selecting metadata to be associated with the captured images	Parulski, McCoy
132	7170552	1/30/2007	3/26/1998	Digital imaging system and file format for storage and selective transmission of processed and unprocessed image data	Parulski, Houchin
131	7158945	1/2/2007	11/30/2001	System and method for providing image products and/or services	Wolcott, McIntyre, Parulski
130	7158175	1/2/2007	11/30/2001	System including a digital camera and a docking unit for coupling to the internet	Belz, Chambers, Parulski
129	7146179	12/5/2006	10/24/2002	Portable imaging device employing geographic information to facilitate image access and viewing	Parulski, Schaeffer, Endsley
128	7136837	11/14/2006	5/10/2004	Providing a discounted payment schedule for utilizing and deleting stored images	Jackson, Parulski
127	7133597	11/7/2006	7/5/2001	Recording audio enabling software and images on a removable storage medium	Tingey, Gilman, Parulski
126	7127164	10/24/2006	6/27/2006	Method for rating images to facilitate image retrieval	Parulski, McCoy
125	7111317	9/19/2006	5/19/2000	Method for providing image goods and/or services to a customer	McIntyre, Willand, Brumlow, White, Parulski
124	7110025	9/19/2006	10/11/2000	Digital camera for capturing a sequence of full and reduced resolution digital images and storing motion and still digital image data	Loui, Parulski, Berarducci, Jackson, Joshi
123	7088396	8/8/2006	12/21/2001	System and camera for creating lenticular output from digital images	Fredlund, Parulski, Manico, Wess, Parker
122	7088388	8/8/2006	2/7/2002	Method and apparatus for calibrating a sensor for highlights and for processing highlights	MacLean, Morton, Parulski, Rodriguez
121	7057648	6/6/2006	3/29/2001	Capturing digital images to be trasferred to an service provider for storage	Parulski, Ward, Hopwood
120	7053953	5/30/2006	12/21/2001	Method and camera system for blurring portions of a verification image to show out of focus areas in a captured archival image	Belz, Adams, Parulski
119	7038714	5/2/2006	5/16/2000	Printing system and method having a digital printer that uses a digital camera image display	Parulski, Romano, Perry, Hadley
118	7035534	4/25/2006	6/16/2004	Photographic lightmeter-remote, system, and method	Shih, Noble, Parulski
117	7034880	4/25/2006	11/20/2000	System and camera for transferring digital images to a service provider	Endsley, Bryant, Fredlund, Parulski
116	7034871	4/25/2006	3/29/2001	Capturing digital images to be transferred to an e-mail address	Parulski, Ward, Hopwood

115	7027172	4/11/2006	8/15/2000	Color digital printer having a graphical user interface for displaying and selecting images for local and remote printing	Parulski, Romano
114	7024054	4/4/2006	9/27/2002	Method and system for generating a foreground mask for a composite image	Cahill, Parulski, Luo, Gindele
113	7024051	4/4/2006	12/8/2000	Customizing a digital imaging device using preferred images	Miller, Parulski
112	7019778	3/28/2006	4/14/2000	Customizing a digital camera	Prabhu, Miller, Akyuz, Wasula, Tintera, Parulski
111	7015955	3/21/2006	12/22/2000	Camera having verification display with viewer adaptation compensation for reference illuminants and method	Funston, Parulski
110	7003139	2/21/2006	2/19/2002	Method for using facial expression to determine affective information in an imaging system	Endrikhovski, Fedorovskaya, Matraszek, Parulski, Mir
109	6999111	2/14/2006	6/26/2001	Electronic camera and system for transmitting digital over a communication network	McIntyre, Parulski, Zacks
108	6989859	1/24/2006	12/22/2000	Camera having user interface ambient sensor viewer adaptation compensation and method	Parulski
107	6989221	1/24/2006		Photographic article	Wexler, Hall, Parulski
106	6985248	1/10/2006		Printing digital images using a print utilization file	Parulski, Ward, Hopwood
105	6950198	9/27/2005	10/18/2000	Effective transfer of images from a user to a service provider	Berarducci, Parulski, Fredlund
104	6947079	9/20/2005	12/22/2000	Camera having verification display with reverse white balanced viewer adaptation compensation and method	Parulski, Funston
103	6937997	8/30/2005	3/24/2000	Configuring and purchasing imaging devices	Parulski
102	6930718	8/16/2005	7/17/2001	Revised recapture camera and method	Parulski, Malloy-Desormeaux
101	6915273	7/5/2005	5/23/2000	Method for providing customized photo products over a network using images captured from a digital camera	Parulski
100	6909463	6/21/2005	12/22/2000	Camera having verification display and white-compensator and imaging method	Parulski
99	6903762	6/7/2005	12/13/2000	Customizing a digital camera for a plurality of users	Prabhu, Miller, Akyuz, Wasula, Tintera, Parulski
98	6890690	5/10/2005	3/14/2003	Photographic article	Wexler, Hall, Parulski
97	6885395	4/26/2005	9/7/2000	Selectively adjusting the resolution levels or the quality levels of digital images stored in a digital camera memory	Rabbani, Joshi, Parulski
96	6870567	3/22/2005	12/22/2000	Camera having user interface with verification display and color cast indicator	Funston, Parulski, Walker
95	6856427	2/15/2005	5/20/1999	System for printing correct exposure in a rendered digital image	Gilman, Parulski, Spaulding, Collette, Hamilton
94	6836617	12/28/2004	3/24/2000	Purchasing configured photographic film products	Parulski
93	6812962	11/2/2004	5/11/2000	System and apparatus for automatically forwarding digital images to a service provider	Fredlund, Simon, Cloutier, Parulski, Wess
92	6812961	11/2/2004	5/11/2000	System and camera for automatically forwarding digital images to a service provider	Parulski, Fredlund
91	6785423	8/31/2004	5/26/2000	Producing a compressed digital image organized into layers having information relating to different viewing conditions and resolutions	Joshi, Brower, Rabbani, Parulski
90	6784924	8/31/2004	1/7/1998	Network configuration file for automatically transmitting images from an electronic still camera	Ward, Parulski, Allen
89	6781713	8/24/2004	5/20/1999	Correcting exposure in a rendered digital image	Gilman, Parulski, Spaulding, Collette, Hamilton
88	6760485	7/6/2004	5/20/1999	Nonlinearly modifying a rendered digital image	Gilman, Parulski, Spaulding, Collette, Hamilton
87	6760128	7/6/2004	12/6/2000	Providing a payment schedule for utilizing stored images using a designated date	Jackson, Parulski
86	6731952	5/4/2004	12/29/2000	Mobile telephone system having a detachable camera / battery module	Schaeffer, Parulski, Schueckler
85	6714249	3/30/2004	12/31/1998	Producing panoramic digital images by digital camera systems	May, Parulski, Rinas, VanSprewenburg, Vermillion, Dunsmore.
84	6661454	12/9/2003	6/14/1999	Digital camera with memory card fullness icon	Hwang, Venturino, Lathrop, Parulski
83	6650366	11/18/2003	3/26/1998	Digital photography system using direct input to output pixel mapping and resizing	Parulski, Adams
82	6629104	9/30/2003	11/22/2000	Method for adding personalized metadata to a collection of digital images	Parulski, McCoy
81	6600510	7/29/2003	7/27/2000	Transmitting digital images to a plurality of selected receivers over a radio frequency link	Parulski, Schueckler
80	6573927	6/3/2003	11/24/1997	Electronic still camera for capturing digital image and creating a print order	Parulski, Ward, Hopwood.
79	6567119	5/20/2003	3/26/1998	Digital imaging system and file format for storage and selective transmission of processed and unprocessed image data	Parulski, Houchin
78	6539177	3/25/2003	7/17/2001	Warning message camera and method	Parulski
77	6516154	2/4/2003	7/17/2001	Image revising camera and method	Parulski, Cannon, Malloy Desormeaux
76	6400908	6/4/2002	3/6/2000	Camera and photography system with multiple, encoded area modes and modification states	Parulski
75	6389159	5/14/2002	1/12/2001	Method for producing prints from digital image files scanned from film	Gilman, Chang, Parulski, Pink.

74	6366316	4/2/2002	1/11/1999	Electronic imaging system for generating a composite image using the difference of two images	Parulski, Luo, Gindele
73	6310647	10/30/2001	2/24/1998	Image format for storing digital images and including multiple application segments	Parulski, Ward, Lathrop, Houchin, Jennings, Vansprewenburg
72	6292219	9/18/2001	3/18/1997	Motion processing system using an effects-enhanced motion storage medium	Fredlund, Parulski.
71	6292218	9/18/2001	7/16/1997	Electronic camera for initiating capture of still images while previewing motion images	Parulski, Tredwell
70	6208770	3/27/2001	9/18/1998	Digital colored corrected prints produced from colored film	Gilman, Chang, Parulski, Pink.
69	6122526	9/19/2000	1/19/1999	Cellular telephone and electronic camera system with programmable transmission capability	Parulski, Schueckler
68	6097901	8/1/2000	9/18/1998	Camera having locator for image modification areas	Parulski
67	6072962	6/6/2000	9/18/1998	Camera and photography system with multiple, encoded area modes and modification states	Parulski
66	6070013	5/30/2000	9/18/1998	Transmogrifying photography systems, film packages, and cameras	Cosgrove, Parulski
65	5983229	11/9/1999	6/5/1997	Extension persistence mechanism for a digital image format	Houchin, Couwenhoven, Parulski
64	5943603	8/24/1999	4/24/1997	Electronic camera system with programmable transmission capability	Parulski, Schueckler
63	5914748	6/22/1999	8/30/1996	Method and apparatus for generating a composite image using the difference of two images	Parulski, Luo, Gindele
62	5900909	5/4/1999	7/17/1997	Electronic still camera having automatic orientation sensing and image correction	Parulski, Severin, Ohmori, Izumi, Mizukoshi
61	5874994	2/23/1999	12/11/1995	Filter employing arithmetic operations for an electronic sychronized digital camera	Xie, Parulski.
60	5859927	1/12/1999	5/13/1997	Method and system for the reduction of memory capacity required for a digital representation of an image	Adams, Spaulding, Parulski.
59	5841471	11/24/1998	9/12/1996	Timing control for a digitally interfaced camera using variable line readout intervals	Endsley, Berarducci, Parulski
58	5828406	10/27/1998	12/30/1994	Electronic camera having a processor for mapping image pixel signals into color display pixels	Parulski, Tredwell
57	5708729	1/13/1998	4/12/1995	Method and system for the reduction of memory capacity required for digital representation of an image	Adams, Spaulding, Parulski.
56	5696850	12/9/1997	12/21/1995	Automatic image sharpening in an electronic imaging system	Parulski, Axman
55	5682562	10/28/1997	5/16/1996	Digitally controlled quench flash circuit	Mizukoshi, Izumi, Lynch, Uebelacker, Parulski, Dunsmore
54	5668597	9/16/1997	12/30/1994	Electronic camera with rapid automatic focus of an image upon a progressive scan image sensor	Parulski, Izumi, Mizukoshi
53	5666159	9/9/1997	4/24/1995	Electronic camera system with programmable transmission capability	Parulski, Schueckler
52	5633678	5/27/1997	12/20/1995	Electronic still camera for capturing and categorizing images	Parulski, Napoli, Lewis
51	5610654	3/11/1997	3/6/1996	Automatic camera exposure control using variable exposure index CCD sensor	Parulski, McGarvey.
50	5595389	1/21/1997	12/30/1993	Method and apparatus for producing personalized" video games using CD discs"	Parulski, Baumeister, Ellson
49	5563658	10/8/1996	12/16/1994	Electronic camera with rapid automatic focus of an image upon an image sensor	Parulski, Lathrop
48	5555098	9/10/1996	4/26/1994	Method and apparatus for providing multiple programmed audio/still image presentations from a digital disc image player	Parulski
47	5523786	6/4/1996	12/22/1993	Color sequential camera in which chrominance components are captured at a lower temporal rate than luminance components	Parulski
46	5519452	5/21/1996	6/17/1994	Mechanism for improving television display of still images using image motion-dependent filter	Parulski
45	5506617	4/9/1996	12/10/1992	Electronic camera incorporating a computer-compatible bus interface	Parulski, Bouvy, Smith, Acello
44	5493335	2/20/1996	6/30/1993	Single sensor color camera with user selectable image record size	Parulski, Vogel, Ohmori
43	5477264	12/19/1995	3/29/1994	Electronic imaging system using a removable software-enhanced storage device	Sarbadhikari, Fredlund, Parulski.
42	5475441	12/12/1995	12/10/1992	Electronic camera with memory card interface to a computer	Parulski, Bouvy, Tredwell, Smith
41	5475428	12/12/1995	9/9/1993	Method for processing color image records subject to misregistration	Hintz, Hibbard, Parulski.
40	5453840	9/26/1995	1/27/1994	Cross correlation image sensor alignment system	Parker, Parulski
39	5440401	8/8/1995	9/14/1990	Image database incorporating low resolution index image data	Parulski, Kristy, O'Brien, Donald E.
38	5440343	8/8/1995	2/28/1994	Motion/still electronic image sensing apparatus	Parulski, Stevens, Hibbard
37	5428456	6/27/1995	3/15/1991	Method and apparatus for adaptively reducing interline flicker of TV-displayed image	Parulski, Axman
36	5414811	5/9/1995	2/25/1994	Method and apparatus for controlling rapid display of multiple images from a digital image database	Parulski, Funston.
35	5410415	4/25/1995	9/30/1993	Recorded digital image presentation control files	Parulski, Brownstein, Caine, Axman.

34	5406325	4/11/1995	7/6/1992	Method and apparatus for forming a source-independent image data metric from second generation photographic films	Parulski, Johnson, Bellis.
33	5402170	3/28/1995	8/31/1992	Hand-manipulated electronic camera tethered to a personal computer	Parulski, Hamel, Acello.
32	5355178	10/11/1994	10/24/1991	Mechanism for improving television display of still images using image motion-dependent filter	Parulski
31	5301244	4/5/1994	7/15/1993	Computer input scanner incorporating multiple scanning modes	Parulski
30	5295204	3/15/1994	7/18/1991	Method for color balancing a computer input scanner incorporating multiple scanning modes	Parulski
29	5285237	2/8/1994	9/16/1991	Photoprint retaining platen for digitizing image scanner	Parulski, Manley, Reddig
28	5270839	12/14/1993	9/16/1991	Dual imaging station photoprint scanner	Parulski, Smith, Manley, Bilson
27	5270831	12/14/1993	9/14/1990	Storage and playback of digitized images in digital database together with presentation control file to define image orientation/aspect ratio	Parulski, Brownstein, Caine, Axman.
26	5251021	10/5/1993	8/5/1992	Color sequential scanner incorporating a synchronized variable exposure shutter	Parulski, Geisbuesch, Rutter.
25	5251019	10/5/1993	7/24/1992	Solid state color image sensor using a field-staggered color filter pattern	Moorman, Hibbard, Parulski
24	5250948	10/5/1993	12/19/1991	High level resolution enhancement for dual-range A/D conversion	Berstein, Parulski
23	5241659	8/31/1993	9/14/1990	Auxiliary removable memory for storing image parameter data	Parulski, O'Brien, Funston.
22	5218459	6/8/1993	9/16/1991	Print scanner with soft key variable magnification	Parulski, Cochrane, Rutter.
21	5189511	2/23/1993	3/19/1990	Method and apparatus for improving the color rendition of hardcopy images from electronic cameras	Parulski, Bellis, Jr., Hibbard, Giorgianni, McInerney
20	5177698	1/5/1993	6/5/1992	Selectable power of two coefficient signal combining circuit	Parulski
19	5173789	12/22/1992	7/18/1991	Image scanner incorporating manually operable magnification and brightness control	Renner, Shelley, Parulski
18	5161006	12/3/1992	7/26/1990	Method for separating chrominance and luminance components of a television signal	Monta, Lim, Parulski
17	5138454	8/11/1992	9/16/1991	Megapixel video previewer framestore and display	Parulski
16	5109273	4/28/1992	5/11/1990	Signal processing circuit for performing a pipelined matrix multiplication upon signals from several linear sensors	Parulski, Cook, D'Luna
15	5101269	3/31/1992	9/18/1990	Stereoscopic electronic slide and print viewer	Shelley, Parulski
14	5086344	2/4/1992	5/11/1990	Digital correlated double sampling circuit for sampling the output of an image sensor	D'Luna, Cook, Parulski
13	5086343	2/4/1992	5/11/1990	Method and apparatus for compensating for sensitivity variations in the output of a solid state image sensor	Cook, Parulski, D'Luna
12	5065229	11/12/1991	9/27/1990	Compression method and apparatus for single-sensor color imaging systems	Tsai, Parulski, Rabbani
11	5053861	10/1/1991	7/24/1989	Compression method and apparatus for single-sensor color imaging systems	Tsai, Parulski, Rabbani
10	5047861	9/10/1991	7/31/1990	Method and apparatus for pixel non-uniformity correction	Houchin, Parulski
9	5040068	8/13/1991	12/28/1989	Electronic imaging apparatus with interchangeable pickup units	Parulski, Moorman
8	5025313	6/18/1991	10/16/1989	System for minimizing optical distortions and chromatic aberrations in a linear color scanner	Parulski, Kessler
7	5008739	4/16/1991	2/13/1989	Real-time digital processor for producing full resolution color signals from a multi-color image sensor	D'Luna, Hibbard, Parulski
6	5001663	3/19/1991	5/3/1989	Programmable digital circuit for performing a matrix multiplication	Parulski, Hibbard, D'Luna
5	4994901	2/19/1991	12/23/1988	Method and apparatus for increasing the gamut of an additive display driven from a digital source	Parulski, Bellis
4	4967264	10/30/1990	5/30/1989	Color sequential optical offset image sampling system	Parulski, Nutting, Moore
3	4962419	10/9/1990	2/13/1989	Detail processing method and apparatus providing uniform processing of horizontal and vertical detail components	Hibbard, Parulski, D'Luna
2	4896207	1/23/1990	6/17/1988	Color imaging apparatus employing a horizontal stripe color filter to reduce rise-time artifacts	Parulski
1	4876590	10/24/1989	6/17/1988	Low resolution verifier for a still video image	Parulski

Exhibit B

JEIDA規格

ディジタルスチルカメラ用画像ファイル フォーマット規格 (Exif) Version2.0

JEIDA-49-1997

平成７年10月 制定

平成９年11月 改正

社団法人 日本電子工業振興協会

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序　文

近年の半導体や光記録媒体、磁気記録媒体等、記録容量の増加傾向は、ディジタル技術の進歩および情報処理技術の技術革新により、静止画像を電気信号として取り込み、電気的に処理、蓄積および編集したりすることが、可能となってきている。

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本規格は、近年のディジタルスチルカメラおよびパーソナルコンピュータ等の情報処理機器の急速な普及をふまえて、データの互換性を確保し、より使いやすい環境を提供するために、ＰＣカード等をはじめとするＤＳＣおよび関連機器にて記録される画像ファイルを規定したVersion1.1の精度をさらに向上させるとともに、異なるメーカ間の画像ファイルの互換性をさらに向上させることを目的に作成したものである。

本規格の作成に当たって、ご支援ご協力を賜った関係各庁、関係会員、ならびに直接労を賜った委員長をはじめ委員各位に厚く感謝の意を表するとともに、本規格が多方面に広く利用され、わが国の電子工業の発展に寄与できることを念願する次第である。

平成9年１１月

社団法人　日本電子工業振興協会
会 長　西 室 泰 三

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JAPAN ELECTRONIC INDUSTRY
DEVELOPMENT ASSOCIATION STANDARD

Digital Still Camera Image File Format Standard
(Exchangeable image file format for Digital Still Camera: Exif)
Version2.0

JEIDA-49-1997

Revised October 1995
Established November 1997

JAPAN ELECTRONIC INDUSTRY
DEVELOPMENT ASSOCIATION

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Revision History

This "Digital Still Camera Image File Format Standard" is issued as a standard for the image file format (Exif: Exchangeable image file format) used in digital still cameras and related systems. It was first published in October, 1996 as Version 1.0. Then in May 1997, Version 1.1[ii] was issued, adding specifications for optional attribute information as well as stipulations relating to format implementation, in addition to the mandatory specifications of Version 1.0.

The desire for a uniform file format standard for the image data stored by digital still cameras has increased as these cameras have grown in popularity. At the same time, with the broadening application of this technology, a similar desire has arisen for uniformity of the attribute information that can be recorded in a file.

The present Version 2.0 makes improvements to the Exif format for greater ease of use, while allowing for backward compatibility with products of manufacturers currently implementing Exif Version 1.x or considering its future implementation.

The following additions and changes are made from Version 1.1 to Version 2.0.

[Additions]

- Audio file format specification
- JPEG compressed thumbnail specification
- Chrominance sampling method Y:Cb:Cr = 4:2:0.
- Tags for FlashPix transformation
- Additional tags for picture-taking conditions
- APP2 marker segment specification for FlashPix extensions
- Definition of color space information

[Changes]

- Combined into one chapter the separate chapters on the Exif file specification and implementation specification (Exif-1).
- Removed the limitation on number of pixels (multiples of 8 and 16) to allow for expanded implementation.

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1. General

1.1. Objectives

This document specifies a standard file format for the image data recorded by digital still cameras (DSC) and related systems, which use a PC Card or other removable memory medium. The aim is to ensure data compatibility and exchangeability, providing a framework in which these products can be used readily by ordinary consumers. In this way it is hoped the standard will contribute to the infrastructure of the information age, as it evolves with the rapid proliferation of personal computers and other information technologies.

1.2. Scope and Abbreviation

This standard applies to the image files recorded on PC Cards and other removable memory by DSC and related systems. The standard is abbreviated as Exif (Exchangeable image file format).

Note: This standard makes no warranty with respect to the use of "Exif" as a trademark.

1.3. Format Structure

This standard consists of the Exif image file specification and the Exif audio file specification (see Fig. 1). The recording medium specification shall conform to the standard for the particular medium used and is not specified here. Recommendations on implementation are given in Appendix D for directory and file naming.

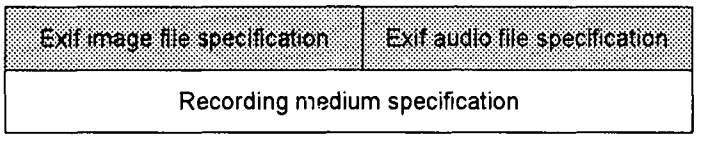


Fig. 1 Format structure

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1.4. Exif Image File Specification

The Exif image file specification stipulates the method of recording image data in files, and specifies the following items:

- Structure of image data files,
- Tags used by this standard,
- Definition and management of format versions.

Features of the Exif image file specification include the following.

The file recording format is based on existing formats. Compressed files are recorded as JPEG (ISO/IEC 10918-1[iii]) with application marker segments (APP1 and APP2) inserted. Uncompressed files are recorded in TIFF Rev. 6.0[iv] format. The use of existing formats means files recorded using a DSC or related system can be read directly by commercial applications, and makes possible the use of functions for viewing and manipulating the images.

Related attribute information for both compressed and uncompressed files is stored in the tag information format defined in TIFF Rev. 6.0. Information specific to the camera system and not defined in TIFF is stored in private tags registered for Exif. The Exif image file specification also specifies the method for recording thumbnails. The reason for using the TIFF Rev. 6.0 tag format in the compressed file APP1 segment is to facilitate exchange of attribute data between Exif compressed and uncompressed files.

Compressed files can record extended data exceeding 64 Kbytes by dividing it into multiple APP2 segments. The APP2 segment is used when recording FlashPix[v] extensions.

A feature of Exif image files is their compatibility with standard formats in wide use today, enabling them to be used on personal computers and other information systems. The intention is to promote widespread use of digital still cameras.

Details of the Exif image file specification are given in **Chapter 2** of this document.

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1.5. Exif Audio File Specification

The Exif audio file specification stipulates the method of writing audio data in files, and specifies the following items:

- Structure of audio data files,
- Chunks,
- Definition and management of format versions.

Features of the Exif audio file specification include the following.

Files are recorded using the existing RIFF WAVE Form Audio File format.[vi] As data formats, PCM and μ-Law PCM (conforming to ITU-T G.711[vii]) are used for uncompressed audio data, and IMA-ADPCM[viii] for compressed audio data. As with the image files specification, the aim is to enable direct reading, playback and manipulation of the files using the functions in commercial applications.

Related attribute information is stored as an *INFO list* in the case of general attributes, and as Exif-specific chunks in the case of attributes specific to Exif. The Exif-specific chunks are newly provided to enable necessary information to be added by making use of chunk extensibility. The recording of data in an Exif-specific chunk is done in the same way as for an *INFO list*.

Exif audio files, like image files, feature compatibility with standard formats already in wide use, in order to promote the widespread use of digital still cameras.

Details of the Exif audio file specification are given in Chapter 3 of this document.

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1.6. Relation between Image and Audio File Specification

This standard includes specifications not only for an image file format but also for an audio file format enabling the recording of audio as a supplementary function.

Also specified in this standard is the relational information indicating the relation between image files and audio files.

Mapping between image files and audio files can be done in various ways; but the Exif standard specifies only the simplest mapping, with others left up to the implementation.

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1.7. Presupposed Systems and Compatibility

The image systems presupposed by this standard consist of three elements as follows:

- Equipment: Imaging devices such as cameras, printers and filing equipment,
- Commercial software: Off-the-shelf image processing software running on personal computers,
- Specialized software: Dedicated (system-specific) image processing software running on personal computers.

Image file compatibility on these systems is achieved as follows. The DSC or other system writes data to files in the format specified in this standard. A basic condition of equipment with a playback function is that it be able to read the files it recorded itself. In a personal computer environment, the basic requirement is that dedicated software be able to read all the images, audio and attribute information recorded in conformance with this standard (see Fig. 2).

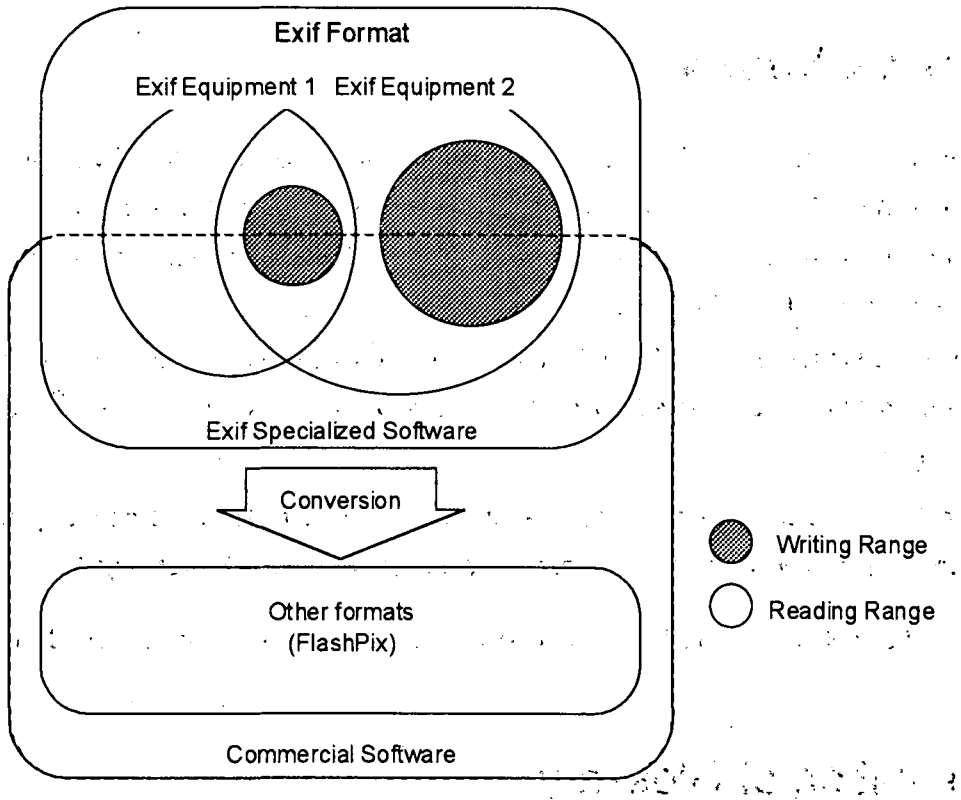


Fig. 2 Compatibility Concepts

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2. Exif Image File Specification

2.1. Outline of the Exif Image File Specification

This chapter gives details of the image file specification, covering the following items:

- Format version definition,
- Specifications relating to image data,
- Basic structure of image data,
- Tags,
- JPEG marker segments,
- Specifications on data recording.

2.2. Format Version

The version of the format specified here is recorded as 4 bytes (see section 2.6.5). The address bytes are recorded as A1, A2, B1, B2, starting with the lowest number. A1 and A2 store the upper part of the standard version, with the lower part stored in B1 and B2. When changes are made to the version number of this standard, the following rules apply.

- When the changes are such that data readers can properly recognize conventional information and skip the data that was recorded using newly added functions, the lower part of the version (B1, B2) is changed.
- When there is a possibility that a data reader implementing the old standard may operate incorrectly due to the new specifications, the upper part of the version (A1, A2) is changed.

Players should be able to play back files of versions earlier than the supported standard.

2.3. Definition of Glossary

Terms and notation are used as follows in this standard:

- "Tag" is used as a synonym of "field",
- ".H" appended to a numerical value means it is hexadecimal notation,
- Unless otherwise indicated, other numerical values are given in decimal notation,

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- The initial IFD in a file is the "0th IFD," with the next IFD being called the 1st IFD,
- The original image is called the "primary image," and small images used to index the primary images are called "thumbnail" images,
- Data referred to in the JPEG standard as "entropy coded data" is here called "compressed data".

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2.4. Specifications Relating to Image Data

2.4.1. Number of Pixels

There is no limit on number of pixels of the primary image when it is recorded as either uncompressed or JPEG compressed data. Note that when recording as JPEG compressed data images for which the number of lines (*ImageLength*) or number of samples/line (*ImageWidth*) is not a multiple of 8 or 16, the method of recording is as stipulated in section 2.8.1. The above specification applies similarly to thumbnails.

2.4.2. Pixel Aspect

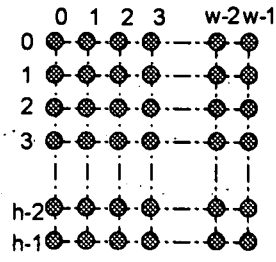
Image data is recorded as square pixels with a pixel aspect ratio of 1:1. This specification is applied similarly to thumbnails.

2.4.3. Pixel Composition and Sampling

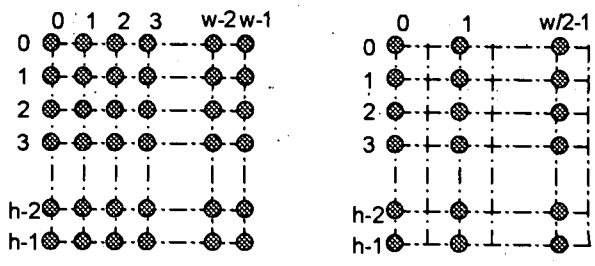
The combination of pixel composition and pixel sampling for image data must be RGB 4:4:4 and either Y:Cb:Cr = 4:2:2 or Y:Cb:Cr = 4:2:0. The pixel composition of image data must also be 8 bits each. This specification is applied similarly to thumbnails.

As sampling points on the elements making up pixels, the Y and Cb,Cr sampling points may be either co-sited or centered. Fig. 3 shows typical pixel sampling for image width w and height h. In the case of Y:Cb:Cr = 4:2:2, spatial co-siting is recommended for the sake of improved image quality on TV systems. For Y:Cb:Cr = 4:2:0, spatial centering is recommended as per the TIFF default and is most common format of the personal computer applications.

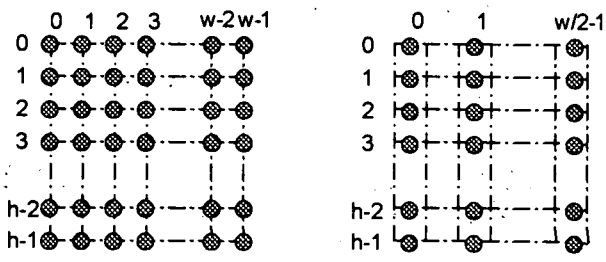
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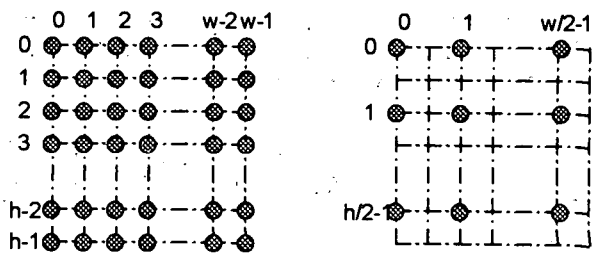
1) RGB 4:4:4



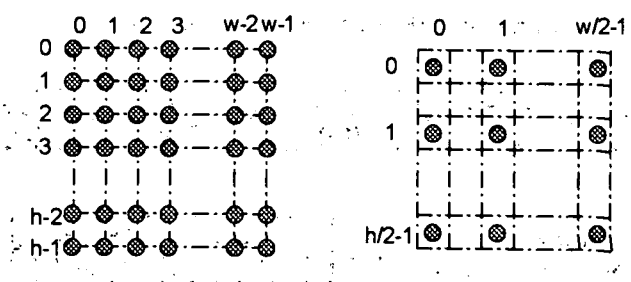
2) YCbCr 4:2:2 (Co-sited)



3) YCbCr 4:2:2 (Centered)



4) YCbCr 4:2:0 (Co-sited)



5) YCbCr 4:2:0 (Centered)

Fig. 3 Pixel Composition and Pixel Sampling

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2.4.4. Image Data Arrangement

Image data must be arranged as follows. Uncompressed data shall consist of pixels with each line traced from left to right, and one screen shall consist of lines traced from top to bottom. JPEG compressed data shall consist of blocks configured of pixels traced in similar sequence. Fig. 4 shows the various data arrangements for recording in files images with pixels of width w and height h

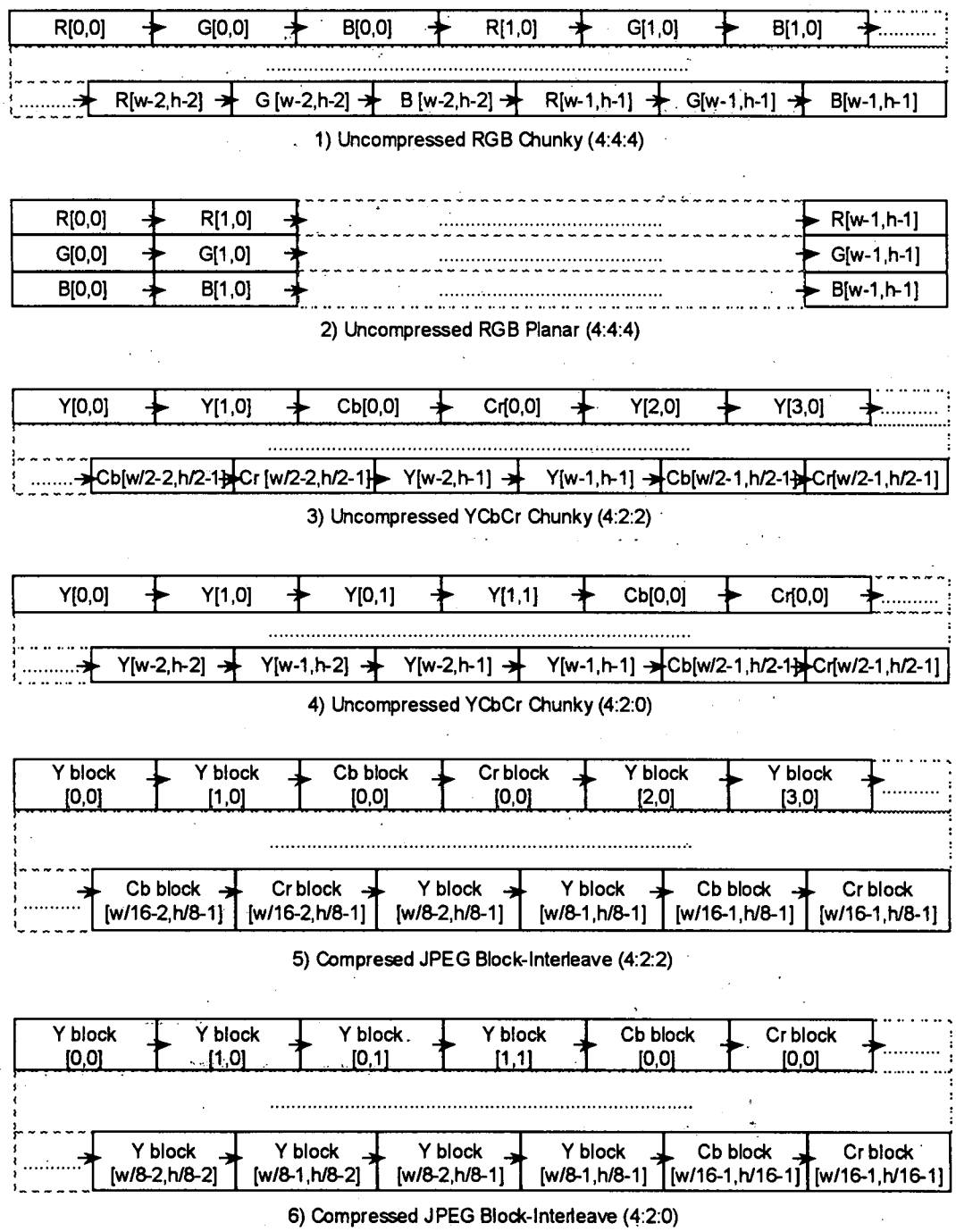


Fig. 4 Data Arrangement

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2.5. Basic Structure of Image Data

2.5.1. Basic Structure of Primary Image Data

Image data emploies following existing image formats, depending on the image data type:

- RGB uncompressed data: Baseline TIFF Rev. 6.0 RGB Full Color Images[iv],
- YCbCr uncompressed data: TIFF Rev. 6.0 Extensions YCbCr Images[iv],
- JPEG compressed data: JPEG Baseline ADCT[iii].

For compressed data, the attribute information required by the DSC application shall be recorded in APP1. Data writing in APP1 shall be compatible with TIFF. The use of a common method of storing attribute information for both compressed and uncompressed data results in a simpler format, while the ability to add private tags for additional information takes advantage of the extensibility of the tag mechanism.

2.5.2. Basic Structure of Uncompressed RGB Data

Uncompressed RGB data is recorded in conformance with Baseline TIFF Rev. 6.0 RGB Full Color Images[iv].

Attribute information is recorded in tags specified in TIFF Rev. 6.0. Attribute information specific to Exif is recorded using private tags reserved in TIFF for this standard. The private tags point to sets of this attribute information (Exif IFD).

Files are structured as follows (see Fig. 5). As in the TIFF standard, the recording location of each IFD value is not specified:

- File Header,
- 0th IFD,
- 0th IFD Value,
- 1st IFD,
- 1st IFD Value,
- 1st (Thumbnail) Image Data,
- 0th (Primary) Image Data.

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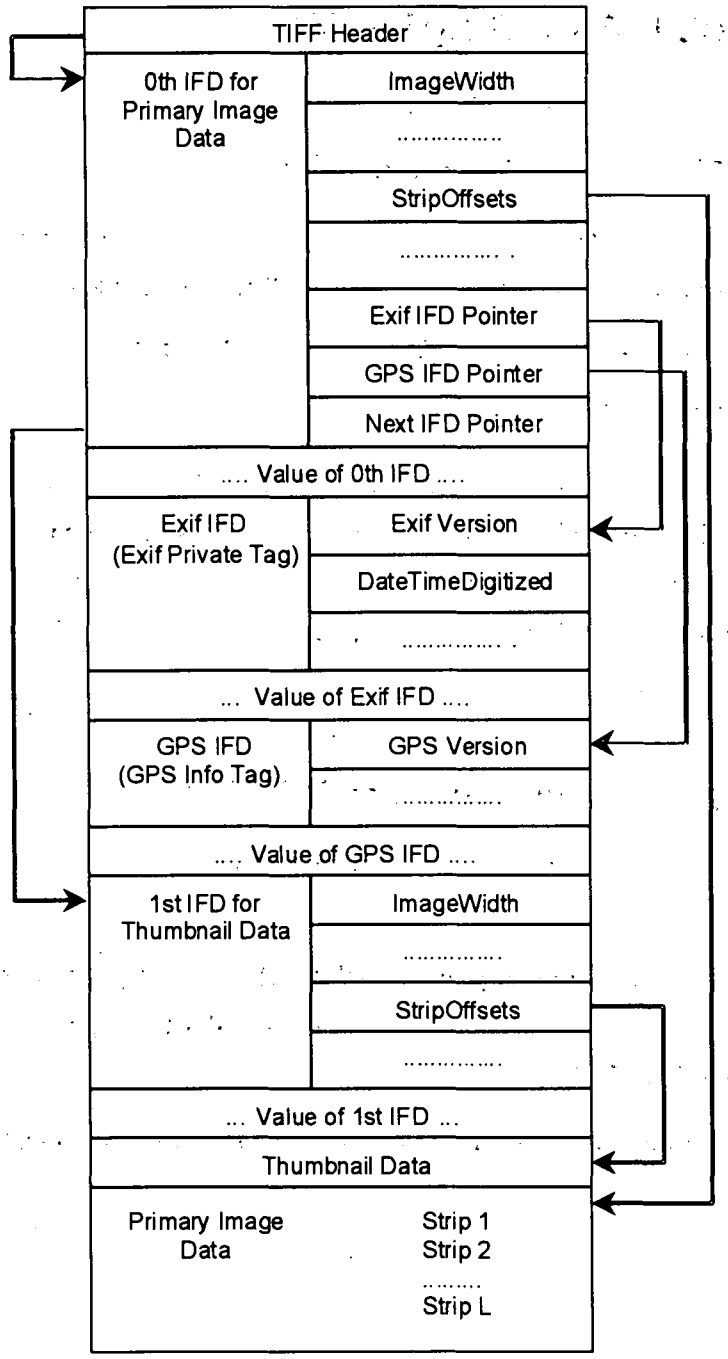


Fig. 5 Basic Structure of Uncompressed Data Files

File Headers are 8 bytes as defined in the TIFF standard, with the Offset of IFD indicating the start address of the 0th IFD (see Table 1).

The 0th IFD Offset of Next IFD indicates the start address of the 1st IFD (thumbnail images). When the 1st IFD is not recorded, the 0th IFD Offset of Next IFD terminates with 00000000.H.

On the IFD description method see section 2.6.2.

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Table 1 TIFF Headers

Name	Size (Bytes)	Value
Byte Order	2	Written as either "II" (4949.H) (little endian) or "MM" (4D4D.H) (big endian) depending on the CPU of the machine doing the recording.
42	2	002A.H (fixed)
Offset of IFD	4	0th IFD offset. If the TIFF header is followed immediately by the 0th IFD, it is written as 00000008.H.

2.5.3. Basic Structure of YCbCr Uncompressed Data

YCbCr uncompressed data is recorded in conformance with TIFF Rev. 6.0 Extensions YCbCr Images[iv]. Tags for the following information are available for YCbCr uncompressed data in addition to the attribute information for RGB uncompressed data;

- RGB-YCbCr color transformation matrix coefficients (*YCbCrCoefficients*),
- Chrominance subsampling information (*YCbCrSubSampling*),
- Information on matching/nonmatching of chrominance and luminance samples (*YCbCrPositioning*).

The method of recording other attribute information is the same as for uncompressed RGB data (see section 2.5.2).

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2.5.4. Basic Structure of JPEG Compressed Data

Compressed data files are recorded in conformance with the JPEG DCT format specified in ISO/IEC 10918-1,[iii] with the Application Market Segment (APP1) inserted. APP1 is recorded immediately after the SOI marker indicating the beginning of the file (see Fig. 6). Multiple APP2 can be recorded as necessary, starting immediately after APP1. APPn other than APP1 and APP2 or COM segments are not used by Exif. However Exif readers should be designed skip over unknown APPn and COM.

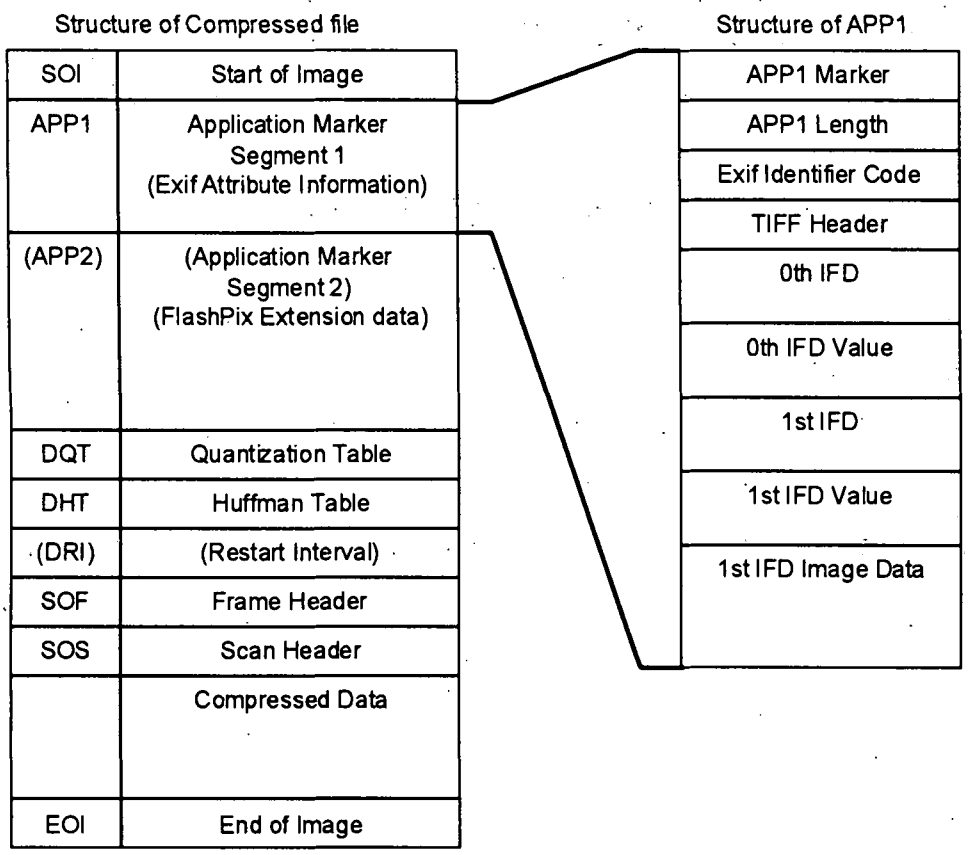


Fig. 6 Basic Structure of Compressed Data Files

Internally, APP1 consists of the APP1 marker, Exif identifier code, and the attribute information itself. The size of APP1 including all these elements must not exceed the 64 Kbytes specified in the JPEG standard.

Attribute information is stored in TIFF structure including a File Header, with a maximum of two IFD (0th IFD, 1st IFD). The 0th IFD records attribute information concerning the compressed image (primary image). The 1st IFD can be used to record a thumbnail image. For details see section 2.7.2.

APP2 consists of the APP2 marker, FPXR (FlashPix Ready) identifier code, and contents list for FlashPix extension recording, or stream data. A string of multiple APP2 marker segments can be used to record data exceeding 64 Kbytes. For details see section 2.7.3.

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2.5.5. Basic Structure of Thumbnail Data

Thumbnail data is recorded in the 1st IFD similarly to primary images, using two existing image formats.

No limit is placed on the size of thumbnail images. Thumbnails are not mandatory, but it is recommended that they be recorded if possible, unless hardware or other restrictions preclude this.

Thumbnail data does not necessarily have to adopt the same data structure as that used for primary images. If, however, the primary images are recorded as uncompressed RGB data or as uncompressed YCbCr data, thumbnail images cannot be recorded as JPEG compressed data (see Table 2).

Table 2 Combinations of primary image and thumbnail data structures

		Primary Image	
		Uncompressed	Compressed
Thumbnail	Uncompressed	Possible	Possible
	Compressed	Not possible	Possible

When thumbnails are recorded in uncompressed format, they are to be recorded in the 1st IFD in conformance with Baseline TIFF Rev. 6.0 RGB Full Color Images or TIFF Rev. 6.0 Extensions YCbCr Images.

An Exif-specific recording method is used to record compressed thumbnails.

In this case the *Compression* tag value is set to "6" and tags in the 1st IFD (*JPEGInterchangeFormat*, *JPEGInterchangeFormatLength*) are used to designate the location and size. The images are recorded at the designated location as a JPEG stream (from SOI to EOI) conforming to the JPEG Baseline DCT format. No APPn marker, COM marker, nor restart marker is recorded in the JPEG stream (see Fig. 7). To avoid duplicate definitions, the 1st IFD is not used to record a tag indicating a TIFF image or information recorded elsewhere as a JPEG marker segment.

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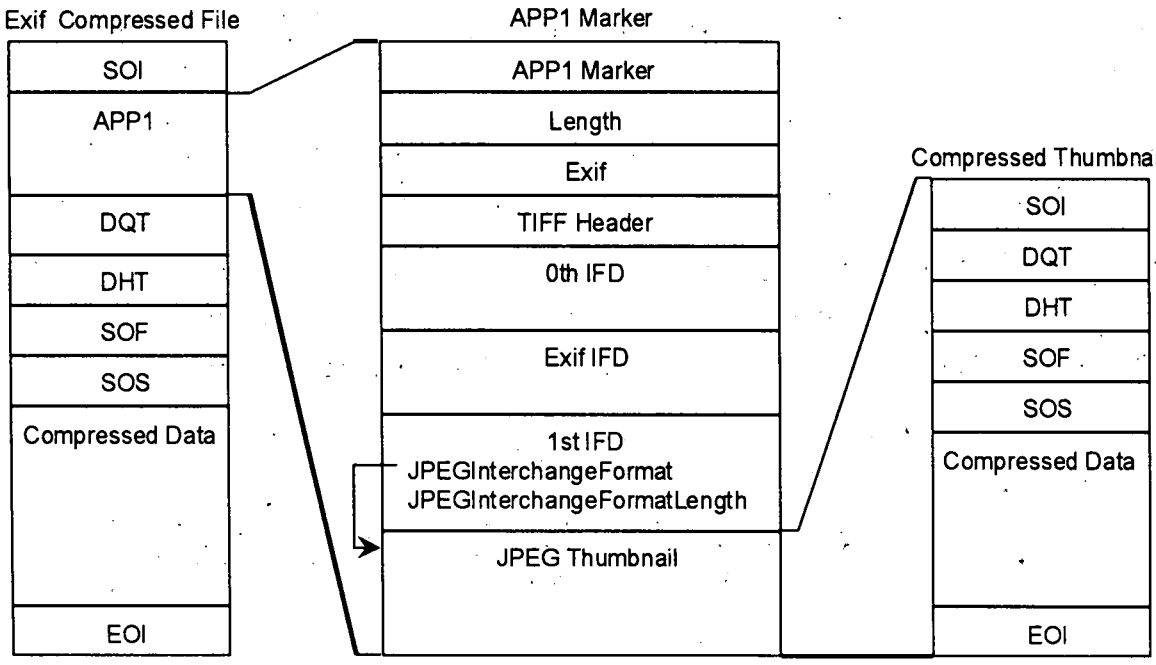


Fig. 7 Structure of Exif file with compressed thumbnail

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2.6. Tags

2.6.1. Features of Attribute Information

RGB data conforms to Baseline TIFF Rev. 6.0 RGB Full Color Images, and YCbCr data to TIFF Rev. 6.0 Extensions YCbCr Images. Accordingly, the parts that follow the TIFF structure must be recorded in conformance to the TIFF standard. In addition to the attribute information indicated as mandatory in the TIFF standard, this Exif standard adds the TIFF optional tags that can be used in a DSC or other system, Exif-specific tags for recording DSC-specific attribute information, and GPS tags for recording position information. There are also Exif-original specifications not found in the TIFF standard for compressed recording of thumbnails.

Recording of compressed data differs from uncompressed data in the following respects:

- When the primary image data is recorded in compressed form, there is no tag indicating the primary image itself or its address (pointer),
- When thumbnail data is recorded in compressed form, address and size are designated using Exif-specific tags,
- Tags that duplicate information given in the JPEG Baseline are not recorded (for either primary images or thumbnails).
- Information relating to compression can be recorded using the tags for this purpose.

2.6.2. IFD Structure

The IFD used in this standard consists of a 2-byte count (number of fields), 12-byte field entry arrays, and 4-byte offset to the next IFD, in conformance with TIFF Rev. 6.0.

Each of the 12-byte field entries consists of the following four elements respectively.

Bytes 0-1	Tag
Bytes 2-3	Type
Bytes 4-7	Count
Bytes 8-11	Value Offset

Each element is explained briefly below. For details see TIFF Rev. 6.0.

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Tag

Each tag is assigned a unique 2-byte number to identify the field. The tag numbers in the Exif 0th IFD and 1st IFD are all the same as the TIFF tag numbers.

Type

The following types are used in Exif:

1 = BYTE	An 8-bit unsigned integer.,
2 = ASCII	An 8-bit byte containing one 7-bit ASCII code. The final byte is terminated with NULL.,
3 = SHOT	A 16-bit (2-byte) unsigned integer,
4 = LONG	A 32-bit (4-byte) unsigned integer,
5 = RATIONAL	Two LONGs. The first LONG is the numerator and the second LONG expresses the denominator.,
7 = UNDEFINED	An 8-bit byte that can take any value depending on the field definition,
9 = SLONG	A 32-bit (4-byte) signed integer (2's complement notation),
10 = SRATIONAL	Two SLONGs. The first SLONG is the numerator and the second SLONG is the denominator.

Count

The number of values. It should be noted carefully that the count is not the sum of the bytes. In the case of one value of SHORT (16 bits), for example, the count is '1' even though it is 2 bytes.

Value Offset

This tag records the offset from the start of the TIFF header to the position where the value itself is recorded. In cases where the value fits in 4 bytes, the value itself is recorded. If the value is smaller than 4 bytes, the value is stored in the 4-byte area starting from the left, i.e., from the lower end of the byte offset area. For example, in big endian format, if the type is SHORT and the value is 1, it is recorded as 00010000.H.

Note that field entries must be recorded in sequence starting from the smallest tag number. There is no stipulation regarding the order or position of tag value (Value) recording.

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2.6.3. Exif-specific IFD

A. Exif IFD

Exif IFD is a set of tags for recording Exif-specific attribute information. It is pointed to by the offset from the TIFF header (Value Offset) indicated by an Exif private tag value.

Exif IFD Pointer

Tag = 34665 (8769.H)
Type = LONG
Count = 1
Default = none

A pointer to the Exif IFD. Internally, Exif IFD has the same structure as that of the IFD specified in TIFF. Ordinarily, however, it does not contain image data as in the case of TIFF.

B. GPS IFD

GPS IFD is a set of tags for recording GPS information. It is pointed to by the offset from the TIFF header (Value Offset) indicated by a GPS private tag value.

GPS Info IFD Pointer

Tag = 34853 (8825.H)
Type = LONG
Count = 1
Default = none

A pointer to the GPS Info IFD. The internal structure of the GPS Info IFD, like that of Exif IFD, has no image data.

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2.6.4. TIFF Rev. 6.0 Attribute Information

Table 3 lists the attribute information used in Exif, including the attributes given as mandatory in Baseline TIFF Rev. 6.0 RGB Full Color Images and TIFF Rev. 6.0 Extensions YCbCr Images, as well as the optional TIFF tags used by DSC and other systems. The contents are explained below.

Table 3 TIFF Rev. 6.0 Attribute Information Used in Exif

Tag Name	Field Name	Tag ID		Type	Count
		Dec	Hex		
A. Tags relating to image data structure					
Image width	ImageWidth	256	100	SHORT or LONG	1
Image height	ImageLength	257	101	SHORT or LONG	1
Number of bits per component	BitsPerSample	258	102	SHORT	3
Compression scheme	Compression	259	103	SHORT	1
Pixel composition	PhotometricInterpretation	262	106	SHORT	1
Orientation of image	Orientation	274	112	SHORT	1
Number of components	SamplesPerPixel	277	115	SHORT	1
Image data arrangement	PlanarConfiguration	284	11C	SHORT	1
Subsampling ratio of Y to C	YCbCrSubSampling	530	212	SHORT	2
Y and C positioning	YCbCrPositioning	531	213	SHORT	1
Image resolution in width direction	XResolution	282	11A	RATIONAL	1
Image resolution in height direction	YResolution	283	11B	RATIONAL	1
Unit of X and Y resolution	ResolutionUnit	296	128	SHORT	1
B. Tags relating to recording offset					
Image data location	StripOffsets	273	111	SHORT or LONG	*S
Number of rows per strip	RowsPerStrip	278	116	SHORT or LONG	1
Bytes per compressed strip	StripByteCounts	279	117	SHORT or LONG	*S
Offset to JPEG SOI	JPEGInterchangeFormat	513	201	LONG	1
Bytes of JPEG data	JPEGInterchangeFormatLength	514	202	LONG	1
C. Tags relating to image data characteristics					
Transfer function	TransferFunction	301	12D	SHORT	3 * 256
White point chromaticity	WhitePoint	318	13E	RATIONAL	2
Chromaticities of primaries	PrimaryChromaticities	319	13F	RATIONAL	6
Color space transformation matrix coefficients	YCbCrCoefficients	529	211	RATIONAL	3
Pair of black and white reference values	ReferenceBlackWhite	532	214	RATIONAL	6
D. Other tags					
File change date and time	DateTime	306	132	ASCII	20
Image title	ImageDescription	270	10E	ASCII	Any
Image input equipment manufacturer	Make	271	10F	ASCII	Any
Image input equipment model	Model	272	110	ASCII	Any
Software used	Software	305	131	ASCII	Any
Person who created the image	Artist	315	13B	ASCII	Any
Copyright holder	Copyright	3432	8298	ASCII	Any

*S Chunky format: StripsPerImage

Planar format: SamplesPerImage * StripsPerImage

StripsPerImage = floor((ImageLength + RowsPerStrip -1)/ RowsPerStrip)

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A. Tags relating to image data structure

ImageWidth

The number of columns of image data, equal to the number of pixels per row. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 256 (100.H)
Type = SHORT or LONG
Count = 1
Default = none

ImageLength

The number of rows of image data. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 257 (101.H)
Type = SHORT or LONG
Count = 1
Default = none

BitsPerSample

The number of bits per image component. In this standard each component of the image is 8 bits, so the value for this tag is 8. See also *SamplesPerPixel*. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 258 (102.H)
Type = SHORT
Count = 3
Default = 8

Compression

The compression scheme used for the image data. When a primary image is JPEG compressed, this designation is not necessary and is omitted. When thumbnails use JPEG compression, this tag value is set to 6.

Tag = 259 (103.H)
Type = SHORT
Count = 1
Default = none
1 = uncompressed
6 = JPEG compression (thumbnails only)

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Other = reserved

PhotometricInterpretation

The pixel composition. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 262 (106.H)
Type = SHORT
Count = 1
Default = none
2 = RGB
6 = YCbCr
Other = reserved

Orientation

The image orientation viewed in terms of rows and columns.

Tag = 274 (112.H)
Type = SHORT
Count = 1
Default = 1
1 = The 0th row is at the visual top of the image, and the 0th column is the visual left-hand side.
2 = The 0th row is at the visual top of the image, and the 0th column is the visual right-hand side.
3 = The 0th row is at the visual bottom of the image, and the 0th column is the visual right-hand side.
4 = The 0th row is at the visual bottom of the image, and the 0th column is the visual left-hand side.
5 = The 0th row is the visual left-hand side of of the image, and the 0th column is the visual top.
6 = The 0th row is the visual right-hand side of of the image, and the 0th column is the visual top.
7 = The 0th row is the visual right-hand side of of the image, and the 0th column is the visual bottom.
8 = The 0th row is the visual left-hand side of of the image, and the 0th column is the visual bottom.
Other = reserved

SamplesPerPixel

The number of components per pixel. Since this standard applies to RGB and YCbCr images, the value set for this tag is 3. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 277 (115.H)
Type = SHORT
Count = 1

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Default = 3

PlanarConfiguration

Indicates whether pixel components are recorded in chunky or planar format. In JPEG compressed files a JPEG marker is used instead of this tag. If this field does not exist, the TIFF default of 1 (chunky) is assumed.

Tag = 284 (11C.H)
Type = SHORT
Count = 1
1 = chunky format
2 = planar format
Other = reserved

YCbCrSubSampling

The sampling ratio of chrominance components in relation to the luminance component. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 530 (212.H)
Type = SHORT
Count = 2
[2, 1] = YCbCr4:2:2
[2, 2] = YCbCr4:2:0
Other = reserved

YCbCrPositioning

The position of chrominance components in relation to the luminance component. This field is designated only for JPEG compressed data or uncompressed YCbCr data. The TIFF default is 1 (centered); but when Y:Cb:Cr = 4:2:2 it is recommended in this standard that 2 (co-sited) be used to record data, in order to improve the image quality when viewed on TV systems. When this field does not exist, the reader shall assume the TIFF default. In the case of Y:Cb:Cr = 4:2:0, the TIFF default (centered) is recommended. If the reader does not have the capability of supporting both kinds of *YCbCrPositioning*, it shall follow the TIFF default regardless of the value in this field. It is preferable that readers be able to support both centered and co-sited positioning.

Tag = 531 (213.H)
Type = SHORT
Count = 1
Default = 1
1 = centered

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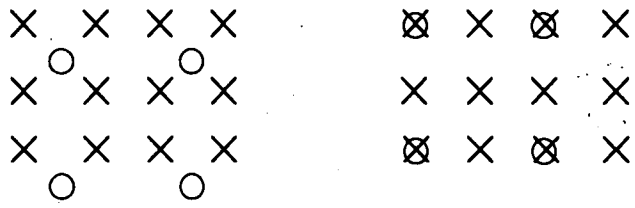
2 = co-sited

Other = reserved



YCbCrPositioning = 1 (centered) YCbCrPositioning = 2 (co-sited)

a) Y:Cb:Cr = 4:2:2



YCbCrPositioning = 1 (centered) YCbCrPositioning = 2 (co-sited)

b) Y:Cb:Cr = 4:2:0

X Luminance Sample

○ Chrominance Sample

Fig. 8 YCbCrPositioning

XResolution

The number of pixels per *ResolutionUnit* in the *ImageWidth* direction. When the image resolution is unknown, 72 [dpi] is designated.

Tag = 282 (11A.H)

Type = RATIONAL

Count = 1

Default = 72

YResolution

The number of pixels per *ResolutionUnit* in the *ImageLength* direction. The same value as *XResolution* is designated.

Tag = 283 (11B.H)

Type = RATIONAL

Count = 1

Default = 72

ResolutionUnit

The unit for measuring *XResolution* and *YResolution*. The same unit is used for both *XResolution* and

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YResolution. If the image resolution in unknown, 2 (inches) is designated.

Tag = 296 (128.H)

Type = SHORT

Count = 1

Default = 2

2 = inches

3 = centimeters

Other = reserved

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B. Tags relating to recording offset

StripOffsets

For each strip, the byte offset of that strip. It is recommended that this be selected so the number of strip bytes does not exceed 64 Kbytes. With JPEG compressed data this designation is not needed and is omitted. See also *RowsPerStrip* and *StripByteCounts*.

Tag	=	273 (111.H)	
Type	=	SHORT or LONG	
Count	=	StripsPerImage	(when PlanarConfiguration = 1)
	=	SamplesPerPixel * StripsPerImage	(when PlanarConfiguration = 2)
Default	=	none	

RowsPerStrip

The number of rows per strip. This is the number of rows in the image of one strip when an image is divided into strips. With JPEG compressed data this designation is not needed and is omitted. See also *RowsPerStrip* and *StripByteCounts*.

Tag

Tag	=	278 (116.H)
Type	=	SHORT or LONG
Count	=	1
Default	=	none

StripByteCounts

The total number of bytes in each strip. With JPEG compressed data this designation is not needed and is omitted.

Tag	=	279 (117.H)	
Type	=	SHORT or LONG	
Count	=	StripsPerImage	(when PlanarConfiguration = 1)
		SamplesPerPixel * StripsPerImage	(when PlanarConfiguration = 2)
Default	=	none	

JPEGInterchangeFormat

The offset to the start byte (SOI) of JPEG compressed thumbnail data. This is not used for primary image JPEG data.

Tag	=	513 (201.H)
Type	=	LONG

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Default = none

JPEGInterchangeFormatLength

The number of bytes of JPEG compressed thumbnail data. This is not used for primary image JPEG data. JPEG thumbnails are not divided but are recorded as a continuous JPEG bitstream from SOI to EOI. APPn and COM markers should not be recorded. Compressed thumbnails must be recorded in no more than 64 Kbytes, including all other data to be recorded in APP1.

Tag = 513 (201.H)

Type = LONG

Default = none

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C. Tags Relating to Image Data Characteristics

TransferFunction

A transfer function for the image, described in tabular style. Normally this tag is not necessary, since color space is specified in the color space information tag (*ColorSpace*).

Tag = 301 (12D.H)
Type = SHORT
Count = 3 * 256
Default = none

WhitePoint

The chromaticity of the white point of the image. Normally this tag is not necessary, since color space is specified in the color space information tag (*ColorSpace*).

Tag = 318 (13E.H)
Type = RATIONAL
Count = 2
Default = none

PrimaryChromaticities

The chromaticity of the three primary colors of the image. Normally this tag is not necessary, since color space is specified in the color space information tag (*ColorSpace*).

Tag = 319 (13F.H)
Type = RATIONAL
Count = 6
Default = none

YCbCrCoefficients

The matrix coefficients for transformation from RGB to YCbCr image data. No default is given in TIFF; but here the value given in Appendix E, "Color Space Guidelines," is used as the default. The color space is declared in a color space information tag, with the default being the value that gives the optimal image characteristics under this condition.

Tag = 529 (211.H)
Type = RATIONAL
Count = 3
Default = See Appendix E.

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ReferenceBlackWhite

The reference black point value and reference white point value. No defaults are given in TIFF, but the values below are given as defaults here. The color space is declared in a color space information tag, with the default being the value that gives the optimal image characteristics under these conditions.

Tag	=	532 (214.H)	
Type	=	RATIONAL	
Count	=	6	
Default	=	[0, 255, 0, 255, 0, 255]	(when PhotometricInterpretation is RGB)
		[0, 255, 0, 128, 0, 128]	(when PhotometricInterpretation is YCbCr)

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D. Other Tags

DateTime

The date and time of image creation. In this standard it is the date and time the file was changed. The format is "YYYY:MM:DD HH:MM:SS" with time shown in 24-hour format, and the date and time separated by one blank character [20.H]. When the date and time are unknown, all the character spaces except colons (":") may be filled with blank characters, or else the entire field may be filled with blank characters. The character string length is 20 bytes including NULL for termination. When the field is left blank, it is treated as unknown.

Tag = 306 (132.H)
Type = ASCII
Count = 20
Default = none

ImageDescription

A character string giving the title of the image. It may be a comment such as "1988 company picnic" or the like. Two-byte character codes cannot be used. When a 2-byte code is necessary, the Exif Private tag *UserComment* is to be used.

Tag = 270 (10E.H)
Type = ASCII
Count = Any
Default = none

Make

The manufacturer of the recording equipment. This is the manufacturer of the DSC, scanner, video digitizer or other equipment that generated the image. When the field is left blank, it is treated as unknown.

Tag = 271 (10F.H)
Type = ASCII
Count = Any
Default = none

Model

The model name or model number of the equipment. This is the model name of number of the DSC, scanner, video digitizer or other equipment that generated the image. When the field is left blank, it

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is treated as unknown.

Tag = 272 (110.H)
Type = ASCII
Count = Any
Default = none

Software

This tag records the name and version of the software or firmware of the camera or image input device used to generate the image. The detailed format is not specified, but it is recommended that the example shown below be followed. When the field is left blank, it is treated as unknown.

Ex.) "Exif Software Version 1.00a"

Tag = 305 (131h)
Type = ASCII
Count = Any
Default = none

Artist

This tag records the name of the camera owner, photographer or image creator. The detailed format is not specified, but it is recommended that the information be written as in the example below for ease of understanding. When the field is left blank, it is treated as unknown.

Ex.) "Camera owner, John Smith; Photographer, Michael Brown; Image creator, Ken James"

Tag = 315 (13Bh)
Type = ASCII
Count = Any
Default = none

Copyright

Copyright information. In this standard the tag is used to indicate both the photographer and editor copyrights. It is the copyright notice of the person or organization claiming rights to the image. The entire copyright statement including date and rights should be written in this field; e.g., "Copyright, John Smith, 19xx. All rights reserved." In this standard the field records both the photographer and editor copyrights, with each recorded in a separate part of the statement. When there is a clear distinction between the photographer and editor copyrights, these are to be written in the order of photographer followed by editor copyright, separated by NULL (in this case, since the statement also ends with a NULL, there are two NULL codes) (see example 1). When only the photographer copyright is given, it is terminated by one NULL code (see example 2). When only the editor copyright

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is given, the photographer copyright part consists of one space followed by a terminating NULL code, then the editor copyright is given (see example 3). When the field is left blank, it is treated as unknown.

Ex. 1) When both the photographer copyright and editor copyright are given.

Photographer copyright + NULL[00.H] + editor copyright + NULL[00.H]

Ex. 2) When only the photographer copyright is given.

Photographer copyright + NULL[00.H]

Ex. 3) When only the editor copyright is given.

Space[20.H]+ NULL[00.H] + editor copyright + NULL[00.H]

Tag	=	33432 (8298.H)
Type	=	ASCII
Count	=	Any
Default	=	none

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2.6.5. Exif IFD Attribute Information

The attribute information (field names and codes) recorded in the Exif IFD is given in Table 4 and Table 5 followed by an explanation of the contents.

Table 4 Exif IFD Attribute Information (1)

Tag Name	Field Name	Tag ID		Type	Count
		Dec	Hex		
A. Tags Relating to Version					
Exif version	ExifVersion	36864	9000	UNDEFINED	4
Supported FlashPix version	FlashPixVersion	40960	A000	UNDEFINED	4
B. Tag Relating to Image Data Characteristics					
Color space information	ColorSpace	40961	A001	SHORT	1
C. Tags Relating to Image Configuration					
Meaning of each component	ComponentsConfiguration	37121	9101	UNDEFINED	4
Image compression mode	CompressedBitsPerPixel	37122	9102	RATIONAL	1
Valid image width	PixelXDimension	40962	A002	SHORT or LONG	1
Valid image height	PixelYDimension	40963	A003	SHORT or LONG	1
D. Tags Relating to User Information					
Manufacturer notes	MakerNote	37500	927C	UNDEFINED	Any
User comments	UserComment	37510	9286	UNDEFINED	Any
E. Tag Relating to Related File Information					
Related audio file	RelatedSoundFile	40964	A004	ASCII	13
F. Tags Relating to Date and Time					
Date and time of original data generation	DateTimeOriginal	36867	9003	ASCII	20
Date and time of digital data generation	DateTimeDigitized	36868	9004	ASCII	20
DateTime subseconds	SubSecTime	37520	9290	ASCII	Any
DateTimeOriginal subseconds	SubSecTimeOriginal	37521	9291	ASCII	Any
DateTimeDigitized subseconds	SubSecTimeDigitized	37522	9292	ASCII	Any

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Table 5 Exif IFD Attribute Information (2)

G. Tags Relating to Picture-Taking Conditions					
Exposure time	ExposureTime	33434	829A	RATIONAL	1
F number	FNumber	33437	829D	RATIONAL	1
Exposure program	ExposureProgram	34850	8822	SHORT	1
Spectral sensitivity	SpectralSensitivity	34852	8824	ASCII	Any
ISO speed rating	ISOSpeedRatings	34855	8827	SHORT	Any
Optoelectric conversion factor	OECF	34856	8828	UNDEFINED	Any
Shutter speed	ShutterSpeedValue	37377	9201	SRATIONAL	1
Aperture	ApertureValue	37378	9202	RATIONAL	1
Brightness	BrightnessValue	37379	9203	SRATIONAL	1
Exposure bias	ExposureBiasValue	37380	9204	SRATIONAL	1
Maximum lens aperture	MaxApertureValue	37381	9205	RATIONAL	1
Subject distance	SubjectDistance	37382	9206	RATIONAL	1
Metering mode	MeteringMode	37383	9207	SHORT	1
Light source	LightSource	37384	9208	SHORT	1
Flash	Flash	37385	9209	SHORT	1
Lens focal length	FocalLength	37386	920A	RATIONAL	1
Flash energy	FlashEnergy	41483	A20B	RATIONAL	1
Spatial frequency response	SpatialFrequencyResponse	41484	A20C	UNDEFINED	Any
Focal plane X resolution	FocalPlaneXResolution	41486	A20E	RATIONAL	1
Focal plane Y resolution	FocalPlaneYResolution	41487	A20F	RATIONAL	1
Focal plane resolution unit	FocalPlaneResolutionUnit	41488	A210	SHORT	1
Subject location	SubjectLocation	41492	A214	SHORT	2
Exposure index	ExposureIndex	41493	A215	RATIONAL	1
Sensing method	SensingMethod	41495	A217	SHORT	1
File source	FileSource	41728	A300	UNDEFINED	1
Scene type	SceneType	41729	A301	UNDEFINED	1
CFA pattern	CFAPattern	41730	A302	UNDEFINED	Any

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A. Tags Relating to Version

ExifVersion

The version of this standard supported. Nonexistence of this field is taken to mean nonconformance to the standard (see section 2.2). Conformance to this standard is indicated by recording "0020" as 4-byte ASCII. Since the type is UNDEFINED, there is no NULL for termination.

Tag = 36864 (9000.H)
Type = UNDEFINED
Count = 4
Default = "0200"

FlashPixVersion

The FlashPix format version supported by a FPXR file. If the FPXR function supports FlashPix format Ver. 1.0, this is indicated similarly to *ExifVersion* by recording "0100" as 4-byte ASCII. Since the type is UNDEFINED, there is no NULL for termination.

Tag = 40960(A000.H)
Type = UNDEFINED
Count = 4
Default = "0100"
0100 = FlashPix Format Version 1.0
Other = reserved

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B. Tag Relating to Color Space

ColorSpace

The color space information tag (*ColorSpace*) is always recorded as the color space specifier.

Normally sRGB (=1) is used to define the color space based on the PC monitor conditions and environment. If a color space other than sRGB is used, Uncalibrated (=FFFF.H) is set. Image data recorded as Uncalibrated can be treated as sRGB when it is converted to FlashPix. On sRGB see Appendix E.

Tag = 40961 (A001.H)

Type = SHORT

Count = 1

1	=	sRGB
FFFF.H	=	Uncalibrated
Other	=	reserved

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C. Tags Relating to Image Configuration

PixelXDimension

Information specific to compressed data. When a compressed file is recorded, the valid width of the meaningful image must be recorded in this tag, whether or not there is padding data or a restart marker. This tag should not exist in an uncompressed file. For details see section 2.8.1 and Appendix F.

Tag = 40962 (A002.H)
Type = SHORT or LONG
Count = 1
Default = none

PixelYDimension

Information specific to compressed data. When a compressed file is recorded, the valid height of the meaningful image must be recorded in this tag, whether or not there is padding data or a restart marker. This tag should not exist in an uncompressed file. For details see section 2.8.1 and Appendix F. Since data padding is unnecessary in the vertical direction, the number of lines recorded in this valid image height tag will in fact be the same as that recorded in the SOF.

Tag = 40963 (A003.H)
Type = SHORT of LONG
Count = 1

ComponentsConfiguration

Information specific to compressed data. The channels of each component are arranged in order from the 1st component to the 4th. For uncompressed data the data arrangement is given in the *PhotometricInterpretation* tag. However, since *PhotometricInterpretation* can only express the order of Y,Cb and Cr, this tag is provided for cases when compressed data uses components other than Y, Cb, and Cr and to enable support of other sequences.

Tag = 37121 (9101.H)
Type = UNDEFINED
Count = 4
Default = 4 5 6 0 (if RGB uncompressed)
1 2 3 0 (other cases)

0 = does not exist
1 = Y
2 = Cb
3 = Cr

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4 = R

5 = G

6 = B

Other = reserved

CompressedBitsPerPixel

Information specific to compressed data. The compression mode used for a compressed image is indicated in unit bits per pixel.

Tag = 37122 (9102.H)

Type = RATIONAL

Count = 1

Default = none

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D. Tags Relating to User Information

MakerNote

A tag for manufacturers of Exif writers to record any desired information. The contents are up to the manufacturer.

Tag = 37500 (927C.H)
Type = UNDEFINED
Count = Any
Default = none

UserComment

A tag for Exif users to write keywords or comments on the image besides those in *ImageDescription*, and without the character code limitations of the *ImageDescription* tag.

Tag = 37510 (9286.H)
Type = UNDEFINED
Count = Any
Default = none

The character code used in the *UserComment* tag is identified based on an ID code in a fixed 8-byte area at the start of the tag data area. The unused portion of the area is padded with NULL ("00.H"). ID codes are assigned by means of registration. The designation method and references for each character code are given in Table 6. The value of Count N is determined based on the 8 bytes in the character code area and the number of bytes in the user comment part. Since the TYPE is not ASCII, NULL termination is not necessary (see Fig. 9).

Table 6 Character Codes and their Designation

Character Code	Code Designation (8 Bytes)	References
ASCII	41.H, 53.H, 43.H, 49.H, 49.H, 00.H, 00.H, 00.H	ITU-T T.50 IA5[ix]
JIS	4A.H, 49.H, 53.H, 00.H, 00.H, 00.H, 00.H, 00.H	JIS X0208-1990[x]
Unicode	55.H, 4E.H, 49.H, 43.H, 4F.H, 44.H, 45.H, 00.H	Unicode Standard [xi]
Undefined	00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H	Undefined

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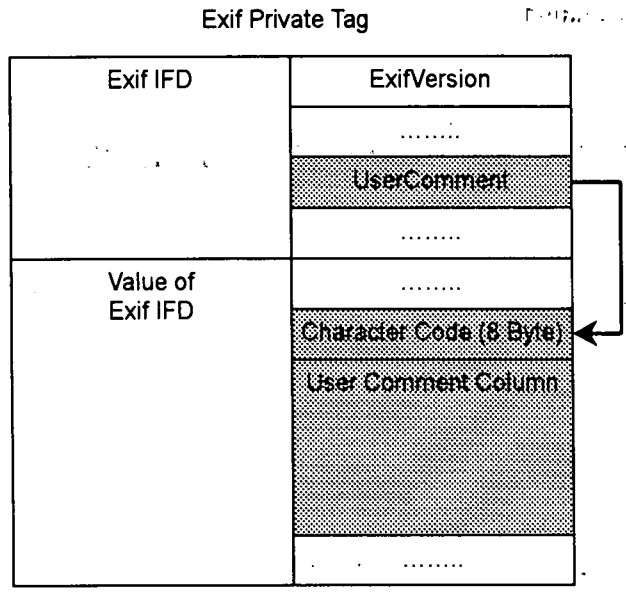


Fig. 9 User Comment Tag

The ID code for the *UserComment* area may be a Defined code such as JIS or ASCII, or may be Undefined. The Undefined name is *UndefinedText*, and the ID code is filled with 8 bytes of all "NULL" ("00.H"). An Exif reader that reads the *UserComment* tag must have a function for determining the ID code. This function is not required in Exif readers that do not use the *UserComment* tag (see Table 7).

Table 7 Implementation of Defined and Undefined Character Codes

ID Code	Exif Reader Implementation
Defined (JIS, ASCII, etc.)	Determines the ID code and displays it in accord with the reader capability.
Undefined (all NULL)	Depends on the localized PC in each country. (If a character code is used for which there is no clear specification like Shift-JIS in Japan, Undefined is used.) Although the possibility of unreadable characters exists, display of these characters is left as a matter of reader implementation.

When a *UserComment* area is set aside, it is recommended that the ID code be ASCII and that the following user comment part be filled with blank characters [20.H].

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E. Tag Relating to Related File

RelatedSoundFile

This tag is used to record the name of an audio file related to the image data. The only relational information recorded here is the Exif audio file name and extension (an ASCII string consisting of 8 characters + '.' + 3 characters). The path is not recorded. Stipulations on audio are given in section 3.6.3. File naming conventions are given in section 3.7.1.

When using this tag, audio files must be recorded in conformance to the Exif audio format. Writers are also allowed to store the data such as Audio within APP2 as FlashPix extension stream data.

Audio files must be recorded in conformance to the Exif audio format.

The mapping of Exif image files and audio files is done in any of the three ways shown in Table 8. If multiple files are mapped to one file as in [2] or [3] of this table, the above format is used to record just one audio file name. If there are multiple audio files, the first recorded file is given.

In the case of [3] in Table 8, for example, for the Exif image file "DSC00001.JPG" only "SND00001.WAV" is given as the related Exif audio file.

When there are three Exif audio files "SND00001.WAV", "SND00002.WAV" and "SND00003.WAV", the Exif image file name for each of them, "DSC00001.JPG," is indicated. By combining multiple relational information, a variety of playback possibilities can be supported. The method of using relational information is left to the implementation on the playback side. Since this information is an ASCII character string, it is terminated by NULL.

Table 8 Mapping between Image and Audio Files

	Relationship	Exif Image File	Exif Audio File
[1]	1 to 1	DSC00001.JPG	SND00001.WAV
[2]	Plural to 1	DSC00001.JPG DSC00002.JPG DSC00003.JPG	SND00001.WAV
[3]	1 to plural	DSC00001.JPG	SND00001.WAV SND00002.WAV SND00003.WAV

When this tag is used to map audio files, the relation of the audio file to image data must also be indicated on the audio file end.

Tag = 40964 (A004.H)

Type = ASCII

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Count = 13

Default = none



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F. Tags Relating to Date and Time

DateTimeOriginal

The date and time when the original image data was generated. For a DSC the date and time the picture was taken are recorded. The format is "YYYY:MM:DD HH:MM:SS" with time shown in 24-hour format, and the date and time separated by one blank character [20.H]. When the date and time are unknown, all the character spaces except colons (":") may be filled with blank characters, or else the entire field may be filled with blank characters. The character string length is 20 bytes including NULL for termination. When the field is left blank, it is treated as unknown.

Tag = 36867 (9003.H)
Type = ASCII
Count = 20
Default = none

DateTimeDigitized

The date and time when the image was stored as digital data. If, for example, an image was captured by DSC and at the same time the file was recorded, then the *DateTimeOriginal* and *DateTimeDigitized* will have the same contents. The format is "YYYY:MM:DD HH:MM:SS" with time shown in 24-hour format, and the date and time separated by one blank character [20.H]. When the date and time are unknown, all the character spaces except colons (":") may be filled with blank characters, or else the entire field may be filled with blank characters. The character string length is 20 bytes including NULL for termination. When the field is left blank, it is treated as unknown.

Tag = 36868 (9004.H)
Type = ASCII
Count = 20
Default = none

SubsecTime

A tag used to record fractions of seconds for the *DateTime* tag.

Tag = 37520 (9290.H)
Type = ASCII
Count = Any
Default = none

SubsecTimeOriginal

A tag used to record fractions of seconds for the *DateTimeOriginal* tag.

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Tag = 37521 (9291.H)

Type = ASCII

N = Any

Default = none

SubsecTimeDigitized

A tag used to record fractions of seconds for the *DateTimeDigitized* tag.

Tag = 37522 (9292.H)

Type = ASCII

N = Any

Default = none

Note: Recording subsecond data (*SubsecTime, SubsecTimeOriginal, SubsecTimeDigitized*)

The tag type is ASCII and the string length including NULL is variable length. When the number of valid digits is up to the second decimal place, the subsecond value goes in the Value position. When it is up to four decimal places, an address value is entered, with the subsecond value put in the location pointed to by that address. (Since the count of ASCII type field entries is a value that includes NULL, when the number of valid digits is up to four decimal places the count is 5, and the offset value goes in the Value Offset field. See section 2.6.2.) Note that the subsecond tag differs from the *DateTime* tag and other such tags already defined in TIFF Rev. 6.0, and that both are recorded in the Exif IFD.

Ex.: September 9, 1998, 9:15:30.130

(the number of valid digits is up to the third decimal place)

DateTime 1996:09:01 09:15:30 [NULL]

SubSecTime 130 [NULL]

If the string length is longer than the number of valid digits, the digits are aligned with the start of the area and the rest is filled with blank characters [20.H]. If the subsecond data is unknown, the entire area can be filled with blank characters.

Examples when subsecond data is 0.130 seconds:

Ex. 1) '1','3','0',[NULL]

Ex. 2) '1','3','0',[20.H],[NULL]

Ex. 3) '1','3','0', [20.H], [20.H], [20.H], [20.H], [20.H], [NULL]

Example when subsecond data is unknown:

Ex. 4) [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [NULL]

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G. Tags Relating to Picture-Taking Conditions

ExposureTime

Exposure time, given in seconds (sec).

Tag = 33434 (829A.H)
Type = RATIONAL
Count = 1
Default = none

ShutterSpeedValue

Shutter speed. The unit is the APEX (Additive System of Photographic Exposure) setting (see Appendix C).

Tag = 37377 (9201.H)
Type = SRATIONAL
Count = 1
Default = none

ApertureValue

The lens aperture. The unit is the APEX value.

Tag = 37378 (9202.H)
Type = RATIONAL
Count = 1
Default = none

BrightnessValue

The value of brightness. The unit is the APEX value. Ordinarily it is given in the range of -99.99 to 99.99.

Tag = 37379 (9203.H)
Type = SRATIONAL
Count = 1
Default = none

ExposureBiasValue

The exposure bias. The unit is the APEX value. Ordinarily it is given in the range of –99.99 to 99.99.

Tag = 37380 (9204.H)
Type = SRATIONAL

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Count = 1

Default = none

MaxApertureValue

The smallest F number of the lens. The unit is the APEX value. Ordinarily it is given in the range of 00.00 to 99.99, but it is not limited to this range.

Tag = 37381 (9205.H)

Type = RATIONAL

Count = 1

Default = none

SubjectDistance

The distance to the subject, given in meters.

Tag = 37382 (9206.H)

Type = RATIONAL

Count = 1

Default = none

MeteringMode

The metering mode.

Tag = 37383 (9207.H)

Type = SHORT

Count = 1

Default = 0

0	=	unknown
1	=	Average
2	=	CenterWeightedAverage
3	=	Spot
4	=	MultiSpot
5	=	Pattern
6	=	Partial
7 to 254	=	reserved
255	=	other

LightSource

The kind of light source.

Tag = 37384 (9208.H)

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Type = SHORT

Count = 1

Default = 0

0 = unknown

1 = Daylight

2 = Fluorescent

3 = Tungsten

17 = Standard light A

18 = Standard light B

19 = Standard light C

20 = D55

21 = D65

22 = D75

23 to 254 = reserved

255 = other

Flash

This tag is recorded when an image is taken using a strobe light (flash). Bit 0 indicates the flash firing status, and bits 1 and 2 indicate the flash return status (see Fig. 10).

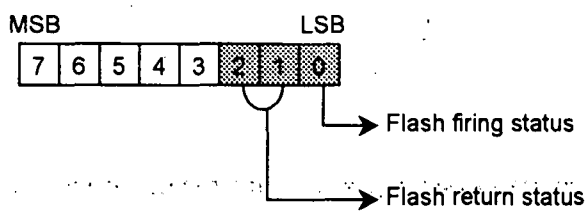


Fig. 10 Bit Coding of the Flash Tag

Tag = 37385 (9209.H)

Type = SHORT

Count = 1

Values for bit 0 indicating whether the flash fired.

0b = Flash did not fire.

1b = Flash fired.

Values for bits 1 and 2 indicating the status of returned light.

00b = No strobe return detection function

01b = reserved

10b = Strobe return light not detected.

11b = Strobe return light detected.

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Resulting Flash tag values.

0000.H = Flash did not fire.

0001.H = Flash fired.

0005.H = Strobe return light not detected.

0007.H = Strobe return light detected.

Other = reserved

FocalLength

The actual focal length of the lens, in mm. Conversion is not made to the focal length of a 35 mm film camera.

Tag = 37386 (920A.H)

Type = RATIONAL

Count = 1

Default = none

FNumber

The F number.

Tag = 33437 (829D.H)

Type = RATIONAL

Count = 1

Default = none

ExposureProgram

The class of the program used by the camera to set exposure when the picture is taken. The tag values are as follows.

Tag = 34850 (8822.H)

Type = SHORT

Count = 1

Default = 0

0 = Not defined

1 = Manual

2 = Normal program

3 = Aperture priority

4 = Shutter priority

5 = Creative program (biased toward depth of field)

6 = Action program (biased toward fast shutter speed)

7 = Portrait mode (for closeup photos with the background out of focus)

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8 = Landscape mode (for landscape photos with the background in focus)

9 to 255 = reserved

SpectralSensitivity

Indicates the spectral sensitivity of each channel of the camera used. The tag value is an ASCII string compatible with the standard[xii] developed by the ASTM Technical committee.

Tag = 34852 (8824.H)

Type = ASCII

Count = Any

Default = none

ISOSpeedRatings

Indicates the ISO Speed and ISO Latitude of the camera or input device as specified in ISO 12232[xiii].

Tag = 34855 (8827.H)

Type = SHORT

Count = Any

Default = none

OECF

Indicates the Opto-Electoric Conversion Function (OECF) specified in ISO 14524[xiv]. *OECF* is the relationship between the camera optical input and the image values.

Tag = 34856 (8828.H)

Type = UNDEFINED

Count = ANY

Default = none

When this tag records an *OECF* of m rows and n columns, the values are as in Fig. 11.

Length	Type	Meaning
2	SHORT	Columns = n
2	SHORT	Rows = m
Any	ASCII	0th row item name (NULL terminated)
:	:	:
Any	ASCII	n-1th row item name (NULL terminated)
8	RATIONAL	OECF value [0,0]
:	:	:
8	RATIONAL	OECF value [n-1,0]
8	RATIONAL	OECF value [0,m-1]
:	:	:
8	RATIONAL	OECF value [n-1,m-1]

Fig. 11 OECF Description

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Table 9 gives a simple example.

Table 9 Example of Exposure and RGB Output Level

Camera log Aperture	R Output Level	G Output Level	B Output Level
-3.0	10.2	12.4	8.9
-2.0	48.1	47.5	48.3
-1.0	150.2	152.0	149.8

FlashEnergy

Indicates the strobe energy at the time the image is captured, as measured in Beam Candle Power Seconds (BCPS).

Tag = 41483 (A20B.H)

Type = RATIONAL

Count = 1

Default = none

SpatialFrequencyResponse

This tag records the camera or input device spatial frequency table and SFR values in the direction of image width, image height, and diagonal direction, as specified in ISO 12233[xv].

Tag = 41484 (A20CH)

Type = UNDEFINED

Count = ANY

Default = none

When the spatial frequency response for m rows and n columns is recorded, the values are as shown in Fig. 12.

Length	Type	Meaning
2	SHORT	Columns = n
2	SHORT	Rows = m
Any	ASCII	0th row item name (NULL terminated)
:	:	:
Any	ASCII	n-1th row item name (NULL terminated)
8	RATIONAL	SFR value [0,0]
:	:	:
8	RATIONAL	SFR value [n-1,0]
8	RATIONAL	SFR value [0,m-1]
:	:	:
8	RATIONAL	SFR value [n-1,m-1]

Fig. 12 Spatial Frequency Response Description

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Table 10 gives a simple example.

Table 10 Example of Spatial Frequency Response

Spatial Frequency (lw/ph)	Along Image Width	Along Image Height
	1.00	1.00
0.2	0.90	0.95
0.3	0.80	0.85

FocalPlaneXResolution

Indicates the number of pixels in the image width (X) direction per *FocalPlaneResolutionUnit* on the camera focal plane.

Tag = 41486 (A20E.H)
Type = RATIONAL
Count = 1
Default = none

FocalPlaneYResolution

Indicates the number of pixels in the image height (Y) direction per *FocalPlaneResolutionUnit* on the camera focal plane.

Tag = 41487 (A20F.H)
Type = RATIONAL
Count = 1
Default = none

FocalPlaneResolutionUnit

Indicates the unit for measuring *FocalPlaneXResolution* and *FocalPlaneYResolution*. This value is the same as the *ResolutionUnit*.

Tag = 41488 (A210.H)
Type = SHORT
Count = 1
Default = 2 (inch)

Note on use of tags concerning focal plane resolution

These tags record the actual focal plane resolutions of the main image which is written as a file after processing instead of the pixel reslution of the image sensor in the camera. It should be noted carefully that the data from the image sensor is resampled.

These tags are used at the same time as a FocalLength tag when the angle of field of the recorded image is to be calculated precisely.

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SubjectLocation

Indicates the location of the main subject in the scene. The value of this tag represents the pixel at the center of the main subject relative to the left edge, prior to rotation processing as per the *Rotation* tag. The first value indicates the X column number and second indicates the Y row number.

Tag = 41492 (A214.H)
Type = SHORT
Count = 2
Default = none

ExposureIndex

Indicates the exposure index selected on the camera or input device at the time the image is captured.

Tag = 41493 (A215.H)
Type = RATIONAL
Count = 1
Default = none

SensingMethod

Indicates the image sensor type on the camera or input device. The values are as follows.

Tag = 41495 (A217.H)
Type = SHORT
Count = 1
Default = none
1 = Not defined
2 = One-chip color area sensor
3 = Two-chip color area sensor
4 = Three-chip color area sensor
5 = Color sequential area sensor
7 = Trilinear sensor
8 = Color sequential linear sensor
Other = reserved

FileSource

Indicates the image source. If a DSC recorded the image, this tag value of this tag always be set to 3, indicating that the image was recorded on a DSC.

Tag = 41728 (A300.H)
Type = UNDEFINED
Count = 1

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Default = 3

3 = DSC

Other = reserved

SceneType

Indicates the type of scene. If a DSC recorded the image, this tag value must always be set to 1, indicating that the image was directly photographed.

Tag = 41729 (A301.H)

Type = UNDEFINED

Count = 1

Default = 1

1 = A directly photographed image

Other = reserved

CFAPattern

Indicates the color filter array (CFA) geometric pattern of the image sensor when a one-chip color area sensor is used. It does not apply to all sensing methods.

Tag = 41730 (A302.H)

Type = UNDEFINED

Count = ANY

Fig. 13 shows how a CFA pattern is recorded for a one-chip color area sensor when the color filter array is repeated in m x n (vertical x lateral) pixel units.

Length	Type	Meaning
2	SHORT	Horizontal repeat pixel unit = n
2	SHORT	Vertical repeat pixel unit = m
1	WORD	CFA value [0.0]
:	:	:
1	WORD	CFA value [n-1.0]
1	WORD	CFA value [0.m-1]
:	:	:
1	WORD	CFA value [n-1.m-1]

Fig. 13 CFA Pattern Description

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The relation of color filter color to CFA value is shown in Table 11.

Table 11 Color Filter Color and CFA Value

Filter Color	CFA Value
RED	00.H
GREEN	01.H
BLUE	02.H
CYAN	03.H
MAGENTA	04.H
YELLOW	05.H
WHITE	06.H

For example, when the CFA pattern values are {0002.H, 0002.H, 01.H, 00.H, 02.H, 01.H}, the color filter array is as shown in Fig. 14.

G	R	G	R	.....
B	G	B	G	.....
G	R	G	R	.....
B	G	B	G	.....
:	:	:	:	

Fig. 14 Color Filter Array

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2.6.6. GPS Attribute Information

The attribute information (field names and codes) recorded in the GPS Info IFD is given in Table 12, followed by an explanation of the contents.

Table 12 GPS Attribute Information

Tag Name	Field Name	Tag ID		Type	Count
		Dec	Hex		
A. Tags Relating to GPS					
GPS tag version	GPSVersionID	0	0	BYTE	4
North or South Latitude	GPSLatitudeRef	1	1	ASCII	2
Latitude	GPSLatitude	2	2	RATIONAL	3
East or West Longitude	GPSLongitudeRef	3	3	ASCII	2
Longitude	GPSLongitude	4	4	RATIONAL	3
Altitude reference	GPSAltitudeRef	5	5	BYTE	1
Altitude	GPSAltitude	6	6	RATIONAL	1
GPS time (atomic clock)	GPSTimeStamp	7	7	RATIONAL	3
GPS satellites used for measurement	GPSSatellites	8	8	ASCII	Any
GPS receiver status	GPSStatus	9	9	ASCII	2
GPS measurement mode	GPSMeasureMode	10	A	ASCII	2
Measurement precision	GPSDOP	11	B	RATIONAL	1
Speed unit	GPSSpeedRef	12	C	ASCII	2
Speed of GPS receiver	GPSSpeed	13	D	RATIONAL	1
Reference for direction of movement	GPSTrackRef	14	E	ASCII	2
Direction of movement	GPSTrack	15	F	RATIONAL	1
Reference for direction of image	GPSImgDirectionRef	16	10	ASCII	2
Direction of image	GPSImgDirection	17	11	RATIONAL	1
Geodetic survey data used	GPSMapDatum	18	12	ASCII	Any
Reference for latitude of destination	GPSDestLatitudeRef	19	13	ASCII	2
Latitude of destination	GPSDestLatitude	20	14	RATIONAL	3
Reference for longitude of destination	GPSDestLongitudeRef	21	15	ASCII	2
Longitude of destination	GPSDestLongitude	22	16	RATIONAL	3
Reference for bearing of destination	GPSDestBearingRef	23	17	ASCII	2
Bearing of destination	GPSDestBearing	24	18	RATIONAL	1
Reference for distance to destination	GPSDestDistanceRef	25	19	ASCII	2
Distance to destination	GPSDestDistance	26	1A	RATIONAL	1

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A. Tags Relating to GPS

GPSVersionID

Indicates the version of *GPSInfoIFD*. The version is given as 2.0.0.0. This tag is mandatory when *GPSInfo* tag is present. (Note: The *GPSVersionID* tag is given in bytes, unlike the *ExifVersion* tag. When the version is 2.0.0.0, the tag value is 02000000.H.)

Tag = 0 (0.H)
Type = BYTE
Count = 4
Default = 2.0.0.0
2.0.0.0 = Version 2.0
Other = reserved

GPSLatitudeRef

Indicates whether the latitude is north or south latitude. The ASCII value 'N' indicates north latitude, and 'S' is south latitude.

Tag = 1 (1.H)
Type = ASCII
Count = 2
Default = none
'N' = North latitude
'S' = South latitude
Other = reserved

GPSLatitude

Indicates the latitude. The latitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. When degrees, minutes and seconds are expressed, the format is dd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format is dd/1,mmmm/100,0/1.

Tag = 2 (2.H)
Type = RATIONAL
Count = 3
Default = none

GPSLongitudeRef

Indicates whether the longitude is east or west longitude. ASCII 'E' indicates east longitude, and 'W'

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is west longitude.

Tag = 3 (3.H)
Type = ASCII
Count = 2
Default = none
'E' = East longitude
'W' = West longitude
Other = reserved

GPSLongitude

Indicates the longitude. The longitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. When degrees, minutes and seconds are expressed, the format is ddd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format is ddd/1,mmmm/100,0/1.

Tag = 4 (4.H)
Type = RATIONAL
Count = 3
Default = none

GPSAltitudeRef

Indicates the altitude used as the reference altitude. In this version the reference altitude is sea level, so this tag must be set to 0. The reference unit is meters. Note that this tag is BYTE type, unlike other reference tags.

Tag = 5 (5.H)
Type = BYTE
Count = 1
Default = 0
0 = Sea level
Other = reserved

GPSAltitude

Indicates the altitude based on the reference in *GPSAltitudeRef*. Altitude is expressed as one RATIONAL value. The reference unit is meters.

Tag = 6 (6.H)
Type = RATIONAL
Count = 1
Default = none

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GPSTimeStamp

Indicates the time as UTC (Coordinated Universal Time). TimeStamp is expressed as three RATIONAL values giving the hour, minute, and second.

Tag = 7 (7.H)
Type = RATIONAL
Count = 3
Default = none

GPSSatellites

Indicates the GPS satellites used for measurements. This tag can be used to describe the number of satellites, their ID number, angle of elevation, azimuth, SNR and other information in ASCII notation. The format is not specified. If the GPS receiver is incapable of taking measurements, value of the tag must be set to NULL.

Tag = 8 (8.H)
Type = ASCII
Count = Any
Default = none

GPSStatus

Indicates the status of the GPS receiver when the image is recorded. 'A' means measurement is in progress, and 'V' means the measurement is interrupted.

Tag = 9 (9.H)
Type = ASCII
Count = 2
Default = none
'A' = Measurement in progress
'V' = Measurement interrupted
Other = reserved

GPSMeasureMode

Indicates the GPS measurement mode. '2' means two-dimensional measurement and '3' means three-dimensional measurement is in progress.

Tag = 10 (A.H)
Type = ASCII
Count = 2
Default = none
'2' = 2-dimensional measurement

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'3' = 3-dimensional measurement

Other = reserved

GPSDOP

Indicates the GPS DOP (data degree of precision). An HDOP value is written during two-dimensional measurement, and PDOP during three-dimensional measurement.

Tag = 11 (B.H)

Type = RATIONAL

Count = 1

Default = none

GPSSpeedRef

Indicates the unit used to express the GPS receiver speed of movement. 'K' 'M' and 'N' represents kilometers per hour,miles per hour, and knots.

Tag = 12 (C.H)

Type = ASCII

Count = 2

Default = 'K'

'K' = Kilometers per hour

'M' = Miles per hour

'N' = Knots

Other = reserved

GPSSpeed

Indicates the speed of GPS receiver movement.

Tag = 13 (D.H)

Type = RATIONAL

Count = 1

Default = none

GPSTrackRef

Indicates the reference for giving the direction of GPS receiver movement. 'T' denotes true direction and 'M' is magnetic direction.

Tag = 14 (E.H)

Type = ASCII

Count = 2

Default = 'T'

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'T' = True direction

'M' = Magnetic direction

Other = reserved

GPSTrack

Indicates the direction of GPS receiver movement. The range of values is from 0.00 to 359.99.

Tag = 15 (F.H)

Type = RATIONAL

Count = 1

Default = none

GPSImgDirectionRef

Indicates the reference for giving the direction of the image when it is captured. 'T' denotes true direction and 'M' is magnetic direction.

Tag = 16 (10.H)

Type = ASCII

Count = 2

Default = 'T'

'T' = True direction

'M' = Magnetic direction

Other = reserved

GPSImgDirection

Indicates the direction of the image when it was captured. The range of values is from 0.00 to 359.99.

Tag = 17 (11.H)

Type = RATIONAL

Count = 1

Default = none

GPSMapDatum

Indicates the geodetic survey data used by the GPS receiver. If the survey data is restricted to Japan, the value of this tag is 'TOKYO' or 'WGS-84'. If a *GPS Info* tag is recorded, it is strongly recommended that this tag be recorded.

Tag = 18 (12.H)

Type = ASCII

Count = Any

Default = none

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GPSDestLatitudeRef

Indicates whether the latitude of the destination point is north or south latitude. The ASCII value 'N' indicates north latitude, and 'S' is south latitude.

Tag = 19 (13.H)
Type = ASCII
Count = 2
Default = none
'N' = North latitude
'S' = Sourth latitude
Other = reserved

GPSDestLatitude

Indicates the latitude of the destination point. The latitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. When degrees, minutes and seconds are expressed, the format is dd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format is dd/1,mmmm/100,0/1.

Tag = 20 (14.H)
Type = RATIONAL
Count = 3
Default = none

GPSDestLongitudeRef

Indicates whether the longitude of the destination point is east or west longitude. ASCII 'E' indicates east longitude, and 'W' is west longitude.

Tag = 21 (15.H)
Type = ASCII
Count = 2
Default = none
'E' = East longitude
'W' = West longitude
Other = reserved

GPSDestLongitude

Indicates the longitude of the destination point. The longitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. When degrees, minutes and seconds are expressed, the format is ddd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format is ddd/1,mmmm/100,0/1.

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Tag = 22 (16.H)
Type = RATIONAL
Count = 3
Default = none

GPSDestBearingRef

Indicates the reference used for giving the bearing to the destination point. 'T' denotes true direction and 'M' is magnetic direction.

Tag = 23 (17.H)
Type = ASCII
Count = 2
Default = 'T'
'T' = True direction
'M' = Magnetic direction
Other = reserved

GPSDestBearing

Indicates the bearing to the destination point. The range of values is from 0.00 to 359.99.

Tag = 24 (18.H)
Type = RATIONAL
Count = 1
Default = none

GPSDestDistanceRef

Indicates the unit used to express the distance to the destination point. 'K', 'M' and 'N' represent kilometers, miles and knots.

Tag = 25 (19.H)
Type = ASCII
Count = 2
Default = 'K'
'K' = Kilometers
'M' = Miles
'N' = Knots
Other = reserved

GPSDestDistance

Indicates the distance to the destination point.

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Tag = 26 (1A.H)

Type = RATIONAL

Count = 1

Default = none

Note: When the tag Type is ASCII, it must be terminated with NULL.

It must be noted carefully that since the value count includes the terminator NULL, the total count is the number of data+1. For example, *GPSLatitudeRef* cannot have any values other than Type ASCII 'N' or 'S'; but because the terminator NULL is added, the value of N is 2.

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2.6.7. Tag Support Levels

The tags and their support levels are given here.

A. Primary Image (0th IFD) Support Levels

The support levels of primary image (0th IFD) tags are given in Table 13, Table 14 and Table 15.

Table 13 Tag Support Levels (1) - 0th IFD TIFF Tags -

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
Image width	ImageWidth	256	100	M	M	M	J
Image height	ImageLength	257	101	M	M	M	J
Number of bits per component	BitsPerSample	258	102	M	M	M	J
Compression scheme	Compression	259	103	M	M	M	J
Pixel composition	PhotometricInterpretation	262	106	M	M	M	J
Image title	ImageDescription	270	10E	R	R	R	R
Manufacturer of image input equipment	Make	271	10F	R	R	R	R
Model of image input equipment	Model	272	110	R	R	R	R
Image data location	StripOffsets	273	111	M	M	M	N
Orientation of image	Orientation	274	112	R	R	R	R
Number of components	SamplesPerPixel	277	115	M	M	M	J
Number of rows per strip	RowsPerStrip	278	116	M	M	M	N
Bytes per compressed strip	StripByteCounts	279	117	M	M	M	N
Image resolution in width direction	XResolution	282	11A	M	M	M	M
Image resolution in height direction	YResolution	283	11B	M	M	M	M
Image data arrangement	PlanarConfiguration	284	11C	O	M	O	J
Unit of X and Y resolution	ResolutionUnit	296	128	M	M	M	M
Transfer function	TransferFunction	301	12D	R	R	R	R
Software used	Software	305	131	O	O	O	O
File change date and time	DateTime	306	132	R	R	R	R
Person who created the image	Artist	315	13B	O	O	O	O
White point chromaticity	WhitePoint	318	13E	O	O	O	O
Chromaticities of primaries	PrimaryChromaticities	319	13F	O	O	O	O
Offset to JPEG SOI	JPEGInterchangeFormat	513	201	N	N	N	N
Bytes of JPEG data	JPEGInterchangeFormatLength	514	202	N	N	N	N
Color space transformation matrix coefficients	YCbCrCoefficients	529	211	N	N	O	O
Subsampling ratio of Y to C	YCbCrSubSampling	530	212	N	N	M	J
Y and C positioning	YCbCrPositioning	531	213	N	N	M	M
Pair of black and white reference values	ReferenceBlackWhite	532	214	O	O	O	O
Copyright holder	Copyright	33432	8298	O	O	O	O
Exif tag	Exif IFD Pointer	34665	8769	M	M	M	M
GPS tag	GPSInfo IFD Pointer	34853	8825	O	O	O	O

Notation
M : Mandatory (must be recorded)
R : Conditionally mandatory (must be recorded if hardware permits)
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

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Table 14 Tag Support Levels (2) - 0th IFD Exif Private Tags –

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
Exposure time	ExposureTime	33434	829A	O	O	O	O
F number	FNumber	33437	829D	O	O	O	O
Exposure program	ExposureProgram	34850	8822	O	O	O	O
Spectral sensitivity	SpectralSensitivity	34852	8824	O	O	O	O
ISO speed ratings	ISOSpeedRatings	34855	8827	O	O	O	O
Optoelectric coefficient	OECF	34856	8828	O	O	O	O
Exif Version	ExifVersion	36864	9000	M	M	M	M
Date and time original image was generated	DateTimeOriginal	36867	9003	O	O	O	O
Date and time image was made digital data	DateTimeDigitized	36868	9004	O	O	O	O
Meaning of each component	ComponentsConfiguration	37121	9101	N	N	N	M
Image compression mode	CompressedBitsPerPixel	37122	9102	N	N	N	O
Shutter speed	ShutterSpeedValue	37377	9201	O	O	O	O
Aperture	ApertureValue	37378	9202	O	O	O	O
Brightness	BrightnessValue	37379	9203	O	O	O	O
Exposure bias	ExposureBiasValue	37380	9204	O	O	O	O
Maximum lens aperture	MaxApertureValue	37381	9205	O	O	O	O
Subject distance	SubjectDistance	37382	9206	O	O	O	O
Metering mode	MeteringMode	37383	9207	O	O	O	O
Light source	LightSource	37384	9208	O	O	O	O
Flash	Flash	37385	9209	O	O	O	O
Lens focal length	FocalLength	37386	920A	O	O	O	O
Manufacturer notes	MakerNote	37500	927C	O	O	O	O
User comments	UserComment	37510	9286	O	O	O	O
DateTime subseconds	SubSecTime	37520	9290	O	O	O	O
DateTimeOriginal subseconds	SubSecTimeOriginal	37521	9291	O	O	O	O
DateTimeDigitized subseconds	SubSecTimeDigitized	37522	9292	O	O	O	O
Supported FlashPix version	FlashPixVersion	40960	A000	M	M	M	M
Color space information	ColorSpace	40961	A001	M	M	M	M
Valid image width	PixelXDimension	40962	A002	N	N	N	M
Valid image height	PixelYDimension	40963	A003	N	N	N	M
Related audio file	RelatedSoundFile	40964	A004	O	O	O	O
Flash energy	FlashEnergy	41483	A20B	O	O	O	O
Spatial frequency response	SpatialFrequencyResponse	41484	A20C	O	O	O	O
Focal plane X resolution	FocalPlaneXResolution	41486	A20E	O	O	O	O
Focal plane Y resolution	FocalPlaneYResolution	41487	A20F	O	O	O	O
Focal plane resolution unit	FocalPlaneResolutionUnit	41488	A210	O	O	O	O
Subject location	SubjectLocation	41492	A214	O	O	O	O
Exposure index	ExposureIndex	41493	A215	O	O	O	O
Sensing method	SensingMethod	41495	A217	O	O	O	O
File source	FileSource	41728	A300	O	O	O	O
Scene type	SceneType	41729	A301	O	O	O	O
CFA pattern	CFAPattern	41730	A302	O	O	O	O

Notation
M : Mandatory (must be recorded)
R : Conditionally mandatory (must be recorded if hardware permits)
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

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Table 15 Tag Support Levels (3) - 0th IFD GPS Info Tags -

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
GPS tag version	GPSVersionID	0	0	O	O	O	O
North or South Latitude	GPSLatitudeRef	1	1	O	O	O	O
Latitude	GPSLatitude	2	2	O	O	O	O
East or West Longitude	GPSLongitudeRef	3	3	O	O	O	O
Longitude	GPSLongitude	4	4	O	O	O	O
Altitude reference	GPSAltitudeRef	5	5	O	O	O	O
Altitude	GPSAltitude	6	6	O	O	O	O
GPS time (atomic clock)	GPSTimeStamp	7	7	O	O	O	O
GPS satellites used for measurement	GPSSatellites	8	8	O	O	O	O
GPS receiver status	GPSStatus	9	9	O	O	O	O
GPS measurement mode	GPSMeasureMode	10	A	O	O	O	O
Measurement precision	GPSDOP	11	B	O	O	O	O
Speed unit	GPSSpeedRef	12	C	O	O	O	O
Speed of GPS receiver	GPSSpeed	13	D	O	O	O	O
Reference for direction of movement	GPSTrackRef	14	E	O	O	O	O
Direction of movement	GPSTrack	15	F	O	O	O	O
Reference for direction of image	GPSImgDirectionRef	16	10	O	O	O	O
Direction of image	GPSImgDirection	17	11	O	O	O	O
Geodetic survey data used	GPSMapDatum	18	12	O	O	O	O
Reference for latitude of destination	GPSDestLatitudeRef	19	13	O	O	O	O
Latitude of destination	GPSDestLatitude	20	14	O	O	O	O
Reference for longitude of destination	GPSDestLongitudeRef	21	15	O	O	O	O
Longitude of destination	GPSDestLongitude	22	16	O	O	O	O
Reference for bearing of destination	GPSDestBearingRef	23	17	O	O	O	O
Bearing of destination	GPSDestBearing	24	18	O	O	O	O
Reference for distance to destination	GPSDestDistanceRef	25	19	O	O	O	O
Distance to destination	GPSDestDistance	26	1A	O	O	O	O

Notation
M : Mandatory (must be recorded)
R : Conditionally mandatory (must be recorded if hardware permits)
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

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B. Thumbnail (1st IFD) Support Levels

The support levels of thumbnail (1st IFD) tags are shown in Table 16.

Table 16 Tag Support Levels (4) - 1st IFD TIFF Tag -

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
Image width	ImageWidth	256	100	M	M	M	J
Image height	ImageLength	257	101	M	M	M	J
Number of bits per component	BitsPerSample	258	102	M	M	M	J
Compression scheme	Compression	259	103	M	M	M	M
Pixel composition	PhotometricInterpretation	262	106	M	M	M	J
Image title	ImageDescription	270	10E	O	O	O	O
Manufacturer of image input equipment	Make	271	10F	O	O	O	O
Model of image input equipment	Model	272	110	O	O	O	O
Image data location	StripOffsets	273	111	M	M	M	N
Orientation of image	Orientation	274	112	O	O	O	O
Number of components	SamplesPerPixel	277	115	M	M	M	J
Number of rows per strip	RowsPerStrip	278	116	M	M	M	N
Bytes per compressed strip	StripByteCounts	279	117	M	M	M	N
Image resolution in width direction	XResolution	282	11A	M	M	M	M
Image resolution in height direction	YResolution	283	11B	M	M	M	M
Image data arrangement	PlanarConfiguration	284	11C	O	M	O	J
Unit of X and Y resolution	ResolutionUnit	296	128	M	M	M	M
Transfer function	TransferFunction	301	12D	O	O	O	O
Software used	Software	305	131	O	O	O	O
File change date and time	DateTime	306	132	O	O	O	O
Person who created the image	Artist	315	13B	O	O	O	O
White point chromaticity	WhitePoint	318	13E	O	O	O	O
Chromaticities of primaries	PrimaryChromaticities	319	13F	O	O	O	O
Offset to JPEG SOI	JPEGInterchangeFormat	513	201	N	N	N	M
Bytes of JPEG data	JPEGInterchangeFormatLength	514	202	N	N	N	M
Color space transformation matrix coefficients	YCbCrCoefficients	529	211	N	N	O	O
Subsampling ratio of Y to C	YCbCrSubSampling	530	212	N	N	M	J
Y and C positioning	YCbCrPositioning	531	213	N	N	O	O
Pair of black and white reference values	ReferenceBlackWhite	532	214	O	O	O	O
Copyright holder	Copyright	33432	8298	O	O	O	O
Exif tag	Exif IFD Pointer	34665	8769	O	O	O	O
GPS tag	GPSInfo IFD Pointer	34853	8825	O	O	O	O

Notation
M : Mandatory (must be recorded)
R : Conditionally mandatory (must be recorded if hardware permits)
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

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2.7. JPEG Marker Segments Used in Exif

In addition to the compressed data (entropy coded data), a compressed file contains one each of the marker segments APP1, DQT, DHT, SOF and SOS. The compressed data begins with an SOI and ends with an EOI marker. A restart marker (DRI, RSTm) can be inserted optionally. Another option is to have two or more APP2 marker segments. APPn other than APP1 and APP2 or COM segments are not used by Exif. However Exif readers should be designed skip over unknown APPn and COM.

APP1 must be recorded immediately after SOI, and if there is an APP2 it follows after APP1. DQT, DHT, DRI and SOF come after APP2 and before SOS, in any order.

The marker segments used in Exif are listed in Table 17.

Table 17 Marker Segments

	Marker Name	Marker Code	Description
SOI	Start of Image	FFD8.H	Start of compressed data
APP1	Application Segment 1	FFE1.H	Exif attribute information
APP2	Application Segment 2	FFE2.H	Exif extended data
DQT	Define Quantization Table	FFDB.H	Quantization table definition
DHT	Define Huffman Table	FFC4.H	Huffman table definition
DRI	Define Restart Interval	FFDD.H	Restart interval definition
SOF	Start of Frame	FFC0.H	Parameter data relating to frame
SOS	Start of Scan	FFDA.H	Parameters relating to components
EOI	End of Image	FFD9.H	End of compressed data

The data structures of markers defined in JPEG Baseline DCT and used in Exif compressed files, as well as the APP1 and APP2 data structures defined specifically for this standard, are explained below.

2.7.1. JPEG Marker Segments

The data structure of JPEG marker segments other than APP1 and APP2 is noted below.

A. Start of compressed data (SOI: Start of Image)

SOI is a marker code indicating the start of compressed data (see Fig. 15).

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	D8	SOI

Fig. 15 SOI Structure

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B. Quantization table definition (DQT: Define Quantization Table)

DQT is a marker code defining a quantization table.

As many as three kinds of tables can be recorded with a precision of 8 bits (Pq=0). All quantization tables must be defined in one DQT marker segment; recording of multiple DQT markers is not allowed. The table may have any values (see Fig. 16). DQT, DHT, DRI and SOF may line up in any order, but must be recorded after APP1 (or APP2 if any) and before SOS.

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	DB	DQT
+02	00 C5	Length of field 2+(1+64)*3=197 (Bytes)
+04	00	Y: Pq=0, Nq=0
+05	: : : :	Quantization table Y:Q0 : : Quantization table Y:Q63
+45	01	Cb: Pq=0, Nq=1
+46	: : : :	Quantization table Cb:Q0 : : Quantization table Cb:Q63
+86	02	Cr: Pq=0, Nq=1
+87	: : : :	Quantization table Cr:Q0 : : Quantization table Cr:Q63

Fig. 16 DQT Structure (with three quantization tables)

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C. Huffman table definition (DHT: Define Huffman Table)

DHT is a marker code defining a Huffman table.

In this standard a single component shall have a Huffman table consisting of a set of DC and AC, and each component must be mapped to one or another of the Huffman tables defined by DHT. All Huffman tables must be recorded in one DHT marker segment; recording of multiple DHT markers is not allowed. A Huffman table may have any values, or the JPEG reference values may be used as the base table (see Fig. 17).

DQT, DHT, DRI and SOF may line up in any order, but must be recorded after APP1 (or APP2 if any) and before SOS.

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	C4	DHT
+02	01 A2	Length of field 2+(1+16+12+1+16+162)*2 = 418 Bytes
+04	00	Table number Y-DC : 00
+05	⋮	DHT parameter
+21	10	Table number Y-AC : 10
+22	⋮	DHT parameter
+D4	01	Table number C-DC : 01
+D5	⋮	DHT parameter
+F1	11	Table number C-AC : 11
+F2	⋮	DHT parameter

Fig. 17 DHT Structure

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D. Restart interval definition (DRI: Define Restart Interval)

DRI is a marker defining the intervals at which restart markers are inserted (see Fig. 18). The recording of DRI and insertion of restart markers are optional. If restart markers are inserted, DRI shall be recorded and its values shall be 4 MCU (Minimum Coding Unit), i.e., 64 pixel units, regardless of whether 4:2:2 or 4:2:0 is used for color sampling (see Appendix F). Only one DRI shall be recorded.

DQT, DHT, DRI and SOF may line up in any order, but must be recorded after APP1 (or APP2 if any) and before SOS.

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+00	DD	DRI
+02	00	Length of field
		2+2 = 4 (Bytes)
+04	XX	00
	YY	04

Fig. 18 DRI Structure

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E. Frame header (SOF: Start of Frame)

SOF is a marker code indicating the start of a frame segment and giving various parameters for that frame (see Fig. 19).

DQT, DHT, DRI and SOF may line up in any order, but must be recorded after APP1 (or APP2 if any) and before SOS.

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+00	C0	SOF
+02	00	Length of field
	11	2+1+2+2+1+2*3 = 17 (Bytes)
+04	08	Data precision (bits)
+05	XX	Vertical lines
	YY	XXYY (Hex) lines
+07	WW	Horizontal lines
	ZZ	WWZZ (Hex) pixels
+09	03	Components
+0A	01	Component number (1:Y)
+0B	21or22	H0 = 2, V0 = 1(4:2:2) or 2(4:2:0)
+0C	00	Quantization designation
+0D	02	Component number (2:Cb)
+0E	11	H1 =1, V1 = 1
+0F	01	Quantization designation
+10	03	Component number (3:Cr)
+11	11	H2 =1, V2 = 1
+12	02	Quantization designation

Fig. 19 SOF Structure

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F. Scan header (SOS: Start of Scan)

SOS is a marker code giving various scan-related parameters (see Fig. 20).

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+00	DA	SOS
+02	00	Length of field
	0C	2+1+3*2+3 = 12 (Bytes)
+04	03	Components in scan
+05	01	Component selector Y : 01
+06	00	Huffman table selector Y : 00
+07	02	Component selector Cb : 02
+08	11	Huffman table selector C : 11
+09	03	Component selector Cr : 03
+0A	11	Huffman table selector C : 11
+0B	00	Scan start position in block
+0C	3F	Scan end position in block
+0D	00	Successive approximation Bit position

Fig. 20 SOS Structure

G. Compressed data

Compressed data is byte data block interleaved at the required ratio of Y:Cb:Cr and Huffman encoded. An EOB (End of Block) is inserted in each block when the last value of its DCT coefficient is 0. If restart marker insertion is defined in DRI, restart markers are inserted at 4 MCU intervals.

H. End of compressed data (EOI : End of Image)

EOI is a marker code indicating the end of entropy coded data, and is paired with SOI (see Fig. 21). No specification is made regarding data arrays that come after EOI.

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	D9	EOI

Fig. 21 EOI Structure

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2.7.2. Internal Structure of APP1 in Compressed Data

APP1 consists of an APP1 marker indicating that it is an application area, a length code indicating its size, and primary image attribute information patterned after the TIFF structure. The APP1 segment cannot record more than 64 Kbytes, a limitation that must be kept in mind when recording thumbnail images.

APP1 also records attribute information for JPEG compressed images. The features of this marker segment are described below.

A. Order of APP1 recording

APP1 is recorded immediately after the SOI marker indicating the start of the file (see Fig. 6).

B. APP1 internal structure

APP1 consists of an APP1 marker, Exif ID code and the attribute information itself (see Fig. 22).

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	E1	APP1
+02		Length of field
+04	45	'E'
+05	78	'x'
+06	69	'i'
+07	66	'f'
+08	00	NULL
+09	00	Padding
+0A		Attribute information

Fig. 22 Basic Structure of APP1 Marker Segment

C. Exif ID code

The Exif ID code indicates that the APP1 segment internally is Exif format. After a 4-byte code, 00.H is recorded in 2 bytes. The reason for recording this code is to avoid duplication with other applications making use of JPEG application marker segments (APPn).

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D. Attribute information

Attribute information is recorded in 2 IFDs (0th IFD, 1st IFD) following the TIFF structure, including the File Header. The 0th IFD records compressed image attributes (the image itself). The 1st IFD can be used for thumbnail images.

E. TIFF header

The TIFF header in APP1 constitutes 8 bytes of data, including the byte order and the Offset of IFD indicating the first IFD. The Offset is referenced to the address of the first byte of the Byte Order. For example, the Offset of IFD address in the TIFF Header is 4 (see Table 1).

F. Relation to JPEG marker segments

Attribute information is recorded in essentially the same format as that used to record uncompressed data attribute information. In order to avoid duplication, however, attribute information recorded in a JPEG marker segment is not recorded in APP1.

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2.7.3. Internal Structure of APP2 in Compressed Data

APP2 consists of an APP2 marker indicating that it is an application area, a length code indicating its size, and FlashPix (see Appendix F) extensions. If there is no need to record extensions, this marker segment can be omitted.

There are two kinds of APP2 marker segments for recording FlashPix extensions.

One is a Contents List Segment recording a storage and stream list making up the extended data. One file contains only one contents list segment.

The second is a Stream Data Segment storing the data for each of the streams listed in the Contents List Segment. If necessary, there can be two or more APP2 marker segments for storing stream data.

In addition there is an APP2 segment reserved for FlashPix use, which is specified in the FlashPix standard.

The contents of data that can be recorded as stream data is left for future specification. It may include one or more Audio data.

A. Order of APP2 recording.

APP2 segments follow after the APP1 segment, in the order of Contents List Segment and Stream Data Segments. If there are two or more stream data segments, their order is as given in the contents list (see Fig. 6).

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B. APP2 internal structure

APP2 consists of an APP2 marker, ID code (FPXR), and Contents List or Stream Data (see Fig. 23).

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	E2	APP2
+02		Length of field
+04	46	'F'
+05	50	'P'
+06	58	'X'
+07	52	'R'
+08	00	NULL
+09	00	Version
+0A		Contents List or Stream Data

Fig. 23 Basic Structure of APP2 Marker Segment

C. FPXR ID code

The FPXR ID code indicates that the APP2 segment contains FPXR data. It is a 4-byte code followed by 00.H recorded in 1 byte. The reason for recording this code is to avoid duplication with other applications making use of JPEG application marker segments (APPn). The subsequent byte gives the version number (00.H).

D. Contents list structure

The contents list segment lists the storages and streams to be created when the file is converted to a FlashPix image file. The first two bytes give the number of entries.

The entry fields on the contents list are as follows.

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Entity size

Indicates the size of the stream, or else FFFFFFFF.H (in the case of a storage). It is recorded in big endian format.

Default value

A fixed value not set explicitly in the stream data segment but used as the default for each byte.

Storage/Stream name

The name of the storage and stream added for transformation to FlashPix. It is given as the full path name from the FlashPix source image object root storage. "/" represents a directory separator and must be the first character of the property value. This name is a 16-bit character string from the Unicode code page, with NULL termination. It is recorded in little endian format.

Entity class ID

The storage ClassID, given only in the case of a storage entry. It is written as 16-bytes in little endian format.

The data structure of the Contents List Segment is given in Fig. 24.

Address Offset (Hex)	Bytes (Hex)	Code (Hex)	Meaning
+00	1	FF	Marker Prefix
+01	1	E2	APP2
+02	2		Length of field
+04	4		"FPXR"
+08	1	00	NULL
+09	1	00	Version
+0A	1	01	Contents List
+0B	2		Entry Count
+0C	4		Entity size 1
+11	1		Default value 0
+12	m_0		Storage or Stream name 0
+12+m_0	(n_0)		(Entity Class ID 0)
+12+m_0+n_0	4		Entity size 1
:	1		Default value 1
:	m_1		Storage or Stream name 1
:	(n_1)		(Entity Class ID 1)
:	:	:	:
:	4		Entity size I
:	1		Default value I
:	m_I		Storage or Stream name I
:	(n_I)		(Entity Class ID I)

Fig. 24 Contents List Segment Structure

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E. Stream Data Segment structure

A stream data segment records part or all of the stream listed in the contents list segment. Because of the 64-Kbyte size limit of a JPEG marker segment, a stream longer than this must be recorded in two or more stream data segments. Instead of writing stream data directly in multiple stream data segments, the segments may be filled based on a fixed default. A stream data segment contains the following data.

Index into Contents Lists

The order of entries recorded in a contents list segment starting from 0.

Offset into the full FlashPix stream

The offset to the first byte of stream data in the FlashPix stream.

Stream Data

The actual data stream recorded as extended data in the transformation to FlashPix. The length of this data is indicated by the length code in the stream data segment.

The data structure of a Stream Data Segment is given in Fig. 25.

Address Offset (Hex)	Bytes (Hex)	Code (Hex)	Meaning
+00	1	FF	Marker Prefix
+01	1	E2	APP2
+02	2		Length of field
+04	4		"FPXR"
+08	1	00	NULL
+09	1	00	Version
+0A	1	02	Stream Data
+0B	2	N	Index to Contents List
+0C	4	(Offset)	Offset to FlashPix stream
+11	Variable	(value)	Stream Data

Fig. 25 Stream Data Segment Structure

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F. Reserved Segment (*Reserved for future use by the FlashPix format)*

This marker segment is reserved for future use. An example is given in Fig. 26.

Address Offset (Hex)	Bytes (Hex)	Code (Hex)	Meaning
+00	1	FF	Marker Prefix
+01	1	E2	APP2
+02	2		Length of field
+04	4		"FPXR"
+08	1	00	NULL
+09	1	00	Version
+0A	1	03	Reserved for FlashPix
+0B	⋮	⋮	

Fig. 26 Structure of Data Segment Reserved for FlashPix

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2.8. Data Description

2.8.1. Stipulations on Compressed Image Size

The JPEG format is adopted for compressed images. Since JPEG compresses images in blocks of 8 x 8 pixels, preferably the pixel number set as the width and height of the image should be exact multiples of the MCU (multiples of 16 for width, and multiples of 8 for height if Y:Cb:Cr = 4:2:2, or 16 if Y:Cb:Cr = 4:2:0). It is not required, however, that all image data be fit within this range.

If a restart marker is inserted every 4 MCU for the sake of transformation to FlashPix, the width of the image must be an exact multiple of 4 MCU (64 pixels). There is no such restriction on height.

Specifications on inserting data to adjust the recorded image size relative to the valid image size, or padding, are given below.

A. Image size recording procedure in the Exif writer

An Exif writer shall record a compressed image with the image width information and height information set in accord with the stipulations below, and padded as necessary.

When the image is padded in the direction of width, the padding data must be appended at the right edge. Padding in the direction of height must be appended at the bottom edge.

The data used for padding is not specified.

Stipulations on image width

Image width information consists of the valid image width tag (*PixelXDimension*), SOF marker information, and JPEG compressed data. Of these three, the recording of a valid image width tag is mandatory.

Image width is padded to the right in the following cases. The value used for padding is not specified.

- When the image width is not an exact multiple of 16 and the JPEG block has unused capacity to be filled.
- When the image width is not a multiple of 64 and the insufficiency must be made up in order to insert restart markers.

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The method of describing the various image width data with and without padding is given in Fig. 27. It must be noted carefully that the value of SOF is used in some cases to describe the valid image width, and in others to describe the image width after padding.

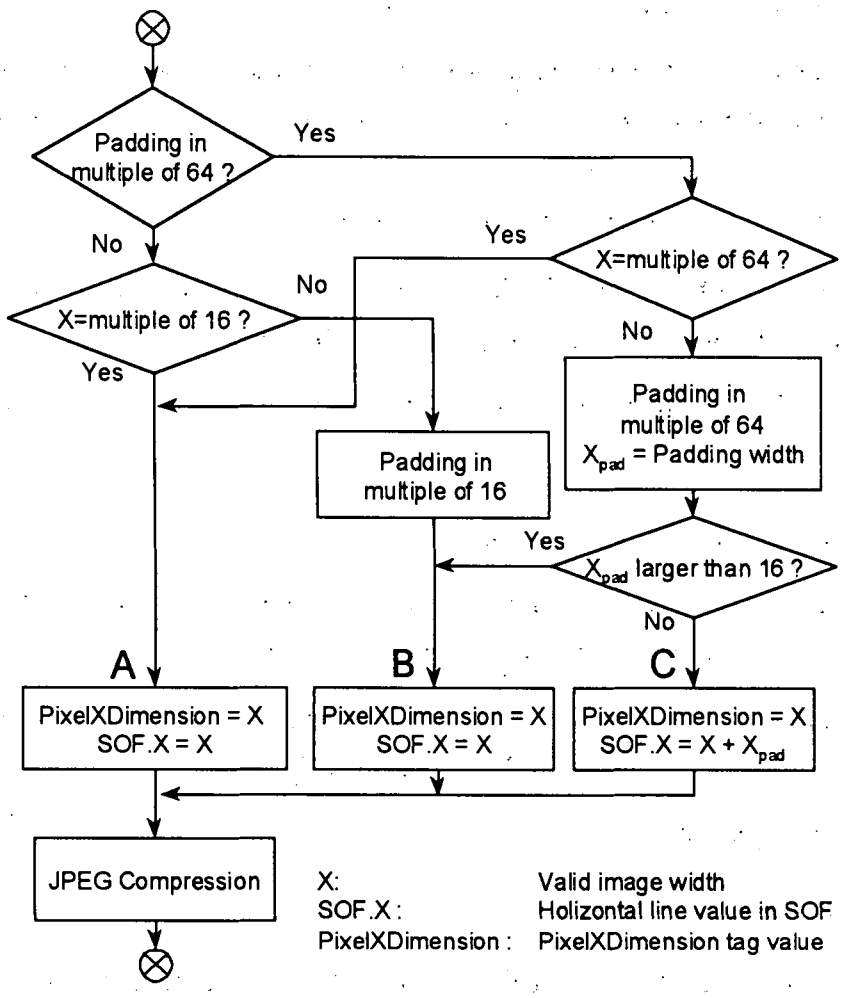


Fig. 27 Image Data Width Description

Table 18 gives examples of information recorded in the direction of image width and padding data width, for each of cases A, B, and C of Fig. 27.

Table 18 Typical Width Direction Information and Padding Data

	Valid Image Width	PixelXDimension	SOF Information	Compressed Data	Padding Width
A	640	640	640	640	0
B	634	634	634	640	6 (< 1MCU)
C	620	620	640	640	20 (> 1MCU)

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Stipulations on image height

Image height information consists of the valid image height tag (*PixelYDimension*), SOF marker information, and JPEG compressed data. Of these three, the recording of a valid image height tag is mandatory.

The image height is padded in the following case. The padding value is not specified.

- When the image height is not an exact multiple of 16 and the JPEG block has unused capacity to be filled.

Insertion of a restart marker does not require padding. The method of recording the various image height data with and without padding is given in Fig. 28. The SOF marker always has the same value as the effective image height tag.

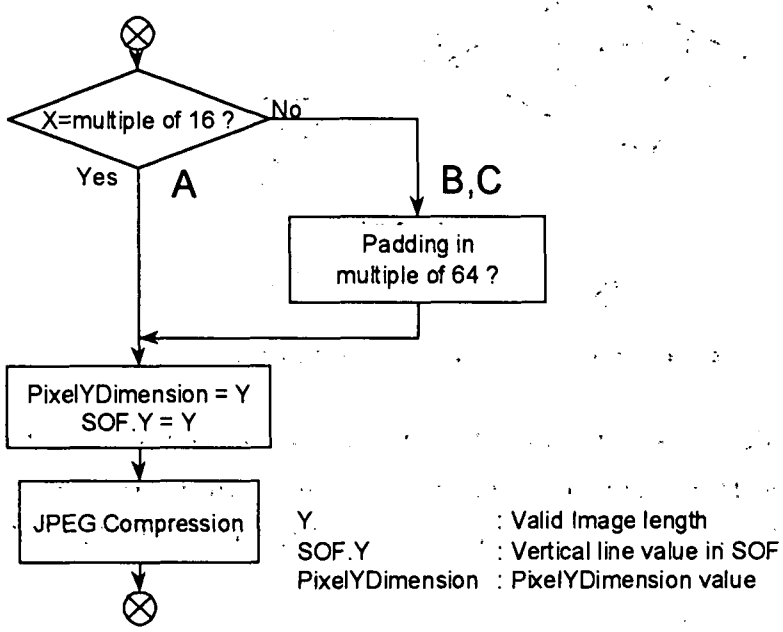


Fig. 28 Image Data Height Description

Table 19 gives examples of information recorded in the direction of image height and padding data height, for each of cases A, B, and C of Fig. 28.

Table 19 Typical Height Direction Information and Padding Data (when Y:Cb:Cr = 4:2:2)

	Valid Image Height	Valid Image Height Tag	SOF Information	Compressed Data	Padding Height
A	480	480	480	480	0
B	474	474	474	480	6 (< 1MCU)
C	460	460	460	464	4 (< 1MCU)

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B. Image size reproduction procedure in the Exif reader

It is recommended that the Exif reader (and in particular, dedicated software) follow the procedure shown in Fig. 29 for reproducing images. First it expands the image based on the SOF information. Next it trims the image on the right and lower edges in accord with information in the valid image width tag and height tag, and reproduces the valid image data. If the SOF information and the valid image width and height tag information are the same, trimming is unnecessary.

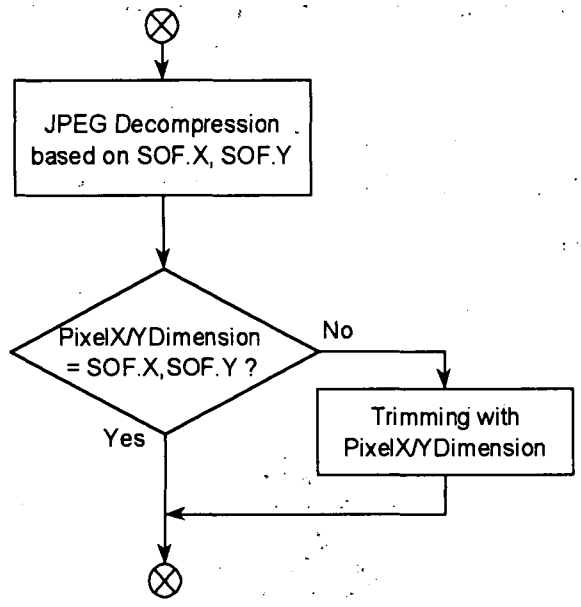


Fig. 29 Procedure for Image Data Reproduction

Some off-the-shelf software lacks a function for handling valid image width and height tags. If the valid image width differs from the number of horizontal pixels recorded in the SOF, padding data may be displayed. The padding data values should be chosen with this possibility in mind.

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2.8.2. Stipulations on Thumbnails

A. Exif writer

The recording of thumbnail images is an optional specification of the Exif reader. It is therefore allowable to have Exif files with and without thumbnails. For details see section 2.5.5.

B. Exif reader

This format is designed so that the primary image will be reproduced intact whether or not thumbnail images are recorded in the file. It is assumed that even when functions are provided for viewing images on the camera or player, for viewing the process of image transfer from camera to PC, or for using thumbnails as an index display in the camera software or other image software, there will still be cases where the file is viewed without thumbnails. The creation and displaying of thumbnails can therefore be performed or not at the discretion of the user.

2.8.3. File Name Stipulations

A. Exif writer

The file name and characters used for file names are not specified, other than to stipulate the use of ASCII alphanumerics. (File names in Japanese or other character sets are not to be used.) File names shall be 8 characters or fewer, not including the extension. (Long file names are not to be used.) The file name extensions are ".JPG" for compressed data files and ".TIF" for uncompressed data files.

2.8.4. Byte Order Stipulations

A. Exif Reader

It is recommended that the Exif reader be able to reproduce Exif files recorded in both little endian and big endian formats.

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3. Exif Audio File Specification

3.1. Outline of the Exif Audio File Specification

This chapter gives details of the audio file specification, covering the following items:

- Format version definition,
- Specifications relating to audio data,
- Basic structure of audio data,
- Chunks,
- File naming conventions.

3.2. Format Version

The version of the format specified here is recorded as 4 bytes (see section 3.6.3). The address bytes are recorded as A1, A2, B1, B2, starting with the lowest number. A1 and A2 store the upper part of the standard version, with the lower part stored in B1 and B2. When changes are made to the version number of this standard, the following rules apply:

- When the changes are such that data readers can properly recognize conventional information and skip the data that was recorded using newly added functions, the lower part of the version (B1, B2) is changed,
- When there is a possibility that a data reader implementing the old standard may operate incorrectly due to the new specifications, the upper part of the version (A1, A2) is changed.

Players should be able to play back files of versions earlier than the supported standard.

3.3. Definition of Terms

Terms and notation are used as follows in this standard:

- Text enclosed in " " is a character string, and " "Z means a character string ending in NULL (00.H),
- ".H" appended to a numerical value means it is hexadecimal notation.
- Unless otherwise indicated, other numerical values are given in decimal notation.

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3.4. Specifications Relating to Audio Data

3.4.1. Sampling Frequency

The sampling frequency shall be any of 8.000 kHz, 11.025 kHz, 22.050 kHz or 44.100 kHz. Only 8.000 kHz shall be used for μ–LAW PCM in accord with ITU-T G.711.

3.4.2. Bit Size

The bit size shall be 8 bits or 16 bits. Only 8 bits shall be used for μ-LAW PCM in accord with ITU-T G.711; and only 4 bits shall be used for IMA-ADPCM in accord with the IMA (Interactive Multimedia Association) specification.

3.4.3. Channels

The number of channels is either monaural or stereo (2 ch).

3.4.4. Compression Schemes

The following three compressions schemes are specified here:

- Uncompressed audio data: PCM ,
- Uncompressed audio data: μ-Law PCM (conforming to ITU-T G.711 [vii]) ,
- Compressed data: IMA-ADPCM [viii].

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3.5. Basic Structure of Audio Data

Exif audio files are based on the RIFF WAVE Form Audio File format [vi] adopted as a Windows™ standard audio file format, with the addition of various DSC attribute information as needed. Exif audio files are data-compatible with WAVE Form Audio files and can be played on accessories supplied with Windows™.

Of the general attribute information required by DSC applications, the common attributes are recorded on an *INFO list*, and the Exif-specific attributes are recorded in Exif chunks. The Exif chunks are provided to enable the addition of information as necessary, taking advantage of chunk extensibility. The method of recording data in the Exif-specific chunks is patterned after that for the *INFO list*.

3.5.1. Basic Structure of WAVE Form Audio Files

The WAVE Form Audio File format is based on the *RIFF (Resource Interchange File Format)* tagged file structure.

A *RIFF* file consists of basic data blocks called chunks.

(1) *Chunk*

Using C language syntax, a chunk can be defined as a structure, like that in Equation 1. The chunk structure can also be expressed in graphical form as in Fig. 30.

```
typedef struct {
        unsigned long   ckID;           // 4-character code
        unsigned long   ckSize;         // Size of member <ckData>
        unsigned char   ckData[ckSize]; // The data in the chunk
} CK;       ---[Equation 1]
```

Address Offset (Hex)	Meaning
+00	ckID (4 Bytes)
+04	ckSize (4 Bytes)
+08	ckData[ckSize]

Fig. 30 Chunk Structure

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Explanation

- *ckID* (chunk ID, a 4-character code) consists of from one to four ASCII alphanumerics, left-justified and filled with blank characters if less than four characters in length. Blanks cannot be inserted between characters. This four-character code identifies the contents of the chunk data, described later. Software processing the chunk is allowed to skip a chunk with an unknown chunk ID.
- *ckSize* (chunk Size) is a 32-bit unsigned integer giving the size (bytes) of the *ckData*[*ckSize*] (chunk Data). This size does not include padding bytes following the ckID, *ckSize* itself and *ckData*. The byte order is little endian (LSB first, MSB last). In the case of *RIFF* files, values of more than one byte are all written in little endian order. If two or more chunks follow in sequence, the value of chSize must be read properly in order to know the start address (ckID) of the next chunk.
- *ckData*[*ckSize*] (chunk Data) is the actual data included in that chunk, and may be recorded as binary data of either fixed length or variable length. The start of *ckData* is aligned with the *RIFF* file start position in word (16-bit) units. If the data size is an odd number of bytes, a padding byte with the value '0' is appended after the *ckData*. This padding byte is not included in the *ckSize* (chunk Size).
- *ckData*[*ckSize*] (chunk Data) can itself have a particular structure rather than being a simple byte array. That is, *ckData* itself can include a chunk (sub-chunk). In other words, chunks can be arranged hierarchically. Only certain chunks are allowed to contain sub-chunks. These are the *RIFF* chunk and *LIST* chunk described later below. Generally two or more sub-chunks may be contained in these chunks. All other chunks store only one binary data element in the *ckData*.

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(2) *RIFF Form*

A "*RIFF* form" is a chunk with "*RIFF*" as its chunk ID (ckID); it is also used to mean a file format with the *RIFF* structure (*RIFF* file).

A "*RIFF* chunk" *ckData* (chunk data) consists of a 4-character code at the beginning called the *formType* (form type), followed by a sub-chunk.

A *RIFF* chunk is at the top of the chunk hierarchy. A *RIFF* form must have this chunk, but can have only one. All other chunks are sub-chunks of the *RIFF* chunk.

A form type is generally a code identifying the data contents, among other things. It is also possible to tell from this code what kind of sub-chunk a chunk contains. A form type must be registered. A registered form type is written in all upper-case letters.

Along with a form type, a chunk ID (ckID) must also be registered. A chunk ID in all upper-case letters indicates a general-purpose chunk that can be used with various form types. A chunk ID used with a specific form type is written in all lower-case letters.

An illustration of the *RIFF* chunk is given in Fig. 31.

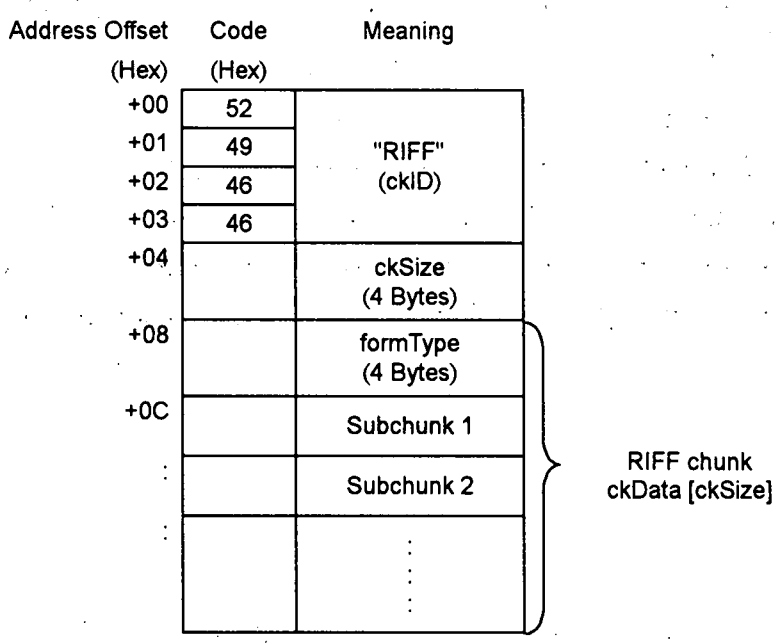


Fig. 31 RIFF Chunk Structure

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Note:

Representative form types are given in Table 20. These are written in all upper-case letters because they are registered form types.

Table 20 Representative Form Types

Form Type	Name
PAL	Palette file form
RDIB	RIFF DIB (Device Independent Bitmap) form
RMID	RIFF MIDI form
RMMP	RIFF multimedia movie form
WAVE	WAVE Form Audio File format

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(3) WAVE Form Audio File Format

The *WAVE* Form is one kind of *RIFF* form. It is a file for handling digitalized sound data. The form type is *WAVE*, in upper-case letters.

The file extension for a *WAVE* Form Audio File is ".WAV".

The data structure of the *WAVE* Form Audio File format is shown in Fig. 32.

As is evident from Fig. 32, the chunk data (*ckData* [*ckSize*]) of a *RIFF* chunk generally consists of the *formType* ("*WAVE*"), *fmt-ck* (format chunk), *fact-ck* (fact chunk), and *data-ck* (data chunk). *fmt-ck* and *data-ck* are mandatory chunks, but *fact-ck* may be mandatory or not, depending on the format type (audio coding format) of the *WAVE* Form.

In addition to these, optional sub-chunks may be recorded and can store various attribute information. These optional sub-chunks are not shown in Fig. 32.

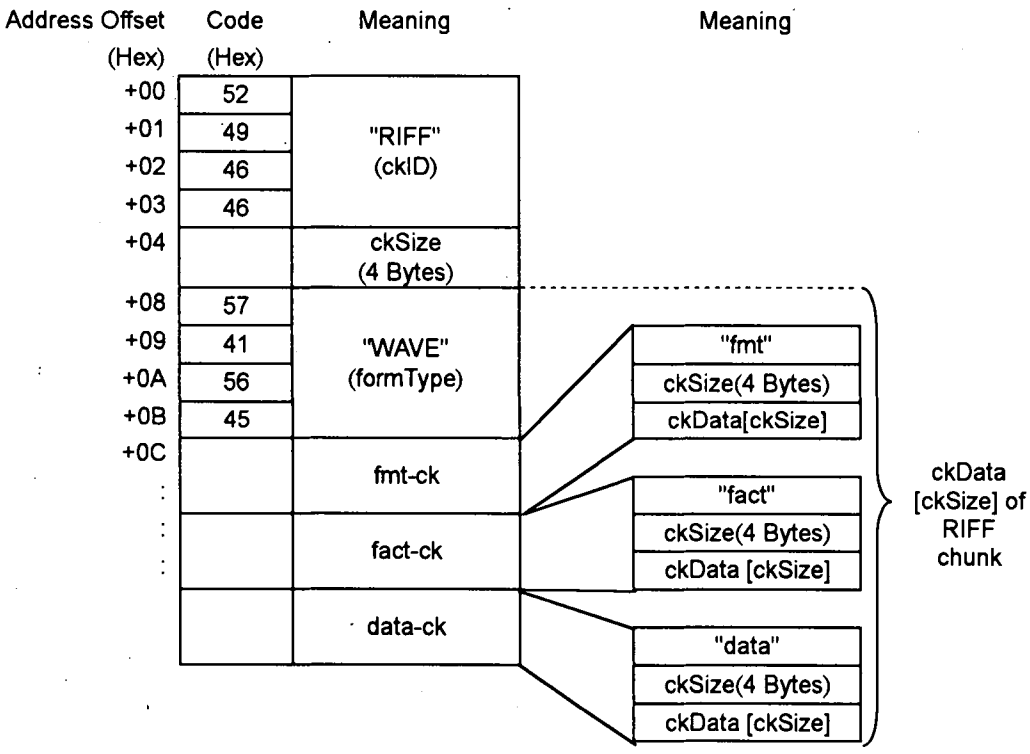


Fig. 32 Data Structure of the WAVE Form Audio File Format

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<fmt-ck>

fmt-ck (format chunk) contains format information designating the format of audio data included in the *data-ck* (data chunk) described later below. The *ckID* (chunk ID) of *fmt-ck* is "fmt."

"fmt " is 3 characters long, so a blank character (20.H) goes at the end.

fmt-ck is mandatory and must always be recorded before *data-ck*.

Since *fmt-ck* has the chunk structure, *ckSize* and *ckData*[*ckSize*] are included as its members; but the contents of the *ckData* depend on the format type (audio coding format). This *ckData* consists of the structure given in Equation 2, and the byte array given in Equation 3.

```
struct{
        unsigned int    wFormatTag;         // Format type
        unsigned int    nChannels;          // Number of channels
        unsigned long   nSamplesPerSec;     // Sampling rate
        unsignrd long   nAvgBytesPerSec;    // Average bytes per second
        unsigned int    nBlockAlign;        // Block alignment
        unsigned int    wBitsPerSample;     // Bits per sample
        unsigned int    cbSize;             // Additional bytes
} WAVEFORMATEX;                                              ---[Equation 2]
unsigned char   extByte[cbSize];            // Additional byte array    ---[Equation 3]
```


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The meaning of each member of the format information is given in Table 21.

Table 21 Format Information Members

Member	Description
wFormatTag	An unsigned 16-bit integer indicating the format type (audio coding format) of the WAVE Form. Typical format types are given below. PCM (Pulse Code Modulation) format: 0001.H μ-Law format (ITU-T G.711): 0007.H IMA-ADPCM (DVI-ADPCM) format: 0011.H
nChannels	An unsigned 16-bit integer indicating the number of channels. Monaural is 1 and stereo is 2.
nSamplesPerSec	An unsigned 32-bit integer indicating the sampling rate (samples per second). Audio is played in each channel at this rate. In PCM format the common values of this member are 8.0kHz, 11.025kHz, 22.05kHz, and 44.1kHz.
nAvgBytesPerSec	An unsigned 32-bit integer indicating the average bytes per second, a value transferred to the data in data-ck. In PCM format, nAvgBytesPerSec is equivalent to the equation below. nChannels * wBitsPerSample/8
nBlockAlign	An unsigned 16-bit integer indicating the (byte unit) block alignment in data-ck. In PCM format, nBlockAlign is equivalent to the equation below. nChannels * wBitsPerSample/8
wBitsPerSample	An unsigned 16-bit integer indicating the bits per sample of each channel. In PCM format, this value is 8 or 16. In the case of compressed sound data, when this value cannot be defined it becomes '0'.
cbSize	An unsigned 16-bit integer indicating the size (in bytes) of the additional format information extByte[cbSize] appended after the WAVEFORMATEX structure. This information is used to store attributes added in non-PCM formats. If additional information is not needed, it becomes '0'. In PCM format, this member is not needed (the cbSize field itself is not necessary).
extByte[cbSize]	A byte array representing the additional format information appended after the WAVEFORMATEX structure. The meaning of this information depends on the format type. If the value of cbSize is 0, this field does not exist. In PCM format, both the cbSize field and extByte[cbSize] field are unnecessary.

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The *fmt-ck* structure can be illustrated as in Fig. 33.

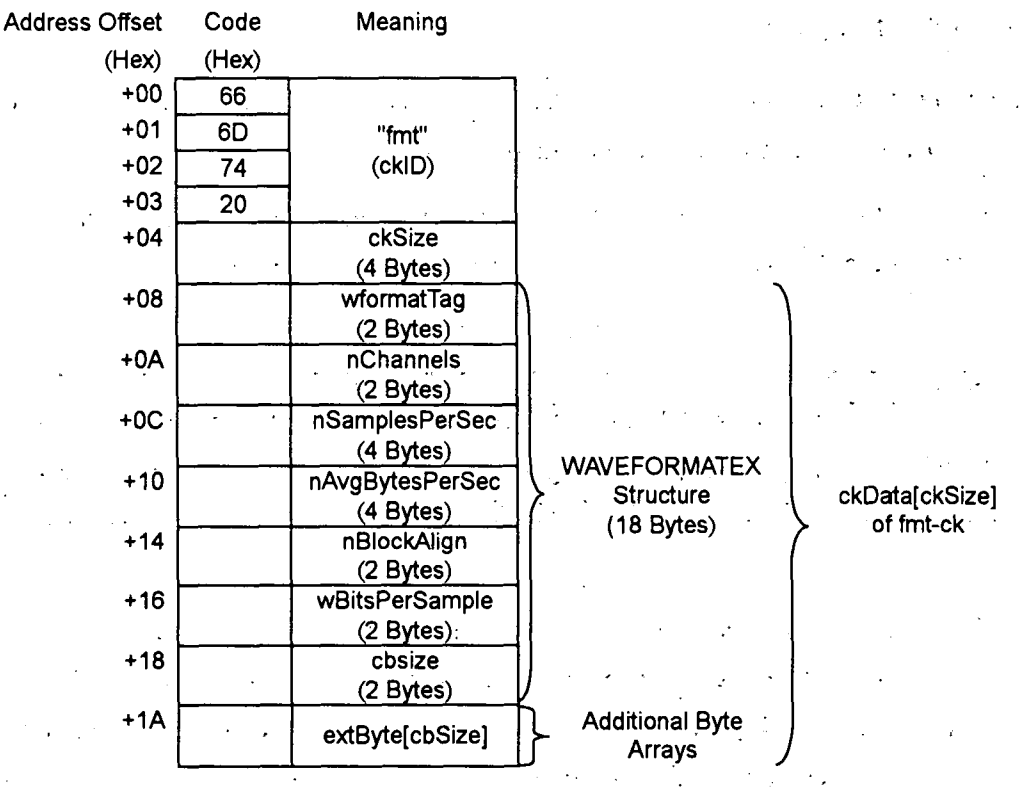


Fig. 33 fmt-ck Structure

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<fact-ck>

fact-ck (fact chunk) is used to store file-dependent information relating to the *WAVE* file contents. The *ckID* (chunk ID) of *fact-ck* is "fact".

It is assumed that *fact-ck* will be extended in the future to store information needed by *WAVE* files at that time, but currently only one information member is defined.

The information that can be stored in *fact-ck* at the present time is defined in [Equation 4].

```
unsigned long  dwSampleLength;          // Sample length  - - - [Equation 4]
```

Table 22 fact-ck Member

Member	Description
dwSampleLength	An unsigned 32-bit integer indicating the number of audio data samples (sample length). When this information is combined with nSamplePerSec in fmt-ck, the data length can be expressed in seconds (recording time).

Since the only information defined presently is dwSampleLength, the value of *ckSize* (chunk Size) for *fact-ck* is '00000004.H'; but *ckSize* may change in the future as information is added (in which case it will be larger than '00000004.H'). Programs must be able to skip over fields they cannot interpret and go on to process the next chunk. For this reason the capability of correctly reading the value of *ckSize* is a necessary requirement.

The structure of *fact-ck* is illustrated in Fig. 34. The value of *ckSize* is fixed at '00000004.H' (this value is used in Write processing).

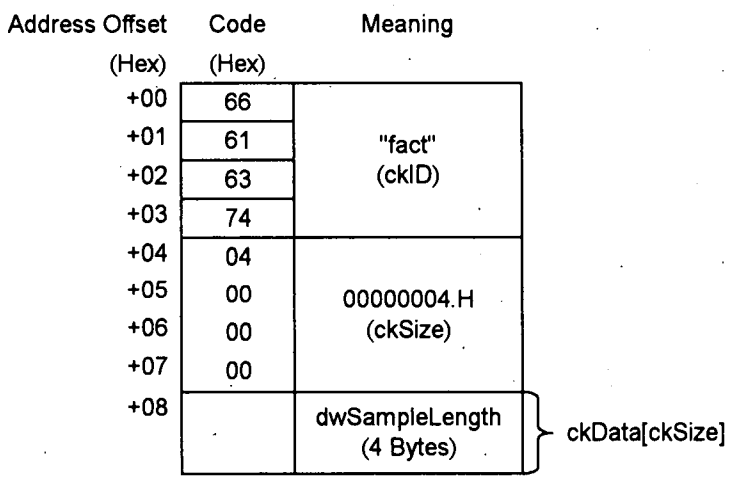


Fig. 34 fact-ck Structure

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<data-ck>

data-ck (data chunk) is a chunk for storing audio data. Its *ckID* (chunk ID) is "data".

The *ckData* (chunk Data) of *data-ck* consists of the audio data only. In some cases the chunk is filled out with padding bytes.

The audio data is coded based on the format type. The information in *fmt-ck* is used when the audio data is played back.

The *ckSize* (chunk Size) of *data-ck* is the size of the coded audio data only. The structure of *data-ck* is illustrated in Fig. 35.

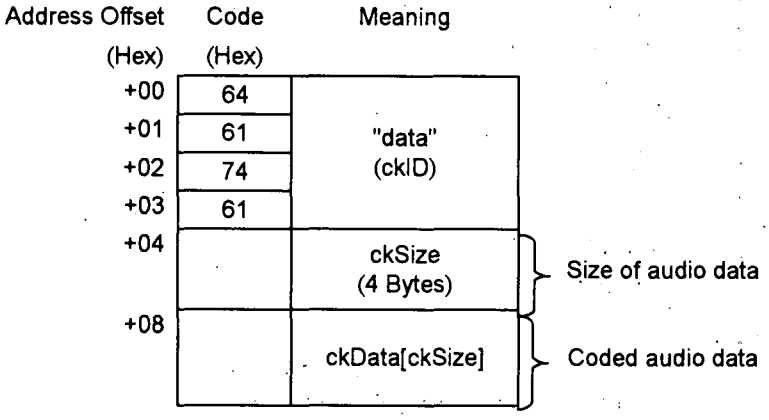


Fig. 35 data-ck Structure

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3.5.2. Basic Structure of PCM Audio Data

PCM audio data has linear quantization (A/D conversion) characteristics, and is not encoded for compression. It therefore does not need to be decompressed for playback, but can simply be played by reading it directly.

The basic structure of audio data when the format type is PCM (Pulse Code Modulation) format is shown in Fig. 36.

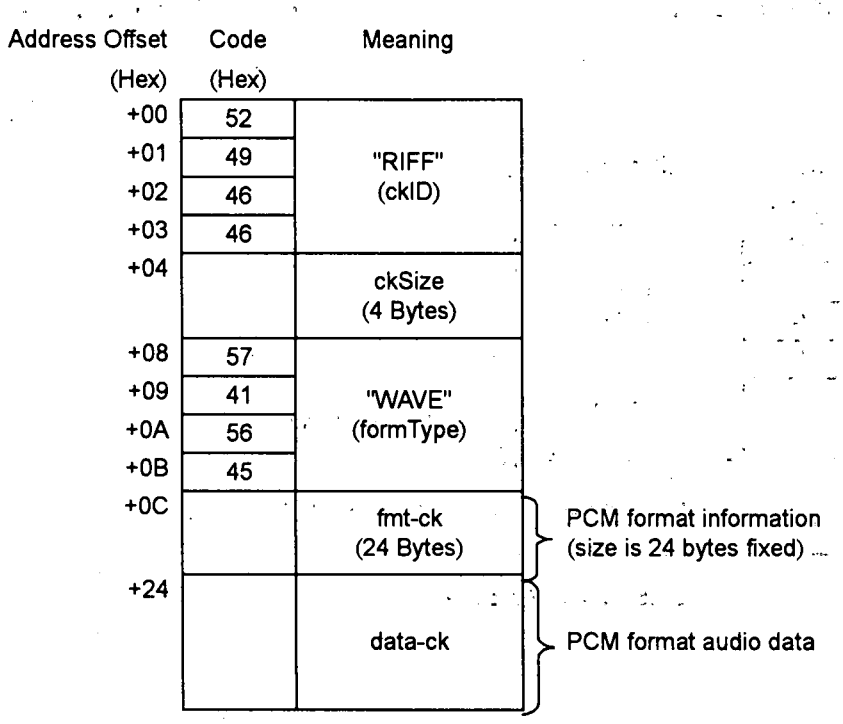


Fig. 36 Basic Structure of PCM Format

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The specific values stored in *fmt-ck* in the case of PCM format are as shown in Table 23.

Table 23 PCM Format fmt-ck Information

PCM (Pulse Code Modulation) Format	
Members	Code
ckSize (fmt-ck)	00000010.H (16 Bytes, since cbSize is unnecessary)
wFormatTag	0001.H (PCM format)
nChannels	The values of each mode are as follows. 0001.H (monaural) or 0002.H (stereo)
nSamplesPerSec	The values of each mode are as follows. 00001F40.H (8.0 kHz) 00002B11.H (11.025 kHz) 00005622.H (22.05 kHz) 0000AC44.H (44.10 kHz)
nAvgBytesPerSec	The values of each mode are as follows. 00001F40.H (8.0 kHz, 8-bit monaural) 00003E80.H (8.0 kHz, 8-bit stereo) 00003E80.H (8.0 kHz, 16-bit monaural) 00007D00.H (8.0 kHz, 16-bit stereo) 00002B11.H (11.025 kHz, 8-bit monaural) 00005622.H (11.025 kHz, 8-bit stereo) 00005622.H (11.025 kHz, 16-bit monaural) 0000AC44.H (11.025 kHz, 16-bit stereo) 00005622.H (22.05 kHz, 8-bit monaural) 0000AC44.H (22.05 kHz, 8-bit stereo) 0000AC44.H (22.05 kHz, 16-bit monaural) 00015888.H (22.05 kHz, 16-bit stereo) 0000AC44.H (44.10 kHz, 8-bit monaural) 00015888.H (44.10 kHz, 8-bit stereo) 00015888.H (44.10 kHz, 16-bit monaural) 0002B110.H (44.10 kHz, 16-bit stereo) Definition: nSamplesPerSec * nBlockAlign
nBlockAlign	The values of each mode are as follows. 0001.H (8-bit monaural) 0002.H (8-bit stereo) 0002.H (16-bit monaural) 0004.H (16-bit stereo) Definition: nChannels * wBitsPerSample/8
wBitsPerSample	The values of each mode are as follows. 0008.H (8bit) or 0010.H (16bit)
cbSize	Not used
extByte[cbSize]	Not used

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In the case of PCM format audio data, the data format of each sample is 8-bit or 16-bit integer. These sample data formats and their values are given in Table 24.

Table 24 Sample Data Formats and Values

Sample Size	Data Format	Minimum	Intermediate	Maximum
8-bit PCM	Unsigned Integer	0 (00.H)	128 (80.H)	255 (FF.H)
16-bit PCM	Signed Integer	-32768 (8000.H)	0 (0000.H)	32767 (7FFF.H)

The PCM format audio data contained in *data-ck* is packed as shown in Fig. 37. Here the left-hand byte stores the lower address and the right-hand byte holds the upper address.

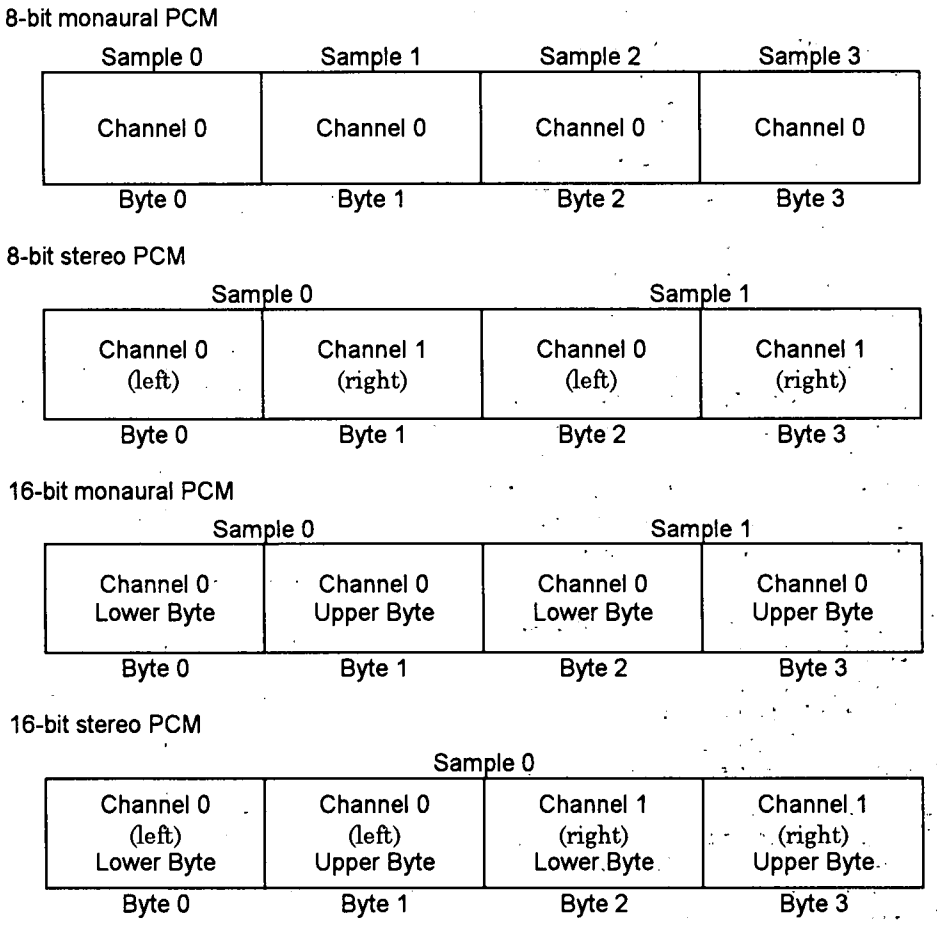


Fig. 37 Packing of PCM Audio Data

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3.5.3. Basic Structure of μ-Law Audio Data

Each of the audio data samples of μ-Law audio data has nonlinear (logarithmic) quantization characteristics. For this reason 16 bits of data can be represented in an 8-bit size. In playback, either the data is first converted to linear 16-bit data and then put through a linear D/A converter, or else the analog signal is derived by going through an 8-bit nonlinear D/A converter with characteristics opposite the μ-Law quantization characteristics. Details of the nonlinear quantization characteristics and of the conversion between 8-bit μ-Law data and 16-bit linear data are given in the ITU-T G.711[vii] standard.

When the format type is μ-Law (ITU-T G.711) format, the basic structure is expressed as in Fig. 38.

The two differences from PCM format are the larger size of *fmt-ck* (the cbSize file exists) and the existence of *fact-ck*.

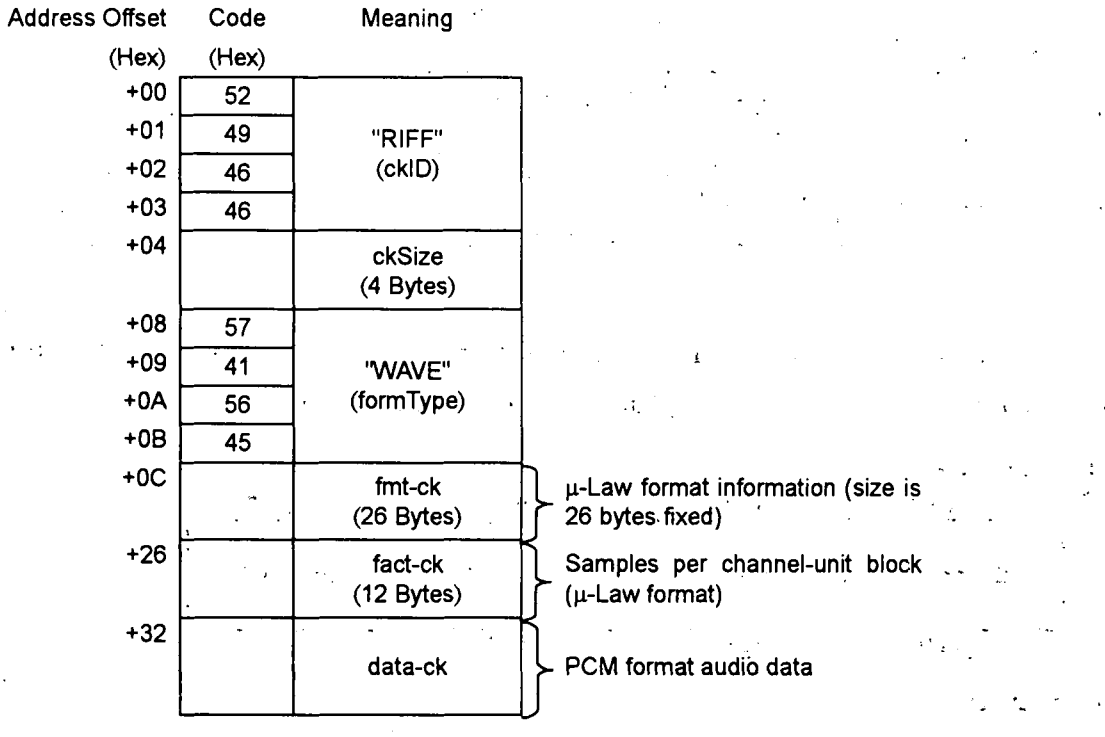


Fig. 38 Basic Structure of μ-Law Format

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The specific values of the information stored in *fmt-ck* and *fact-ck* in the case of the μ-Law format are given in Table 25.

Table 25 fmt-ck and fact-ck Information in μ-Law Format

μ-Law (ITU-T G.711) Format	
Members	Code
ckSize(fmt-ck)	00000012.H (18 bytes, WAVEFORMATEX only)
wFormatTag	0007.H (μ-Law format)
nChannels	The values of each mode are as follows. 0001.H (monaural) or 0002.H (stereo)
nSamplesPerSec	00001F40.H (8.0kHz)
nAvgBytesPerSec	The values of each mode are as follows. 00001F40.H (8.0kHz, 8-bit monaural) 00003E80.H (8.0kHz, 8-bit stereo) Definition: nSamplesPerSec * nBlockAlign
nBlockAlign	The values of each mode are as follows. 0001.H (8bit monaural) 0002.H (8bit stereo) Definition: nChannels * wBitsPerSample/8
wBitsPerSample	0008.H (8bit)
cbSize	0000.H (extByte[cbSize] does not exist)
extByte[cbSize]	Not used
dwSampleLength	It is recommended that the actual number of samples that can be played be recorded here. Definition: (ckSize_of_data-ck) / nBlockAlign

The μ-Law audio data contained in *data-ck* is packed as shown in Fig. 39. Here the left-hand byte stores the lower address and the right-hand byte holds the upper address.

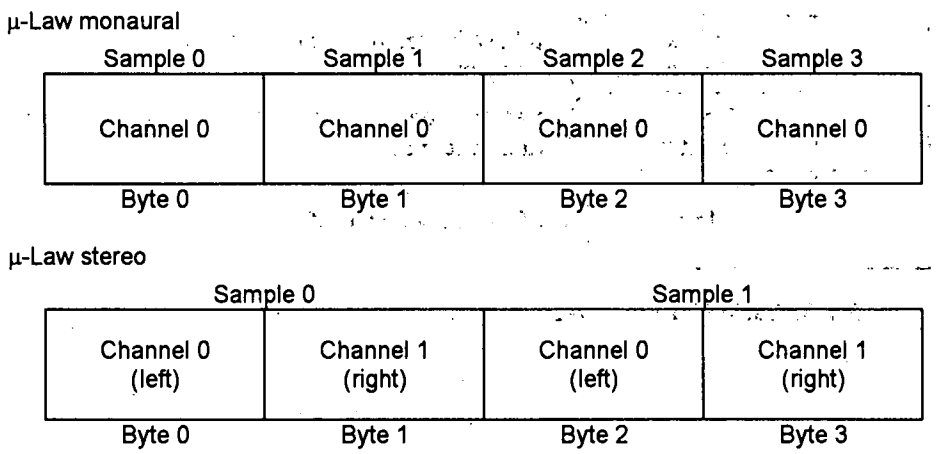


Fig. 39 Packing of μ-Law Audio Data

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3.5.4. Basic Structure of IMA-ADPCM Audio Data

IMA-ADPCM audio data is 4-bit data obtained by compressing 16-bit linear PCM audio data. IMA-ADPCM, as seen in its other name DVI-ADPCM, uses a compression algorithm originally developed by the Intel DVI Group (DVI: Digital Video Interactive). It was later adopted by the IMA (Interactive Multimedia Association) as a standard audio data format.

Details of the IMA-ADPCM algorithm are given in the IMA Digital Audio Doc-Pac[xvi] and other documents.

When the format type is IMA-ADPCM (DVI-ADPCM), the basic structure is as shown in Fig. 40.

A *fact-ck* is recorded as with the μ-Law format, but a difference from that format is the larger *fmt-ck* size (in addition to a cbSize field there is a wSamplesPerBlock field).

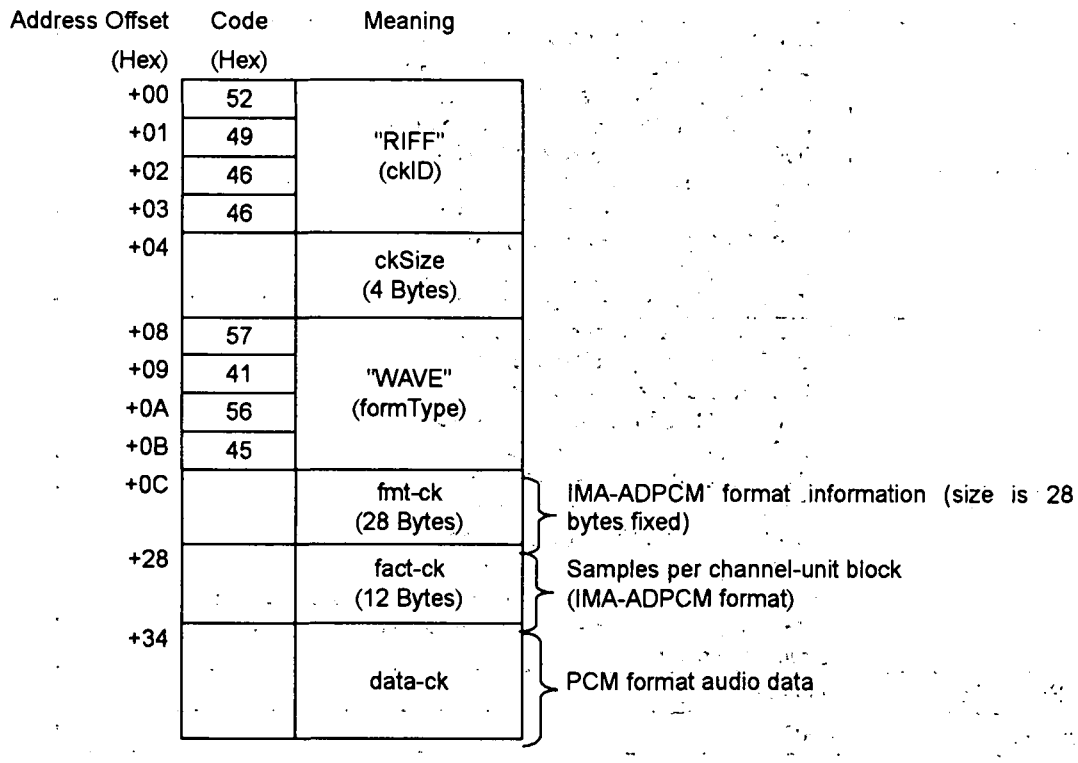


Fig. 40 Basic Structure of IMA-ADPCM Format

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The specific values of the information stored in *fmt-ck* and *fact-ck* in the case of the IMA-ADPCM format are given in Table 26 and Table 27.

Table 26 IMA-ADPCM Format fmt-ck and fact-ck Information (1)

IMA-ADPCM (DVI-ADPCM) Format	
Members	Code
ckSize(fmt-ck)	00000014.H (20 bytes)
wFormatTag	0011.H (IMA-ADPCM format)
nChannels	0001.H (monaural) or 0002.H (stereo)
nSamplesPerSec	The values of each mode are as follows. 00001F40.H (8.0 kHz) 00002B11.H (11.025 Hz) 00005622.H (22.050 Hz) 0000AC44.H (44.10 Hz)
nAvgBytesPerSec	The values of each mode are as follows. 00000FD7.H (8.0 kHz, 4-bit monaural) 00001FAE.H (8.0 kHz, 4-bit stereo) 000015D4.H (11.025 kHz, 4-bit monaural) 00002BA9.H (11.025 kHz, 4-bit stereo) 00002B5C.H (22.05 kHz, 4-bit monaural) 000056B9.H (22.05 kHz, 4-bit stereo) 0000566D.H (44.10 kHz, 4-bit monaural) 0000ACDB.H (44.10 kHz, 4-bit stereo) Definition: nSamplesPerSec*nBlockAlign/wSamplesPerBlock
nBlockAlign	The values of each mode are as follows. 0100.H (8.0 kHz, 4-bit monaural) 0200.H (8.0 kHz, 4-bit stereo) 0100.H (11.025 kHz, 4-bit monaural) 0200.H (11.025 kHz, 4-bit stereo) 0200.H (22.05 kHz, 4-bit monaural) 0400.H (22.05 kHz, 4-bit stereo) 0400.H (44.10 kHz, 4-bit monaural) 0800.H (44.10 kHz, 4-bit stereo) Although the definition is (N+1) * 4 * nChannels, the use of 256 * nChannels * max (1,nSamplesPerSec / 11.025kHz) is recommended.
wBitsPerSample	0004.H (4 bits)
cbSize	0002.H

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Table 27 IMA-ADPCM Format fmt-ck and fact-ck Information (2)

IMA-ADPCM (DVI-ADPCM) Format	
extByte[cbSize]	The values of each mode are as follows. 01F9.H (8.0 kHz, 4-bit monaural) 01F9.H (8.0 kHz, 4-bit stereo) 01F9.H (11.025 kHz, 4-bit monaural) 01F9.H (11.025 kHz, 4 bit stereo) 03F9.H (22.05 kHz, 4-bit monaural) 03F9.H (22.05 kHz, 4-bit stereo) 07F9.H (44.10 kHz, 4-bit monaural) 07F9.H (44.10 kHz, 4-bit stereo) If the definition is, wSamplesPerBlock (an unsigned 16-bit integer indicating the samples per channel-unit block), and X = (nBlockAlign -(4 * nChannels))* 8 Y = wBitsPerSample * nChannels then, wSamplesPerBlock =(X/Y)+1
dwSampleLength	It is recommended that the actual number of samples that can be played back be recorded. The definition is as follows. If X = ckSize_of_data-ck/nBlockAlign then, dwSampleLength = (X+1) * wSamplesPerBlock

The IMA-ADPCM audio data contained in *data-ck* is packed as shown in Fig. 41, Fig. 42, and Fig. 43 when it is recorded.

A feature of this format is the existence of a header at the start of each block. The header records the initial sample value for that block and a step (quantization table) index. The audio data in each channel is independent, so the number of header words is the same as the number of channels.

A header word consists of 4 bytes, and is defined as in [equation 5]. The existence of a header means IMA-ADPCM audio data can be played from any block. In other words, random access is possible on a per-block basis.

In Fig. 41 to Fig. 43, the left-hand byte stores the lower address and the right-hand byte holds the upper address.

```
typedef struct {
        signed int   iSamp0;              // Initial sample value of the block
        unsigned char  bStepTableIndex;   // Step table index
        unsigned char  bReserved;         // reserved byte
} IMA_ADPCMBLOCKHEADER;                                    ---[Equation 5]
```


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In Fig. 41 to Fig. 43, N, M, and P have the following significance.

N = (nBlockAlign/(4*nChannels)) - 1 ---[Equation 6]

M = 0, 1, 2, 3, ... , N-1 ---[Equation 7]

P = (M * 8) + 1 ---[Equation 8]

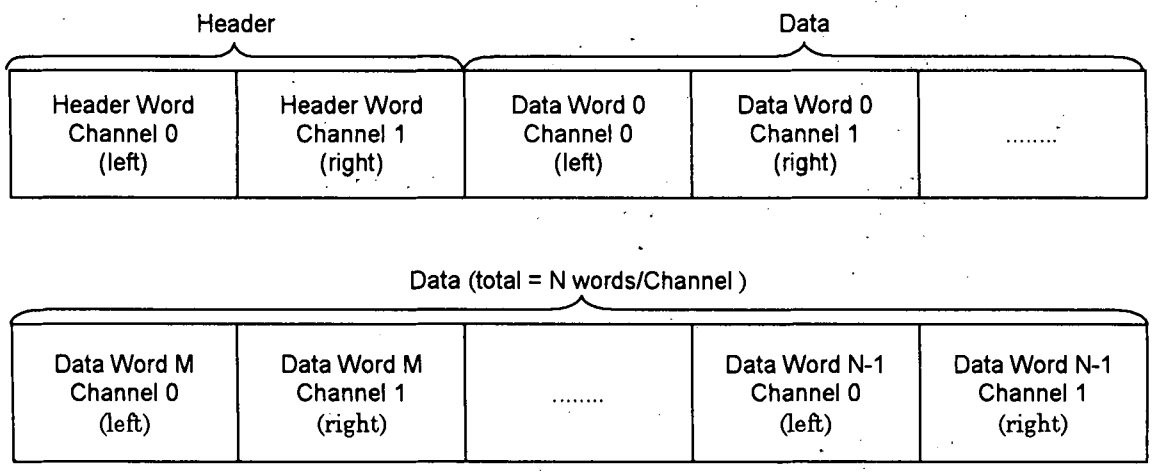


Fig. 41 Packing of IMA-ADPCM Audio Data

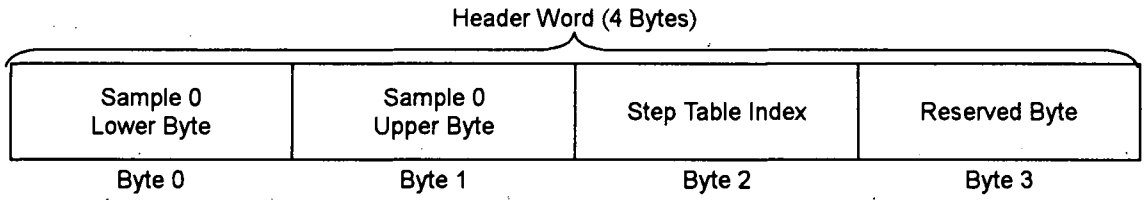


Fig. 42 Header Word of IMA-ADPCM Audio Data

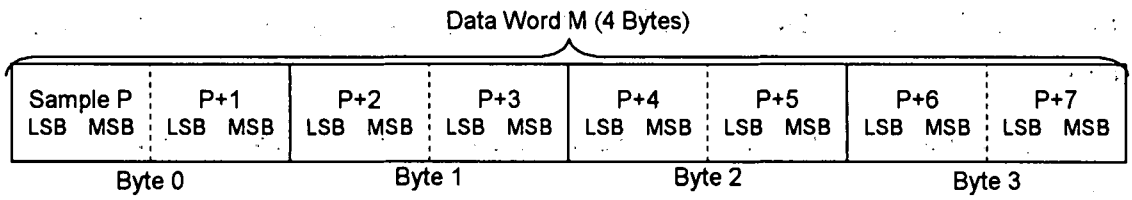


Fig. 43 Data Word M of IMA-ADPCM Audio Data

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3.6. Chunks Used

The chunks used in Exif audio files are described here.

3.6.1. WAVE Form Audio File Basic Chunks

The basic chunks of a WAVE Form Audio File, as is evident from the basic structure of the *WAVE* file shown in Fig. 32, are the four below.

- RIFF chunk
- fmt chunk
- fact chunk
- data chunk

[Additional Explanation]

- The fmt chunk, fact chunk and data chunk are sub-chunks of the *RIFF* chunk. A *WAVE* file consists of one *RIFF* chunk, with specific information recorded in the sub-chunks.
- Only when the form type is PCM (Pulse Code Modulation) format, the fact chunk is unnecessary. With non-PCM formats such as μ-Law and IMA-ADPCM, it is mandatory, which is why *fact-ck* is included in the basic chunks here.
- It is possible to add other optional sub-chunks as well.
- At the head of the chunk data (*ckData*) of the *RIFF* chunk there is a form type called "*WAVE*".

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3.6.2. LIST Chunk and INFO List

A *WAVE* form and other *RIFF* forms store a variety of information in sub-chunks of the *RIFF* chunk. These sub-chunks in many cases are specific to each form type; but there are also general-purpose chunks for storing additional information regardless of the data specified for a given form type.

One of these general-purpose chunks is the *LIST* chunk. Here the use of the *LIST* chunk is explained.

(1) LIST Chunk

The *LIST* chunk is a general-purpose chunk that can be used with the files of many different form types. The *LIST* chunk is a pre-registered general-purpose chunk, so its *ckID* (chunk ID) is written in upper-case letters.

Included in the *LIST* chunk is a sub-chunk list (series of sub-chunks) and sequence designation.

The *LIST* chunk *ckData* (chunk data) consists of a four-character code at the beginning called a listType (list type), followed by the sub-chunk list.

This structure resembles that of the *RIFF* chunk, but the *LIST* chunk is always farther down the hierarchy than the *RIFF* chunk.

The list type is used to identify the list contents. For this reason there are list types that are used only with certain form types. If a list type is encountered that cannot be interpreted, that *LIST* chunk can be ignored.

The list type must be registered. A general-purpose list type that is registered and can be used with various form types is written in all upper-case letters.

A list type that can be used only with a specific form type is written in lower-case letters.

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The *LIST* chunk structure is illustrated in Fig. 44.

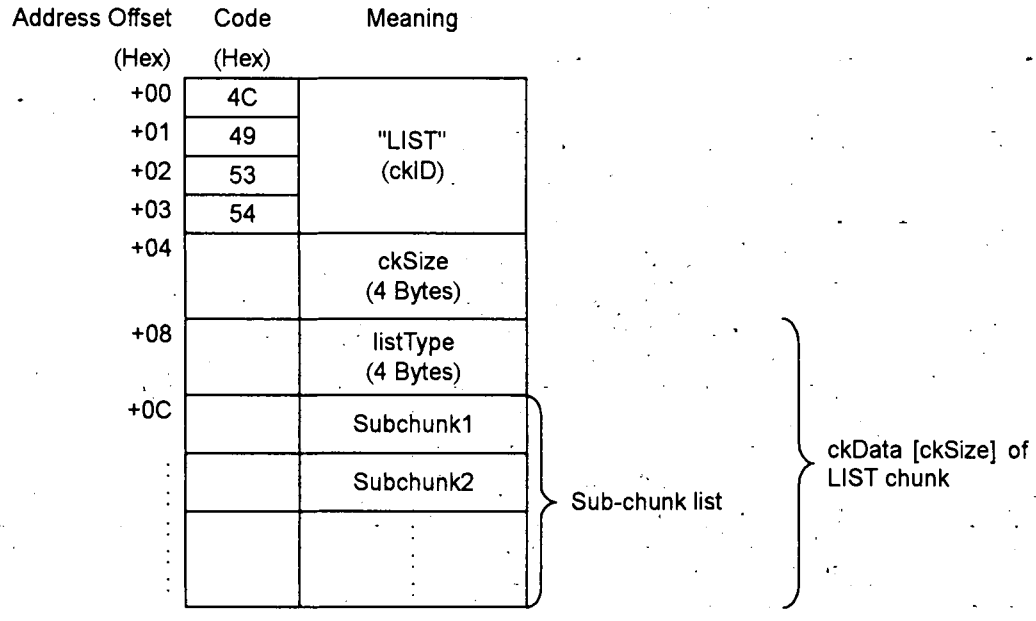


Fig. 44 LIST Chunk Structure

(2) INFO List

An "*INFO list*" is a *LIST* chunk having the registered, general-purpose listType "*INFO*".

The need for information such as title, copyright and comments is similar in each of the form types. The *INFO list* is used for storing these kinds of information.

The information itself in an *INFO list* is stored in the sub-chunk lists. These sub-chunks use only pre-registered, general-purpose chunks, described later below.

The *INFO list* information is supplementary and has no influence on the interpretation of the main data, such as WAVE form audio data. It can therefore be skipped without problem. If an unknown chunk is included on the *INFO list*, as when a new chunk has been defined, it is to be ignored.

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The *INFO list* chunks currently defined are given in Table 28. These pre-registered chunks are stored as ASCII text strings terminated by NULL (the final byte is '00.H').

Table 28 INFO List Chunks

Channel ID	Description
IARL	Archival Location. Indicates where the subject of the file is archived.
IART	Artist. Lists the artist of the original subject of the file.
ICMS	Commissioned. Lists the name of the person or organization that commissioned the subject of the file.
ICMT	Comments. Provides general comments about the file or the subject of the file.
ICOP	Copyright. Records the copyright information for the file.
ICRD	Creation date. Indicates the date the subject of the file was created.
ICRP	Cropped. Indicates whether an image has been cropped
IDIM	Dimensions. Specifies the size of the original subject of the file.
IDPI	Dots Per Inch. Stores the dots per inch (DPI) setting of the digitizer used to produce the file.
IENG	Engineer. Stores the name of the engineer who worked on the file.
IGNR	Genre. Describes the genre of the original work.
IKEY	Keywords. Provides a list of keywords that refer to the file or subject of the file.
ILGT	Lightness. Describes the changes in lightness settings on the digitizer required to produce the file.
IMED	Medium. Describes the original subject of the file, such as, "computer image," "drawing," "lithograph," and so forth.
INAM	Name. Stores the title of the subject of the file.
IPLT	Palette Setting. Specifies the number of colors requested when digitizing an image.
IPRD	Product. Specifies the name of the title the file was originally intended for, such as "Encyclopedia of Pacific Northwest Geography."
ISBJ	Subject. Describes the file contents, such as "Aerial view of Seattle."
ISFT	Software. Identifies the name of the software package used to create the file.
ISHP	Sharpness. Identifies the changes in sharpness for the digitizer required to produce the file.
ISRC	Source. Identifies the name of the person or organization who supplied the original subject of the file.
ISRF	Source Form. Identifies the original form of the material that was digitized, such as "slide," "paper," "map," and so forth.
ITCH	Technician. Identifies the technician who digitized the subject file.

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A typical *INFO list* is shown in Fig. 45.

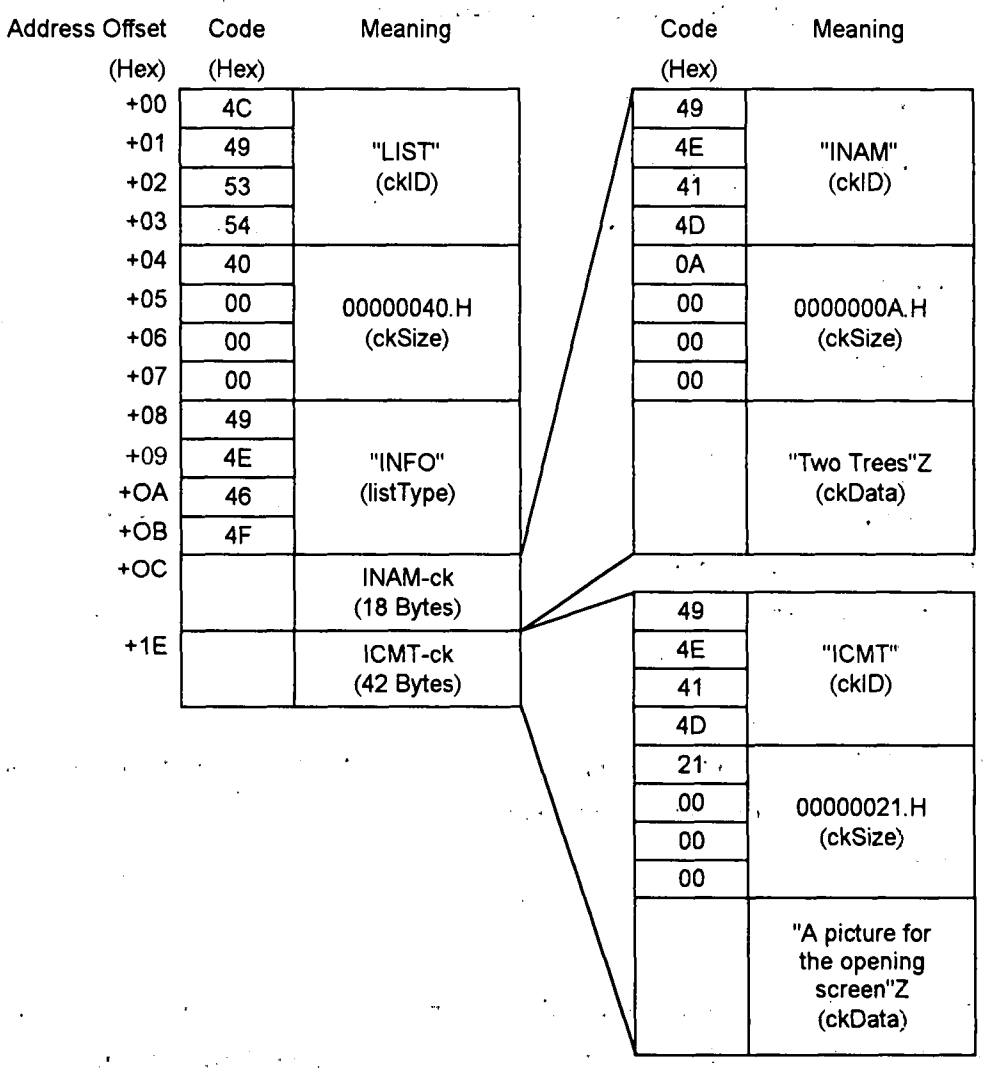


Fig. 45 Typical INFO List

The following points need to be observed in using the *INFO list*. They are explained in reference to Fig. 45.

- The 'Z' at the end of the text string information in the *INAM* and *ICMT* chunks means NULL termination. The actual code appended is '00.H'.
- The chunk data (*ckData*) in each chunk must be an even number of bytes. If the data itself is an odd number of bytes, it must be padded by one additional byte.
- In the example in Fig. 45, the *ICMT* chunk has 33 bytes of information including the NULL termination, so a padding byte '00.H' must be appended. No padding is necessary with the *INAM* chunk information, since the size including NULL termination is 10 bytes.
- The value of the chunk size (*ckSize*) of the *ICMT* chunk does not include the padding byte.

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However, the chunk size of the *LIST* chunk that is its parent chunk must include the padding bytes in the sub-chunks. If this rule is not observed, it will not be possible to determine the start address of a chunk following after this *LIST* chunk.

(3) INFO List used by Exif audio files

The *INFO list* used with Exif audio files is as follows.

The chunks that can be included on the *INFO list* are those given in Table 28; but of these, only the following are used with Exif audio files.

[Chunks Used with Exif]

INAM

Records the title of the Exif audio file. The title is written in an ASCII string and terminated with NULL. Recording this information is optional.

Ex.) "Exif Audio File Example"Z

IGNR

Records the genre of the Exif audio file subject. The genre name is written in an ASCII string and terminated with NULL. Recording this information is optional.

Ex.) "narration"Z

ICRD

Records the date the Exif audio file was created. It is written as a fixed-length ASCII string, in the format year-month-day. That is, the year, month, and day are separated by a hyphen. The year is four digits, while month and day are two digits each. If the number of the month or the day is less than 10, the first digit is 0. The order must be year-month-day. Since this information is written as an ASCII string, it must be terminated with NULL. This chunk is fixed-length (the chunk data is 11 bytes, and a padding byte is added to make it an even byte number). Recording this information is optional.

Ex.) "1997-04-08"Z (Note: =April 8, 1997)

ICMT

Records a general comment on the Exif audio file or its subject. Comments are written in ASCII text terminated with NULL. If there are two or more comments, each statement ends with a period. A carriage return or line feed character must not be used. Recording this information is optional.

Ex.) "Recorded by Digital Still Camera"Z

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IART

Records the name of the Exif audio file creator. The name is written in an ASCII string and terminated with NULL. Recording this information is optional.

Ex.) "Taro Yamada"Z

ICOP

Records copyright information for the Exif audio file. The copyright is written in ASCII text and terminated with NULL. In case of multiple copyright information, each is separated by a semicolon followed by one blank space (20.H). Recording this information is optional.

Ex.) "Copyright Exif Corporation 1997."Z

[Notes and Additional Information]

- A camera shall not record chunks other than those listed above.
- If a camera encounters an unknown chunk when reading the *INFO list*, it shall skip that chunk. It is possible that the *INFO list* will be expanded in the future, and this provision ensures that compatibility will be maintained.
- Information shall be recorded in accord with the general *INFO list* stipulations.
- All the information on the *INFO list* is optional, and does not have to be recorded.
- The *INFO list* used for Exif audio files consists of pre-registered, general-purpose chunks only, which means this information can be read by commercial "RIFF Form Reader" software (such as the utility software provided with Windows™).

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3.6.3. Chunks for Attribute Information Specific to Exif Audio Files

Recording of attribute information specific to Exif audio files is done as follows.

Exif-specific attributes are those not defined for ordinary WAVE Form Audio Files but only for Exif audio files. This is auxiliary information with no influence on interpretation of the audio data itself. For this reason an Exif audio file can still be compatible with a standard WAVE Form Audio File.

The attributes specific to Exif audio files are recorded as follows.

(1) LIST chunk is used.

The compatibility noted above is realized by using a pre-registered, general-purpose *LIST* chunk to record the attribute information specific to Exif audio files. Since it can be used with all the *LIST* chunk form types, this chunk can be put in the WAVE Form Audio File. The individual information is recorded in sub-chunks of the *LIST* chunk.

(2) A dedicated list type "exif" is defined.

The information in the *LIST* chunk is explicitly labeled as information specific to Exif audio files by defining a dedicated list type. The following is used as this list type.

- Dedicated Exif list type: "exif" (all lower-case letters)

The attributes specific to Exif audio files cannot be used in the WAVE Form Audio File format, so it is all written in lower-case letters.

Hereafter, the notation "exif list" is used to mean the *LIST* chunk whose list type is exif.

(3) A dedicated chunk is defined for each of the attributes.

Since there are no corresponding existing chunks, a dedicated chunk is defined to record the attribute information specific to Exif audio files. The information items and their chunks are described below.

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[Information items and chunks]

ever

Records the version information (number) of this standard.

As with Exif image files, it is recorded in 4 bytes. The address bytes are recorded as A1, A2, B1, B2, starting with the lowest number. A1 and A2 store the upper part of the standard version, with the lower part stored in B1 and B2. A1, A2, B1 and B2 are ASCII numerals giving the version number, but NULL termination is unnecessary. This chunk is mandatory.

On the conventions for version number updating, see section 3.2.

Ex.) "0200" (Note: =Version 2.00)

erel

Records information pointing to an Exif image file related to the Exif audio file recorded in this chunk. Recording this information makes it possible for a camera or application software to map an image to sound during playback.

The relational information consists of the name of the corresponding Exif image file, given as an 8-character file name plus 3-character extension in ASCII format. The path is not written. Stipulations on images are given in section 2.6.5. File naming rules are covered in section 3.7.1.

The mapping of Exif image files and audio files is done in any of the three ways shown in Table 29. If multiple files are mapped to one file as in [2] or [3] of Table 29, the above format is used to record just one destination file name. If there are multiple destination files, the first recorded file is given.

In the case of [2] in Table 29, for the Exif audio file "SND00001.WAV" only "DSC00001.JPG" is given as the related image file. When there are three Exif image files "DSC00001.JPG," "DSC00002.JPG" and "DSC00003.JPG," the related Exif audio file name for each of them, "SND00001.WAV," is indicated. By combining multiple relational information, a variety of playback possibilities can be supported. The method of using relational information is left to the implementation on the playback side. Since this information is an ASCII character string, it is terminated by NULL. If there is a related Exif image file, this chunk is mandatory.

Ex.) "DSC00001.JPG"Z

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Table 29 Mapping between Image and Audio Files

	Relationship	Exif Image File	Exif Audio File
[1]	1 to 1	DSC00001.JPG	SND00001.WAV
[2]	Many to 1	DSC00001.JPG DSC00002.JPG DSC00003.JPG	SND00001.WAV
[3]	1 to many	DSC00001.JPG	SND00001.WAV SND00002.WAV SND00003.WAV

etim

Records the time of Exif audio file creation. This is defined as the time the recording of audio data was started. Time is expressed as a variable-length ASCII string. In order to conform as closely as possible to the Exif image file, time is recorded in the format "hour:minute:second.subsecond," with a colon in between each time unit and a period before the subsecond position.

Hour, minute and second are written as two digits each, with the first digit a zero if the value is one digit. Subseconds can be expressed to any desired decimal place. If there is no subsecond information, the string ends with a period only.

The order of time units is hour, minute, second, subsecond. The information is written as an ASCII string, so it must be terminated with NULL. Recording this information is optional.

Ex.) "10:05:10.130"Z

ecor

Records the name of the manufacturer of the equipment on which the Exif audio file was created. The manufacturer name is written in an ASCII string and terminated with NULL. Recording this information is optional.

Ex.) "Digital Still Camera Corporation"Z

emdl

Records the model name of the equipment on which the Exif audio file was created. The model name is written in an ASCII string and terminated with NULL. Recording this information is optional.

Ex.) "DSCamera1000"Z

emnt

As with Exif image files, this chunk is used by the writer manufacturer to record design information,

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version history and other maker-specific information. The contents and format of the information are up to each manufacturer. Other manufacturers see this information only as a byte array of the size determined by the chunk size (*ckSize*).

Recording this information is optional.

eucm

Records user comment information that cannot be recorded on, or is not suitable for, the *INFO list*. Basically this is text information. Character code information is included so languages that do not use ASCII can be used here. Recording this chunk is optional.

Recording of user comments is discussed below. The structure of the user comment chunk is shown in Fig. 46.

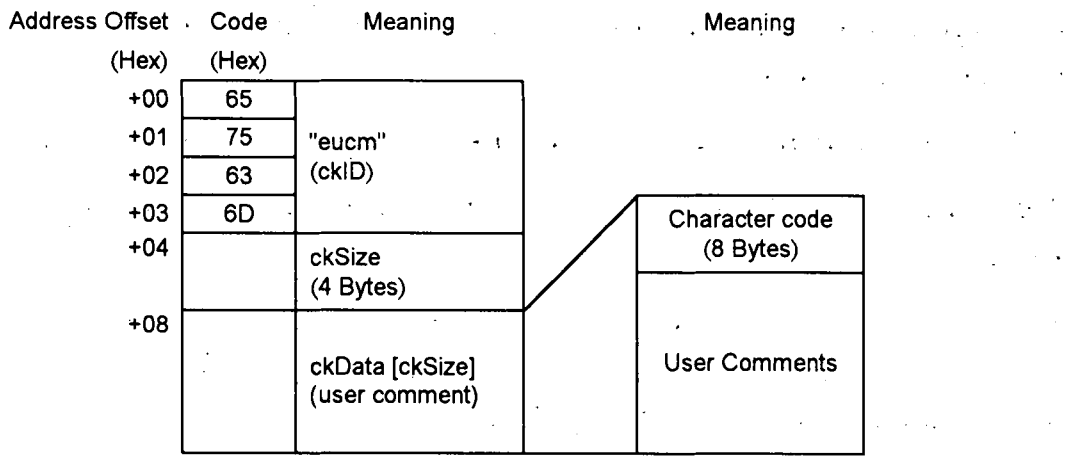


Fig. 46 Structure of User Comment Chunk

As seen in Fig. 46, the chunk data area storing the user comment starts with an 8-byte character code area, where the character code is given. The rest of the chunk data area is the user comment area, used for writing comments. The currently defined character codes are shown in Table 30. A registration system is used for character codes to avoid duplication. When a character code is registered, a standard document is indicated in the reference column to indicate the character format specification. If a character code is used for which there is no clear specification like Shift-JIS in Japan, Undefined is designated.

The character code is written from the start of the character code area, and the unused portion is padded with NULL ('00.H'). In order to match the format of the actual comments in the user comment part to that of the Exif image file *UserComment* tag, NULL termination is not used even if the comment is written in ASCII text. In accord with the chunk specification, however, a padding byte ('00.H') is used if the chunk data is not an even number of bytes.

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Table 30 Character Codes and Character Code Designation

Character Code	Code Designation (8 Bytes)	Reference
ASCII	41.H, 53.H, 43.H, 49.H, 49.H, 00.H, 00.H, 00.H	ITU-T T.50 IA5[ix]
JIS	4A.H, 49.H, 53.H, 00.H, 00.H, 00.H, 00.H, 00.H	JIS X0208-1990[x]
Unicode	55.H, 4E.H, 49.H, 43.H, 4F.H, 44.H, 45.H, 00.H	Unicode Standard [xi]
Undefined	00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H	Undefined

[Notes and Additional Information]

- The above chunks incorporated in exif list are used with a specific form type ('*WAVE*') and are therefore written in all lower-case letters.
- Only the *ever* chunk is mandatory; the others are optional. If an Exif image file related to an audio file exists, the *erel* chunk is also mandatory.
- When the exif list is read by a camera, information that cannot be recognized may be encountered, such as the *emnt* chunk or an Undefined string in the *eucm* chunk. In that case the chunk is to be skipped.
- An Exif reader and writer must conform to the stipulations for an ordinary *LIST* chunk.
- A general-purpose RIFF Form Reader will ignore the exif list. A dedicated Exif reader is required for reading the exif list.
- Fig. 47 shows the exif list structure and a coding example. The *ever* chunk is mandatory and has a fixed length (chunk data is 4 bytes). The *erel* chunk data is 13 bytes (odd), so a padding byte is added. The *erel* chunk is also fixed length.

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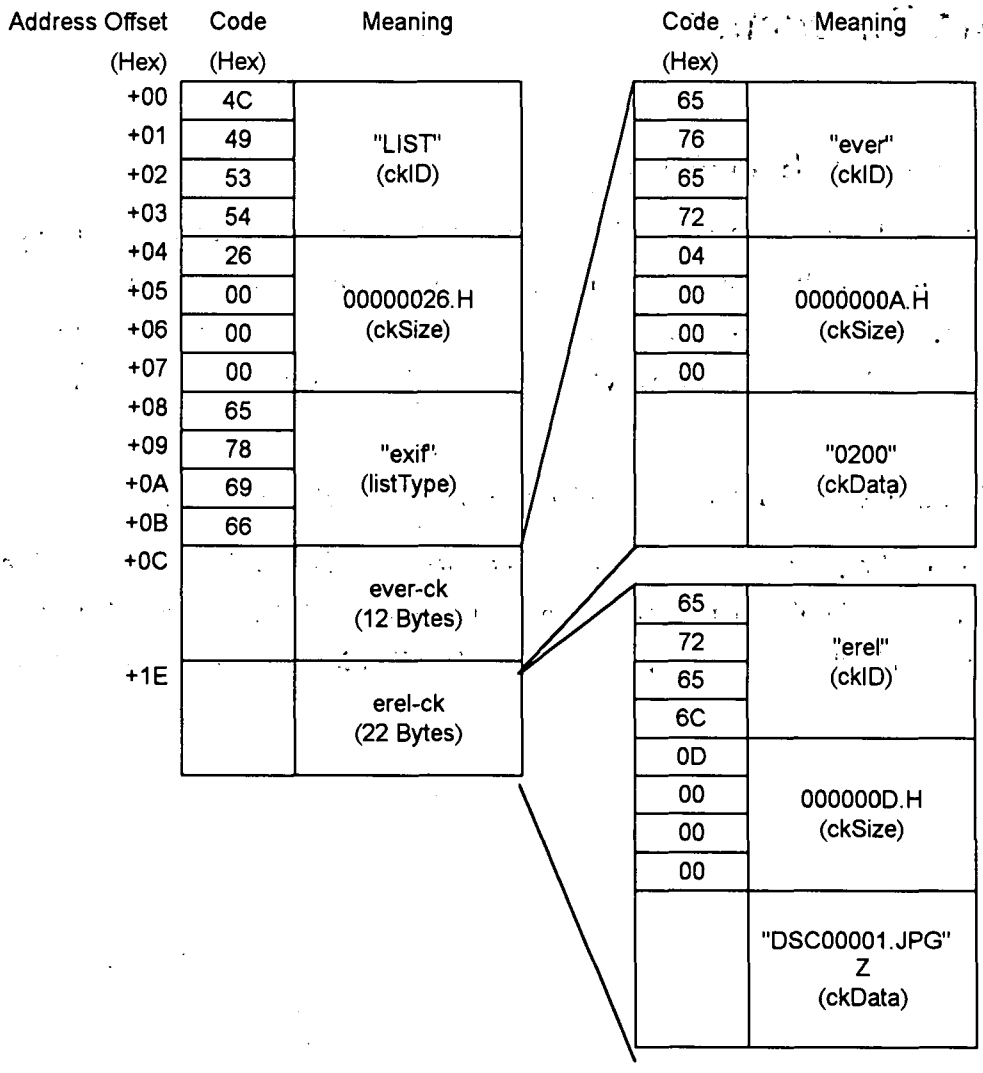


Fig. 47 exif List Structure and Typical Coding

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3.7. Data Description

3.7.1. File Naming Stipulation

The file name and characters used for file names are not specified, other than to stipulate the use of ASCII alphanumerics. (File names in Japanese or other character sets are not to be used.) File names shall be 8 characters or fewer, not including the extension. (Long file names are not to be used.) The file extension is ".WAV" (to match the WAVE Form Audio File extension) regardless of the audio data format type.

Typical Exif Audio File Fig. 48 shows the configuration of a typical Exif audio file.

The shaded parts of Fig. 48 are the mandatory elements of an Exif audio file. The hatching (*fact-ck* only) means that this chunk is not required if the audio data is PCM (Pulse Code Modulation) format, but is mandatory for all non-PCM formats (μ-Law, IMA-ADPCM), etc. The non-shaded elements are optional.

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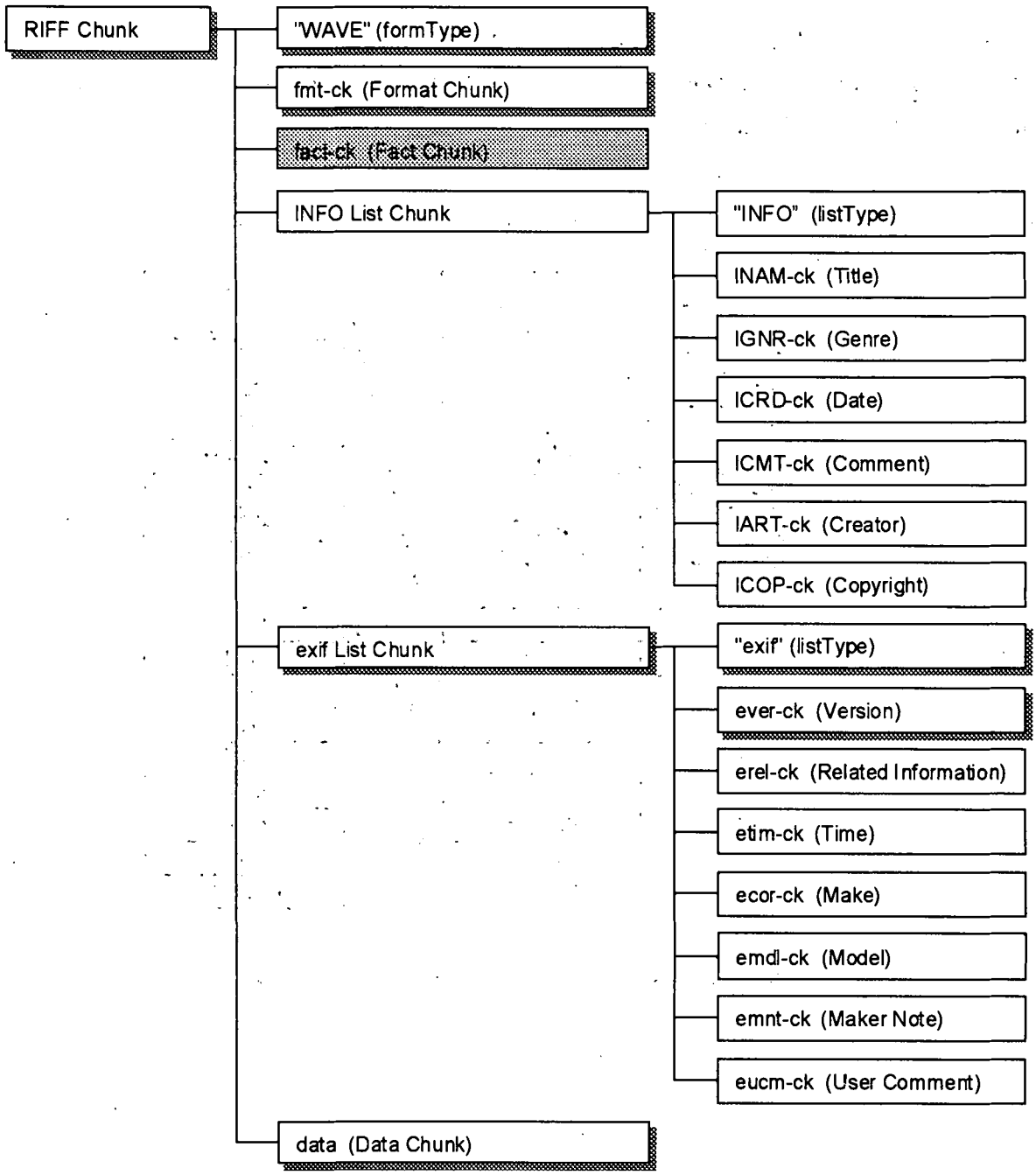


Fig. 48 Exif Audio File Configuration

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The means of recording the data of each element is given in the section for that element.

Fig. 49 shows the most common Exif audio file data structure. Exif audio file data is recorded in accord with the structure shown in Fig. 49. Each sub-chunk is recorded in accord with its stipulations. Optional chunks may be omitted.

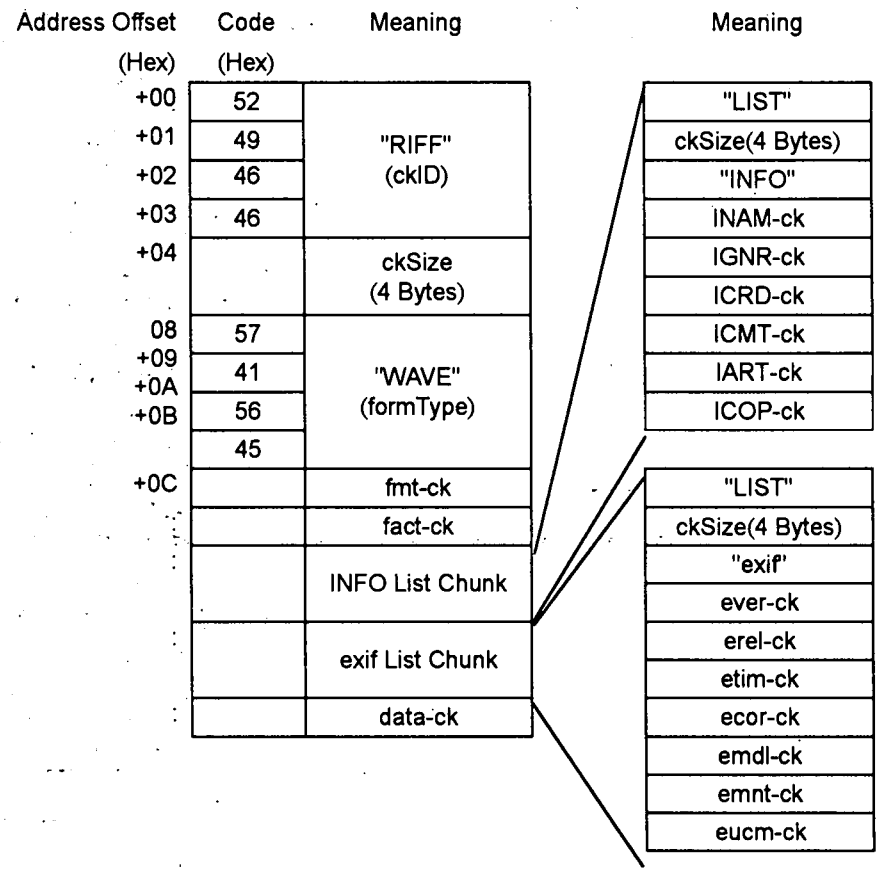


Fig. 49 Data Structure of a Typical Exif Audio File

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Appendix A Image File Description Examples

A.1 Uncompressed RGB File

Table 31 Uncompressed RGB File Description Sample Contents

Primary Image	
Pixels	640 (W) x 480 (H)
Image Title	Exif_TIFF_RGB
Image Input Equipment Manufacturer	DSCompany
Image Input Equipment Model Name	Example
Orientation	Normal
Strips	96
Lines per Strip	5
Bytes per Strip	9600
Image Resolution	72 dpi (Width), 72 dpi (Length)
Image Data Arrangement	Chunky
File Change Date and Time	1997:09:01 12:00:00.000
Copyright	Copyright, ABCDE,1997
Exif-specific Information	
Version	Ver. 2.0
Date and Time of Original Image Creation	1997:09:01 12:00:00.000
Date and Time of File Creation	1997:09:01 12:00:00.000
Thumbnail	
Pixels	80 (W) x 60 (H)
Orientation	Normal
Strips	1
Lines per Strip	60
Bytes per Strip	14400
Image Resolution	72 dpi (Width), 72 dpi (Length)

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Table 32 Uncompressed RGB File Description Sample

Header	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0000	Byte Order	4D4D ("MM")			
	0002	42	002A			
	0004	0th IFD Offset	00000008			
0th IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	0008	Number of Entries	0014			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageWidth	0100	0004	00000001	00000280
	0016	ImageLength	0101	0004	00000001	000001E0
	0022	BitsPerSample	0102	0003	00000003	000000FE
	002E	Compression	0103	0003	00000001	00010000
	003A	PhotometricInterpretation	0106	0003	00000001	00020000
	0046	ImageDescription	010E	0002	0000000E	00000104
	0052	Make	010F	0002	00000009	00000112
	005E	Model	0110	0002	00000008	0000011C
	006A	StripOffsets	0111	0004	00000060	00000124
	0076	Orientation	0112	0003	00000001	00010000
	0082	SamplesPerPixel	0	0003	00000001	00030000
	008E	RowsPerStrip	0116	0004	00000001	00000005
	009A	StripByteCounts	0117	0004	00000060	000002A4
	00A6	XResolution	011A	0005	00000001	00000424
	00B2	YResolution	011B	0005	00000001	0000042C
	00BE	PlanarConfiguration	011C	0003	00000001	00010000
	00CA	ResolutionUnit	0128	0003	00000001	00020000
	00D6	DateTime	0132	0002	00000014	00000434
	00E2	Copyright	8298	0002	00000015	00000484
	00EE	Exif IFD Pointer	8769	0004	00000001	0000045E
	Offset (Hex)	**Name**	**Offset (Hex)**			
	00FA	Next IFD Offset	000004EC			
Value longer than 4byte of 0th IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	00FE	BitPerSample Value	000800080008			
	0104	ImageDescription Value	"Exif_TIFF_RGB"00			
	0112	Make Value	"DSCompany"00			
	011C	Model Value	"Example"00			
	0124	StripOffsets Value	offset0,offset1,offset2.....offset95			
	02A4	StripByteCounts Value	count0, count1, count2....count95			
	0424	XResolution Value	0000004800000001			
	042C	YResolution Value	0000004800000001			
	0434	DateTime Value	"1997:09:01 12:00:00"00			
	0448	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	045E	Exif IFD Number	0008			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	0460	ExifVersion	9000	0007	00000004	"0200"
	046C	DateTimeOriginal	9003	0002	00000014	000004C4

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	0478	DateTimeDigitized	9004	0002	00000014	000004D8
	0484	SubSecTime	9290	0002	00000004	"000"00
	0490	SubSecTimeOriginal	9291	0002	00000004	"000"00
	049C	SubSecTimeDigitized	9292	0002	00000004	"000"00
	04A8	FlashPixVersion	A000	0007	00000004	"0100"
	04B4	Colorspace	A001	0003	00000001	0001
	Offset (Hex)	**Name**	**Offset (Hex)**			
	04C0	Next IFD Offset	00000000			
Value longer than 4byte of Exif IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	04C4	SubSecTimeOriginal Value	"1997:09:01 12:00:00"00			
	04D8	SubSecTimeDigitized Value	"1997:09:01 12:00:00"00			
1st IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	04EC	Number Of Entries	000D			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex)**
	04EE	ImageWidth	0100	0004	00000001	00000050
	04FA	ImageLength	0101	0004	00000001	0000003C
	0506	BitsPerSample	0102	0003	00000003	0000058E
	0512	Compression	0103	0003	00000001	00010000
	051E	PhotometricInterpretation	0106	0003	00000001	00020000
	052A	StripOffsets	0111	0004	00000001	000005A4
	0536	SamplesPerPixel	011	0003	00000001	00030000
	0542	RowsPerStrip	0116	0004	00000001	0000003C
	054E	StripByteCounts	0117	0004	00000001	00003840
	055A	XResolution	011A	0005	00000001	00000594
	0566	YResolution	011B	0005	00000001	0000059C
	0572	PlanarConfiguration	011C	0003	00000001	00010000
	057E	ResolutionUnit	0128	0003	00000001	00020000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	058A	Next IFD Offset	00000000			
Value longer than 4byte of 1st IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	058E	BitPerSample Value	000800080008			
	0594	XResolution Value	0000004800000001			
	059C	YResolution Value	0000004800000001			
	05A4	Thumbnail Image Data Strip	:			
Primary Image	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	3DE4	Primary Image Data Strip0	:			
	6364	Primary Image Data Strip1	:			
	:	:	:			
	:	:	:			
	0E2864	Primary Image Data Strip95	:			

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A.2 Uncompressed YCbCr File

Table 33 Uncompressed YCbCr File Description Sample Contents

Primary Image	
Pixels	640 (W) x 480 (H)
Image Title	Exif_TIFF_YCC
Image Input Equipment Manufacturer	DSCompany
Image Input Equipment Model Name	Example
Orientation	Normal
Strips	69
Lines per Strip	7
Bytes per Strip	8960
Image Resolution	72 dpi (Width), 72 dpi (Length)
Image Data Arrangement	Chunky
File Change Date and Time	1997:09:01 12:00:00
Pixel Composition	Subsampling = 4:2:2 Chrominance subsampling point matches luminance point
Copyright	Copyright, ABCDE,1997
Exif-specific Information	
Version	Ver. 2.0
Date and Time of Original Image Creation	1997:09:01 12:00:00
Date and Time of File Creation	1997:09:01 12:00:00
Shutter Speed	59/10 (equivalent to 1/60 sec.)
Aperture	50/10 (equivalent to F:5.6)
Brightness	80/10
Exposure Bias	0/0
Maximum Lens Aperture	200/10
Subject Distance	20/10
Metering Mode	MultiSpot
Light Source	Daylight
Flash ON/OFF	ON
GPS Information	
Version	Ver. 2.0
Measurement Position	North Latitude 35 deg. 48 min. 8 sec., East Longitude 139 deg. 34 min. 55 sec.
Altitude	30.48 meters above sea level
GPS Time	0:00:00
GPS Receiver Movement	Moving at 1km/h at 0 deg. true direction
Image Direction	0 deg. true direction
Geodetic Data Used for Measurement	TOKYO
Thumbnail	
Pixels	80 (W) x 60 (H)
Orientation	Normal
Strips	1
Lines per Strip	60
Bytes per Strip	9600
Image Resolution	72 dpi (Width), 72 dpi (Length)

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Table 34 Uncompressed YCbCr File Description Sample

Header	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0000	Byte Order	4D4D ("II")			
	0002	42	2A00			
	0004	0th IFD Offset	08000000			
0th IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	0008	Number of Entries	1700			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageWidth	0001	0400	01000000	80020000
	0016	ImageLength	0101	0400	01000000	E0010000
	0022	BitsPerSample	0201	0300	03000000	22010000
	002E	Compression	0301	0300	01000000	01000000
	003A	PhotometricInterpretation	0601	0300	01000000	06000000
	0046	ImageDescription	0E01	0200	0E000000	28010000
	0052	Make	0F01	0200	09000000	36010000
	005E	Model	1001	0200	08000000	40010000
	006A	StripOffsets	1101	0400	45000000	48010000
	0076	Orientation	1201	0300	01000000	01000000
	0082	SamplesPerPixel	1501	0300	01000000	03000000
	008E	RowsPerStrip	1601	0400	01000000	07000000
	009A	StripByteCounts	1701	0400	45000000	5C020000
	00A6	XResolution	1A01	0500	01000000	70030000
	00B2	YResolution	1B01	0500	01000000	78030000
	00BE	PlanarConfiguration	1C01	0300	01000000	01000000
	00CA	ResolutionUnit	2801	0300	01000000	02000000
	00D6	DateTime	3201	0200	14000000	80030000
	00E2	YCbCrSubSampling	1202	0300	02000000	02000100
	00EE	YCbCrPositioning	1302	0300	01000000	02000000
	00FA	Copyright	9882	0200	15000000	94030000
	0106	Exif IFD Pointer	6987	0400	01000000	AA030000
	0112	GPS IFD Offset	2588	0400	01000000	10050000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	011E	Next IFD Offset	7E060000			
Value longer than 4byte of 0th IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0122	BitPerSample Value	080008000800			
	0128	ImageDescription Value	"Exif_TIFF_YCC"00			
	0136	Make Value	"DSCompany"00			
	0140	Model Value	"Example"00			
	0148	StripOffsets Value	(offset0,offset1,offset2.....offset95)			
	025C	StripByteCounts Value	(count0, count1, count2....count95)			
	0370	XResolution Value	4800000001000000			
	037C	YResolution Value	4800000001000000			
	0380	DateTime Value	"1997:09:01 12:00:00"00			
	0394	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	03AA	Exif IFD Number	1400			

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	Offset (Hex)	Name	Tag ID (Hex)	Type (Hex)	Count (Hex)	ValueOffset (Hex or "ASCII")
	03AC	ExposureTime	9A82	0500	01000000	A0040000
	03B8	FNumber	9D82	0500	01000000	A8040000
	03C4	ExifVersion	0090	0700	04000000	"0200"
	03D0	DateTimeOriginal	0390	0200	14000000	B0040000
	03DC	DateTimeDigitized	0490	0200	14000000	C4040000
	03E8	ShutterSpeedValue	0192	0A00	01000000	D8040000
	03F4	ApertureValue	0292	0500	01000000	E0040000
	0400	BrightnessValue	0392	0A00	01000000	E8040000
	040C	ExposureBiasValue	0492	0A00	01000000	F0040000
	0418	MaxApertureRatioValue	0592	0500	01000000	F8040000
	0424	SubjectDistance	0692	0500	01000000	00050000
	0430	MeteringMode	0792	0300	01000000	01000000
	043C	LightSource	0892	0300	01000000	01000000
	0448	Flash	0992	0300	01000000	00000000
	0454	FocalLength	0A92	0500	01000000	08050000
	0460	SubSecTime	9092	0200	04000000	"000"00
	046C	SubSecTimeOriginal	9192	0200	04000000	"000"00
	0478	SubSecTimeDigitized	9292	0200	04000000	"000"00
	0484	FlashPixVersion	A000	0700	04000000	"0100"
	0490	ColorSpace	A001	0300	01000000	01000000
	Offset (Hex)	**Name**			**Offset (Hex)**	
	049C	Next IFD Offset			00000000	
Value longer than 4 Bytes of Exif IFD	**Offset (Hex)**	**Name**			**Data (Hex or "ASCII")**	
	04A0	ExposureTime Value			010000003C000000	
	04A8	FNumber Value			0400000001000000	
	04B0	DateTimeOriginal Value			"1997:09:01 12:00:00"00	
	04C4	DateTimeDigitized Value			"1997:09:01 12:00:00"00	
	04D8	ShutterSpeed Value			0600000001000000	
	04E0	ApertureValue Value			0400000001000000	
	04E8	BrightnessValue Value			0000000001000000	
	04F0	ExposureBiasValue Value			0000000001000000	
	04F8	MaxApertureRatio Value			0100000001000000	
	0500	SubjectDistance Value			0F0000000A000000	
	0508	FocalLength Value			3200000001000000	
GPS IFD	**Offset (Hex)**	**Name**			**Entry Number (Hex)**	
	0510	GPS IFD Number			0013	
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	0512	GPSVersionIF	0000	0100	04000000	02000000
	051E	GPSLatitudeRef	0100	0200	02000000	"N"000000
	052A	GPSLatitude	0200	0500	03000000	FA050000
	0536	GPSLongitudeRef	0300	0200	02000000	"E"000000
	0542	GPSLongitude	0400	0500	03000000	12060000
	054E	GPSAltitudeRef	0500	0100	01000000	00000000
	055A	GPSAltitude	0600	0500	01000000	2A060000
	0566	GPSTimeStamp	0700	0500	03000000	32060000
	0572	GPSSatellites	0800	0200	0D000000	4A060000
	057E	GPSStatus	0900	0200	02000000	"A"000000
	058A	GPSMeasureMode	0A00	0200	02000000	"2"000000
	0596	GPSDOP	0B00	0500	01000000	58060000

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	05A2	GPSSpeedRef	0C00	0200	02000000	"K"000000
	05AE	GPSSpeed	0D00	0500	01000000	60060000
	05BA	GPSTrackRef	0E00	0200	02000000	"T"000000
	05C6	GPSTrack	0F00	0500	01000000	68060000
	05D2	GPSImgDirectionRef	1000	0200	02000000	"T"000000
	05DE	GPSImgDirection	1100	0500	01000000	70060000
	05EA	GPSMapDatum	1200	0200	06000000	78060000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	05F6	Next IFD Offset	00000000			
Value longer than 4 Bytes of GPS IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	05FA	GPSLatitude Value	230000000100000030000000010000000800000001000000			
	0612	GPSLongitude Value	8B0000000100000022000000010000003700000001000000			
	062A	GPSAltitude Value	E80B000064000000			
	0632	GPSTimeStamp Value	000000000100000000000000010000000000000001000000			
	064A	GPSSatellites Value (Last Byte is padded)	"2,7,14,15,16"0000			
	0658	GPSDOP Value	0100000001000000			
	0660	GPSSpeed Value	0000000001000000			
	0668	GPSTrack Value	0000000001000000			
	0670	GPSImgDirection Value	0000000001000000			
	0678	GPSMapDatum Value	"TOKYO"00			
1st IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	067E	Number Of Entries	0F00			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	0680	ImageWidth	0001	0400	01000000	50000000
	068C	ImageLength	0101	0400	01000000	3C000000
	0698	BitsPerSample	0201	0300	03000000	38070000
	06A4	Compression	0301	0300	01000000	01000000
	06B0	PhotometricInterpretation	0601	0300	01000000	06000000
	06BC	StripOffsets	1101	0400	01000000	4E070000
	06C8	SamplesPerPixel	1501	0300	01000000	03000000
	06D4	RowsPerStrip	1601	0400	01000000	3C000000
	06E0	StripByteCounts	1701	0400	01000000	80250000
	06EC	XResolution	1A01	0500	01000000	3E070000
	06F8	YResolution	1B01	0500	01000000	46070000
	0704	PlanarConfiguration	1C01	0300	01000000	01000000
	0710	ResolutionUnit	2801	0300	01000000	02000000
	071C	YCbCrSubSampling	1202	0300	02000000	02000100
	0728	YCbCrPositioning	1302	0300	01000000	02000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	0734	Next IFD Offset	00000000			
Value longer than 4byte of 1st IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0738	BitPerSample Value	080008000800			
	073E	XResolution Value	4800000001000000			
	0746	YResolution Value	4800000001000000			
	074E	(Thumbnail Image Data Strip)				
Primary Image Data	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	2CCE	Image Data Strip0	:			

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	4FCE	Image Data Strip1	
	:	:	
	:	:	
	0978CE	Image Data Strip68	

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A.3 JPEG Compressed (4:2:2) File

Table 35 JPEG Compressed (4:2:2) File Description Sample Contents

Primary Image	
Recording Format	JPEG
Subsampling	YCC 4:2:2
Restart Markers	Inserted
Quantization Tables	3
Pixels	640 (W) x 480 (H)
Image Title	Exif_JPEG_422
Image Input Equipment Manufacturer	DS Company
Image Input Equipment Model Name	Example
Orientation	Normal
Image Resolution	72 dpi (Width), 72 dpi (Length)
File Change Date and Time	1997:09:01 12:00:00
Copyright	Copyright, ABCDE,1997
Exif-specific Information	
Version	Ver. 2.0
Date and Time of Original Image Creation	1997:09:01 12:00:00
Date and Time of File Creation	1997:09:01 12:00:00
Components	Y,Cb,Cr
Image Compression Mode	2bit/pel
Shutter Speed	59/10 (equivalent to 1/60 sec.)
Aperture	50/10 (equivalent to F:5.6)
Brightness	80/10
Exposure Bias	0/0
Maximum Lens Aperture	200/10
Subject Distance	20/10
Metering Mode	MultiSpot
Light Source	Daylight
Flash ON/OFF	ON
Thumbnails	
Recording Format	JPEG
Subsampling	YCC 4:2:2
Pixels	80 (W) x 60 (H)
Image Resolution	72 dpi (Width), 72 dpi (Length)

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Table 36 JPEG Compressed (4:2:2) File JPEG Stream Description Sample

Offset (Hex)	Maker Segment	Name	Code (Hex)	Comment
0000	SOI	SOI Marker	FFD8	Start of Image
0002	APP1	APP1 Marker	FFE1	
0004		APP1 Length	291C	
0006		Identifier	"Exif"00	
000B		Pad	00	
000C		APP1 Body		See Next Table
0E39	DQT	DQT Marker	FFDB	Define Quantization Table
0E3B		DQT Length	00C5	
0E3D		Pq, Tq	00	
0E3E		table elements	100B0C0E....	64 Bytes of Data
0E7E		Pq,Tq	01	
0E7F		table elements	0F101016....	64 Bytes of Data
0EBF		Pq,Tq	02	
0EC0		table elements	0F101016.....	64 Bytes of Data
0F00	DHT	DHT Marker	FFC4	
0F02		DHT Length	01A2	
0F04		Th	00	Table 0 for DC
0F05		Li	00010501....	
0F15		Vij	00010203....	
0F21		Th	10	Table 0 for AC
0F22		Li	00020103....	
0F32		Vij	01020300....	
0FD4		Th	01	Table 1 for DC
0FD5		Li	00030101....	
0FE5		Vij	00010203....	
0FF1		Th	11	Table 1 for AC
0FF2		Li	00020102....	
1002		Vij	00010203....	
10A4	DRI	DRI Marker	FFDD	
10A6		DRI Length	0004	
10A8		Ri	0004	
10AA	SOF0	SOF0 Marker	FFC0	
10AC		SOF0 Length	0011	
10AE		P	08	
10AF		Y	01E0	
10B1		X	0280	
10B3		Nf	03	
10B4		C1	01	
10B5		H1,V1	21	
10B6		Tq1	00	
10B7		C2	02	
10B8		H2,V2	11	
10B9		Tq2	01	
10BA		C3	03	
10BB		H3,V3	11	
10BC		Tq3	02	
10BD	SOS	SOS Marker	FFDA	
10BF		SOS Length	000C	
10C1		Ns	03	
10C2		Cs1	01	

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10C3		Td1,Ta1	00	
10C4		Cs2	02	
10C5		Td2,Ta2	11	
10C6		Cs3	03	
10C7		Td3,Ta3	11	
10C8		Ss	00	
10C9		Se	3F	
10CA		Ah,Al	00	
10CB	Image Data		F36A....	Compressed Data
111C4	EOI		FFD9	

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Table 37 JPEG Compressed (4:2:2) File APP1 Description Sample

Header	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0000	Byte Order	4D4D ("II")			
	0002	42	2A00			
	0004	0th IFD Offset	08000000			
0th IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	0008	Number of Entries	0B00			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageDescription	0E01	0200	0E000000	92000000
	0016	Make	0F01	0200	09000000	A0000000
	0022	Model	1001	0200	08000000	AA000000
	002E	Orientation	1201	0300	01000000	01000000
	003A	XResolution	1A01	0500	01000000	B2000000
	0046	YResolution	1B01	0500	01000000	BA000000
	0052	ResolutionUnit	2801	0300	01000000	02000000
	005E	DateTime	3201	0200	14000000	C2000000
	006A	YCbCrPositioning	1302	0300	01000000	02000000
	0076	CopyRight	9882	0200	15000000	D6000000
	0082	Exif IFD Pointer	6987	0400	01000000	EC000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	008E	Next IFD Offset	C402			
Value longer than 4byte of 0th IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0092	ImageDescription Value	"Exif_JPEG_422"00			
	00A0	Make Value	"DSCompany"00			
	00AA	Model Value	"Example"00			
	00B2	XResolution Value	4800000001000000			
	00BA	YResolution Value	4800000001000000			
	00C2	DateTime Value	"1997:09:01 12:00:00"00			
	00D6	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	00EC	Exif IFD Number	1900			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	00EE	ExposureTime	9A82	0500	01000000	1E020000
	00FA	FNumber	9D82	0500	01000000	26020000
	0106	ExifVersion	0090	0700	04000000	"0200"
	0112	DateTimeOriginal	0390	0200	14000000	2E020000
	011E	DateTimeDigitized	0490	0200	14000000	42020000
	012A	ComponentsConfiguration	0191	0700	04000000	01020000
	0136	CompressedBitsPerPixel	0292	0500	01000000	56020000
	0142	ShutterSpeedValue	0192	0A00	01000000	5E020000
	014E	ApertureValue	0292	0500	01000000	66020000
	015A	BrightnessValue	0392	0A00	01000000	6E020000
	0166	ExposureBiasValue	0492	0A00	01000000	76020000
	0172	MaxApertureRatioValue	0592	0500	01000000	7E020000
	017E	SubjectDistance	0692	0500	01000000	86020000
	018A	MeteringMode	0792	0300	01000000	01000000

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	0196	LightSource	0892	0300	01000000	01000000
	01A2	Flash	0992	0300	01000000	00000000
	01AE	FocalLength	0A92	0500	01000000	8E020000
	01BA	UserComments	8692	0700	2E000000	96020000
	01C6	SubSecTime	9092	0200	04000000	"000"00
	01D2	SubSecTimeOriginal	9192	0200	04000000	"000"00
	01DE	SubSecTimeDigitized	9292	0200	04000000	"000"00
	01EA	FlashPixVersion	A000	0700	04000000	"0100"
	01F6	Colorspace	A001	0300	01000000	01000000
	0202	Pixel X Dimension	A002	0400	01000000	80020000
	020E	Pixel Y Dimension	A003	0400	01000000	E0010000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	021A	Next IFD Offset	00000000			
Value longer than 4 Bytes of Exif IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	021E	ExposureTime Value	010000003C000000			
	0226	FNumber Value	0400000001000000			
	022E	DateTimeOriginal Value	"1997:09:01 12:00:00"00			
	0242	DateTimeDigitized Value	"1997:09:01 12:00:00"00			
	0256	CompressedBitsPerPixel Value	0200000001000000			
	025E	ShutterSpeedValue Value	0600000001000000			
	0266	ApertureValue Value	0400000001000000			
	026E	BrightnessValue Value	0000000001000000			
	0276	ExposureBiasValue Value	0000000001000000			
	027E	MaxApertureRatioValue Value	0100000001000000			
	0286	SubjectDistance Value	0F0000000A000000			
	028E	FocalLength Value	3200000001000000			
	0296	UserComment Value (46 Bytes)	4A49530000000000....			
1st IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	02C4	Number Of Entries	0700			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	02C6	Compression	0301	0300	01000000	01000000
	02D2	XResolution	1A01	0500	01000000	1E030000
	02DE	YResolution	1B01	0500	01000000	26030000
	02EA	ResolutionUnit	2801	0300	01000000	02000000
	02F6	JPEGInterchangeFormat	0102	0400	01000000	2D0E0000
	0302	JPEGInterchangeFormatLength	0202	0400	01000000	FF0A0000
	030E	YCbCrPositioning	1302	0300	01000000	02000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	031A	Next IFD Offset	00000000			
Value longer than 4byte of 1st IFD	**Offset (Hex)**	**Data (Hex or "ASCII")**	**Name**			
	031E	4800000001000000	XResolution Value			
	0326	4800000001000000	YResolution Value			
Thumbnail Image Data	**Offset (Hex)**	**Name**	**Data**			
	032E	Thumbnail Data	(JPEG Stream)			

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A.4 JPEG Compressed (4:2:0) File

Table 38 JPEG Compressed (4:2:0) File Description Sample Contents

Primary Image	
Recording Format	JPEG
Subsampling	YCC 4:2:0
Restart Markers	Inserted
Quantization Tables	2
Pixels	620 (W) x 475 (H)
Image Title	620x475
SOF Recorded Pixels	640x475
DCT Data	640x480
Image Title	Exif_JPEG_420
Image Input Equipment Manufacturer	DSCompany
Image Input Equipment Model Name	Example
Orientation	Normal
Image Resolution	72 dpi (Width), 72 dpi (Length)
File Change Date and Time	1997:09:01 12:00:00
Copyright	Copyright, ABCDE,1997
Exif-specific Information	
Version	Ver. 2.0
Date and Time of Original Image Creation	1997:09:01 12:00:00
Date and Time of File Creation	1997:09:01 12:00:00
Components	Y,Cb,Cr
Image Compression Mode	2bit/pel
Shutter Speed	59/10 (equivalent to 1/60 sec.)
Aperture	50/10 (equivalent to F:5.6)
Brightness	80/10
Exposure Bias	0/0
Maximum Lens Aperture	200/10
Subject Distance	20/10
Metering Mode	MultiSpot
Light Source	Daylight
Flash ON/OFF	ON
Thumbnails	
Recording Format	TIFF
Subsampling	YCC 4:2:0
Pixels	80x60
Image Resolution	72 dpi (Width), 72 dpi (Length)

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Table 39 JPEG Compressed (4:2:0) File JPEG Stream Description Sample

Offset (Hex)	Maker Segment	Name	Code (Hex)	Comment
0000	SOI	SOI Marker	FFD8	Start of Image
0002	APP1	APP1 Marker	FFE1	
0004		APP1 Length	1FBC	
0006		Identifier	"Exif"00	
000B		Pad	00	
000C		APP1 Body		See Next Table
1FC0	DQT	DQT Marker	FFDB	Define Quantization Table
1FC2		DQT Length	0084	
1FC4		Pq, Tq	00	
1FC5		table elements	08060607....	64 Bytes of Data
2005		Pq,Tq	01	
2006		table elements	0909090C....	64 Bytes of Data
2046	DHT	DHT Marker	FFC4	
2048		DHT Length	01A2	
204A		Th	00	Table 0 for DC
204B		Li	00010501....	
205B		Vij	00010203....	
2067		Th	10	Table 0 for AC
2068		Li	00020103....	
2078		Vij	01020300....	
211A		Th	01	Table 1 for DC
211B		Li	00030101....	
212B		Vij	00010203....	
2137		Th	11	Table 1 for AC
2138		Li	00020102....	
2148		Vij	00010203....	
21EA	DRI	DR Marker	FFDD	
21EC		DRI Length	0004	
21EE		Ri	0004	
21F0	SOF0	SOF0 Marker	FFC0	
21F2		SOF0 Lentth	0011	
21F4		P	08	
21F5		Y	01DB	
21F7		X	0280	
21F9		Nf	03	
21FA		C1	01	
21FB		H1,V1	22	
21FC		Tq1	00	
21FD		C2	02	
21FE		H2,V2	11	
21FF		Tq2	01	
2200		C3	03	
2201		H3,V3	11	
2202		Tq3	01	
2203	SOS	SOS Marker	FFDA	
2205		SOS Length	000C	
2207		Ns	03	
2208		Cs1	01	
2209		Td1,Ta1	00	
220A		Cs2	02	

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220B		Td2,Ta2	11	
220C		Cs3	03	
220D		Td3,Ta3	11	
220E		Ss	00	
220F		Se	3F	
2210		Ah,Al	00	
2211	Image Data		F9FE....	Compressed Data
13BA4	EOI		FFD9	

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Table 40 JPEG Compressed (4:2:0) File APP1 Description Sample

Header	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0000	Byte Order	4D4D ("II")			
	0002	42	2A00			
	0004	0th IFD Offset	08000000			
0th IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	0008	Number of Entries	0B00			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageDescription	0E01	0200	0E000000	92000000
	0016	Make	0F01	0200	09000000	A0000000
	0022	Model	1001	0200	08000000	AA000000
	002E	Orientation	1201	0300	01000000	01000000
	003A	XResolution	1A01	0500	01000000	B2000000
	0046	YResolution	1B01	0500	01000000	BA000000
	0052	ResolutionUnit	2801	0300	01000000	02000000
	005E	DateTime	3201	0200	14000000	C2000000
	006A	YCbCrPositioning	1302	0300	01000000	02000000
	0076	Copyright	9882	0200	15000000	D6000000
	0082	Exif IFD Pointer	6987	0400	01000000	EC000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	008E	Next IFD Offset	C402			
Value longer than 4byte of 0th IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0092	ImageDescription Value	"Exif_JPEG_420"00			
	00A0	Make Value	"DSCompany"00			
	00AA	Model Value	"Example"00			
	00B2	XResolution Value	4800000001000000			
	00BA	YResolution Value	4800000001000000			
	00C2	DateTime Value	"1997:09:01 12:00:00"00			
	00D6	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	00EC	Exif IFD Number	1900			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	00EE	ExposureTime	9A82	0500	01000000	1E020000
	00FA	FNumber	9D82	0500	01000000	26020000
	0106	ExifVersion	0090	0700	04000000	"0200"
	0112	DateTimeOriginal	0390	0200	14000000	2E020000
	011E	DateTimeDigitized	0490	0200	14000000	42020000
	012A	ComponentsConfiguration	0191	0700	04000000	01020300
	0136	CompressedBitsPerPixel	0292	0500	01000000	56020000
	0142	ShutterSpeedValue	0192	0A00	01000000	5E020000
	014E	ApertureValue	0292	0500	01000000	66020000
	015A	BrightnessValue	0392	0A00	01000000	6E020000
	0166	ExposureBiasValue	0492	0A00	01000000	76020000
	0172	MaxApertureRatioValue	0592	0500	01000000	7E020000
	017E	SubjectDistance	0692	0500	01000000	86020000
	018A	MeteringMode	0792	0300	01000000	01000000

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	0196	LightSource	0892	0300	01000000	01000000
	01A2	Flash	0992	0300	01000000	00000000
	01AE	FocalLength	0A92	0500	01000000	8E020000
	01BA	UserComments	8692	0700	2E000000	96020000
	01C6	SubSecTime	9092	0200	04000000	30303000
	01D2	SubSecTimeOriginal	9192	0200	04000000	"000"00
	01DE	SubSecTimeDigitized	9292	0200	04000000	"000"00
	01EA	FlashPixVersion	A000	0700	04000000	"0100"
	01F6	ColorSpace	A001	0300	01000000	01000000
	0202	Pixel X Dimension	A002	0400	01000000	6C020000
	020E	Pixel Y Dimension	A003	0400	01000000	DB010000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	021A	Next IFD Offset	00000000			
Value longer than 4 Bytes of Exif IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	021E	ExposureTime Value	010000003C000000			
	0226	FNumber Value	0400000001000000			
	022E	DateTimeOriginal Value	"1997:09:01 12:00:00"00			
	0242	DateTimeDigitized Value	"1997:09:01 12:00:00"00			
	0256	CompressedBitsPerPixel Value	0200000001000000			
	025E	ShutterSpeedValue Value	0600000001000000			
	0266	ApertureValue Value	0400000001000000			
	026E	BrightnessValue Value	0000000001000000			
	0276	ExposureBiasValue Value	0000000001000000			
	027E	MaxApertureRatioValue Value	0100000001000000			
	0286	SubjectDistance Value	0F0000000A000000			
	028E	FocalLength Value	3200000001000000			
	0296	UserComment Value (46 Bytes)	4A49530000000000....			
1st IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	02C4	Number Of Entries	0F00			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	02C6	ImageWidth	0001	0400	01000000	50000000
	02D2	ImageLength	0101	0400	01000000	3C000000
	02DE	BitsPerSample	0201	0300	03000000	7E030000
	02EA	Compression	0301	0300	01000000	01000000
	02F6	PhotometricInterpretation	0601	0300	01000000	06000000
	0302	StripOffsets	1101	0400	01000000	94030000
	030E	SamplesPerPixel	1501	0300	01000000	03000000
	031A	RowsPerStrip	1601	0400	01000000	3C000000
	0326	StripByteCounts	1701	0400	01000000	201C0000
	0332	XResolution	1A01	0500	01000000	84030000
	033E	YResolution	1B01	0500	01000000	8C030000
	034A	PlanarConfiguration	1C01	0300	01000000	01000000
	0356	ResolutionUnit	2801	0300	01000000	02000000
	0362	YCbCrSubSampling	1202	0300	02000000	02000200
	036E	YCbCrPositioning	1302	0300	01000000	02000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	037A	Next IFD Offset	00000000			
Value longer than 4byte of 1st IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			

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	037E	BitsPerSample Value	080008000800
	0384	XResolution Value	4800000001000000
	038C	YResolution Value	4800000001000000
Thumbnail Image Data	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**
	0394	Thumbnail Image Data Strip	

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Appendix B Audio File Description Examples

B.1 PCM Audio Data

Table 41 PCM Audio File Description Sample Contents

Audio Data	
Format Type	PCM Format
Channels	monaural
Sampling Frequency	22.05 kHz
Bits per Sample	8 Bits/Sample
Total Samples	27768 Samples
Attribute Information	
Audio Title	ExifPCMExampleZ
Audio Genre	None
Recording Date	1997-07-13
Recording Engineer	Taro Yamada
Copyright	Copyright Exif Corporation on 1997.
Exif-specific Information	
Exif Version	0200 (Version 2.0)
Related Exif Image File	DSC00001.JPGZ
Recording Start Time	10:15:30.130Z
Recording Equipment Manufacturer	DSC CorporationZ
Recording Equipment Model	DSC1000Z
Manufacturer Note	None
User Comment	None

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Table 42 PCM Audio File Description Example

	Offset (Hex)	Name	Comment	Data (Hex or "Ascii")
RIFF-ck	0000	ckID	RIFF	52494646
	0004	ckSize		766D0000
	0008	formType	WAVE	57415645
fmt-ck	000C	ckID	fmt_	666D7420
	0010	ckSize		10000000
	0014	wFormatTag	PCM Format	0100
	0016	nchannels	monaural	0100
	0018	nSamplesPerSec	22.05 kHz	22560000
	001C	nAvgBytesPerSec	22050 bytes/sec	22560000
	0020	nBlockAlign	1 byte/block	0100
	0022	wBitsPerSample	8 bits/sample	0800
INFO-LIST	0024	ckID	LIST	4C495354
	0028	ckSize		6E000000
	002C	listType	"INFO"	494E464F
INAM-ck	0030	ckID	INAM	494E414D
	0034	ckSize		0F000000
	0038	ckData	(audio title)	"ExifPCMExample"0000
ICRD-ck	0048	ckID	ICRD	49435244
	004C	ckSize		0B000000
	0050	ckData	(July 13, 1997)	"1997-07-13"0000
IART-ck	005C	ckID	IART	49415254
	0060	ckSize		0C000000
	0064	ckData	(creator)	"Taro Yamada"00
ICOP-ck	0070	ckID	ICOP	49434F50
	0074	ckSize		21000000
	0078	ckData	(copyright)	"Copyright Exif Corporation on 1997."0000
exif-LIST	009A	ckID	LIST	4C495354
	009E	ckSize		64000000
	00A2	listType	exif	65786966
ever-ck	00A6	ckID	ever	65766572
	00AA	ckSize		4000000
	00AE	ckData	Ver. 2.0	200
erel-ck	00B2	ckID	erel	6572656C
	00B6	ckSize		0D000000
	00BA	ckData	(relation to Exif image file)	"DSC00001.JPG"0000
etim-ck	00C8	ckID	etim	6574696D
	00CC	ckSize		0D000000
	00D0	ckData	(10:15:30.130)	"10:15:30.130"0000
ecor-ck	00DE	ckID	ecor	65636F72
	00E2	ckSize		10000000
	00E6	ckSize	(equipment manufacturer)	"DSC Corporation"00
emdl-ck	00F6	ckID	emdl	656D646C
	00FA	ckSize		8000000
	00FE	ckData	(equipment model)	"DSC1000"00
data-ck	0106	ckID	data	64617461
	010A	ckSize		706C0000
	010E	ckData	PCM Audio Data	00000000000.....

(Total samples = 27768)

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B.2 μ-Law Audio Data

Table 43 μ-Law Audio File Description Sample Contents

Audio Data	
Format Type	μ-LAW PCM
Channels	monaural
Sampling Frequency	8.000 kHz
Bits per Sample	8 bits
Total Samples	111912
Attribute Information	
Audio Title	μ-LAW PCM ExampleZ
Audio Genre	GreetingZ
Recording Date	1997-07-17
Recording Engineer	Interactive Multimedia AssociationZ
Copyright	Copyright ABCZ
Exif-specific Information	
Exif Version	0200 (Version 2.0)
Related Exif Image File	DSC00001.JPGZ
Recording Start Time	10:20:30.130Z
Recording Equipment Manufacturer	ABCD CorporationZ
Recording Equipment Model	Camera XYZZ
Manufacturer Note	0000000000000000
User Comment	User Comment (ASCII)

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Table 44 μ-Law Audio File Description Sample

	Offset (Hex)	Name	Comment	Data (Hex or "Ascii")
RIFF-ck	0000	ckID	RIFF	52494646
	0004	ckSize		AAB60100
	0008	formType	WAVE	57415645
fmt-ck	000C	ckID	fmt_	666D7420
	0010	ckSize		12000000
	0014	wFormatTag	μ-Law Format	0700
	0016	nchannels	monaural	0100
	0018	nSamplesPerSec	8.00 kHz	401F0000
	001C	nAvgBytesPerSec	8.00Kbytes/sec	401F0000
	0020	nBlockAlign	1 byte/block	0100
	0022	wBitsPerSample	8 bits/sample	0800
	0024	cbSize	0	0000
fact-ck	0026	ckID	fact	66616374
	002A	ckSize		04000000
	002E	dwSampleLength		28B50100
INFO-LIST	0032	ckID	LIST	4C495354
	0036	ckSize		AC000000
	003A	listType	INFO	494E464F
INAM-ck	003E	ckID	INAM	494E414D
	0042	ckSize		12000000
	0046	ckData	(audio title)	"uLAW PCM Example"00
IGNR-ck	0058	ckID	IGNR	49474E52
	005C	ckSize		09000000
	0060	ckData	(recording genre)	"Greeting"Z
ICRD-ck	006A	ckID	ICRD	49435244
	006E	ckSize		0B000000
	0072	ckData	(July 17, 1997)	"1997-07-17"00
ICMT-ck	007E	ckID	ICMT	49434D54
	0082	ckSize		18000000
	0086	ckData	(This File μ-LAW Sample)	"This File uLAW Sample"000000
IART-ck	009E	ckID	IART	49415254
	00A2	ckSize		23000000
	00A6	ckData	(creator)	"Interactive Multimedia Association"00
ICOP-ck	00CA	ckID	ICOP	49434F50
	00CE	ckSize		10000000
	00D2	ckData	(creator)	"ABCD Corporation"00
exif-LIST	00E2	ckID	LIST	4C495354
	00E6	ckSize		94000000
	00EA	listType	exif	65786966
ever-ck	00EE	ckID	ever	4C495354
	00F2	ckSize		94000000
	00F6	ckData	Ver. 2.0	65786966
erel-ck	00FA	ckID	erel	4C495354
	00FE	ckSize		94000000
	0102	ckData	(relation to Exif image file)	"DSC00001.JPG"00
etim-ck	0110	ckID	etim	4C495354
	0114	ckSize		94000000
	0118	ckData	(10:20:30.130)	"10:20:30.130"00
ecor-ck	0126	ckID	ecor	4C495354
	012A	ckSize		94000000

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		012E	ckSize	(equipment manufacturer)	"ABCD Corporation"00
	emdl-ck	0140	ckID	emdl	656D646C
		0144	ckSize		0A000000
		0148	ckData	(equipment model)	"Camera XY"0000
	emnt-ck	0152	ckID	emnt	656D6E74
		0156	ckSize		08000000
		015A	ckData	(manufacturer note)	0000000000000000
	eucm-ck	0162	ckID	eucm	6575636D
		0166	ckSize		14000000
		016A	ckData	(user comment)	415343494900000055736572204 36F6D
data-ck		017E	ckID	data	64617461
		0182	ckSize		28B50100
		0186	ckData	μ-Law Audio Data	F2FE00007FFF0000E3.....

(Total samples = 111912)

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B.3 IMA-ADPCM Audio Data

Table 45 IMA-ADPCM Audio File Description Sample Contents

Audio Data	
Format Type	IMA-ADPCM Format
Channels	stereo
Sampling Frequency	8.000 kHz
Bytes per Block	8110 bytes/sec
Bits per Sample	4 bits/sample
Total Data Bytes	35840 bytes
Attribute Information	
Audio Title	IMA-ADPCM ExampleZ
Audio Genre	None
Recording Date	1997-08-11Z
Comment	None
Recording Engineer	Hanako YamadaZ
Copyright	Copyright XYZ on 1997.Z
Exif-specific Information	
Exif Version	0200 (Version 2.0)
Related Exif Image File	DSC00001.JPGZ
Recording Start Time	15:14:13.135Z
Recording Equipment Manufacturer	DSC International CorporationZ
Recording Equipment Model	DSC Camera-2Z
Manufacturer Note	None
User Comment	None

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Table 46 IMA-ADPCM Audio File Description Example

	Offset (Hex)	Name	Comment	Data (Hex or "Ascii")
RIFF-ck	0000	ckID	RIFF	52494646
	0004	ckSize		248D0000
	0008	formType	WAVE	57415645
fmt-ck	000C	ckID	"fmt_"	666D7420
	0010	ckSize	IMA-ADPCM Format	14000000
	0014	wFormatTag		1100
	0016	nchannels	stereo	0200
	0018	nSamplesPerSec	8.0kHz	401F0000
	001C	nAvgBytesPerSec	8110 bytes/sec	AE1F0000
	0020	nBlockAlign	512 bytes/block	0002
	0022	wBitsPerSample	4 bits/sample	0400
	0024	cbSize	Additional bytes = 2	0200
	0026	wSamplesPerBlock	505 bytes/block	F901
fact-ck	0028	ckID	fact	66616374
	002C	ckSize		04000000
	0030	dwSampleLength	35350 samples	168A0000
INFO-LIST	0034	ckID	LIST	4C495354
	0038	ckSize		68000000
	003C	listType	INFO	494E464F
INAM-ck	0040	ckID	INAM	494E414D
	0044	ckSize		12000000
	0048	ckData	(audio title)	"IMA-ADPCM Example"00
IGNR-ck	0058	ckID	IGNR	49474E52
	005C	ckSize		09000000
	0060	ckData	(recording genre)	"Greeting"Z
ICRD-ck	005A	ckID	ICRD	49435244
	005E	ckSize		0B000000
	0062	ckData	(August 11, 1997)	"1997-08-11"0000
IART-ck	006E	ckID	IART	49415254
	0072	ckSize		0E000000
	0076	ckData	(creator)	"Hanako Yamada"00
ICOP-ck	0084	ckID	ICOP	49434F50
	0088	ckSize		17000000
	008C	ckData	(copyright)	"Copyright XYZ on 1997."0000
exif-LIST	00E2	ckID	LIST	4C495354
	00E6	ckSize		94000000
	00EA	listType	exif	65786966
ever-ck	00A4	ckID	LIST	4C495354
	00A8	ckSize		78000000
	00AC	listType	exif	65786966
erel-ck	00BC	ckID	erel	6572656C
	00C0	ckSize		0D000000
	00C4	ckData	(relation to Exif image file)	"DSC00001.JPG"0000
etim-ck	00D2	ckID	etim	6574696D
	00D6	ckSize		0D000000
	00DA	ckData	(15:14:13.135)	"15:14:13.135"0000
ecor-ck	00E8	ckID	ecor	65636F72
	00EC	ckSize		1E000000
	00F0	ckSize	(equipment manufacturer)	"DSC International Corporation"00
emdl-ck	010E	ckID	emdl	656D646C

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	0112	ckSize		0D000000
	0116	ckData	(equipment model)	"DSC Camera-2"0000
data-ck				
	0124	ckID	data	64617461
	0128	ckSize		008C0000
	012C	ckData		.....

(Total bytes = 35840)

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Appendix C APEX Units

The camera information in this standard conforms to the APEX (Additive System of Photographic Exposure) unit system. APEX is a convenient unit for expressing exposure (Ev). The relation of APEX to other units is essentially as follows.

- ApertureValue (Av) = 2 $\log_2$ (F number)
- ShutterSpeedValue (Tv) = - $\log_2$ (exposure time)
- BrightnessValue (Bv) = $\log_2$ (B/NK) Note that: B:cd/cm^2, N,K: constant

Film sensitivity (not used in this standard) is expressed as follows.

Film sensitivity (Sv) = $\log_2$ (ASA / 3.125)

Using these values, exposure (Ev) is calculated as follows.

Ev = Av + Tv = Bv + Sv

The table below gives examples of values actually used as camera information.

Table 47 Typical APEX Values

ApertureValue (APEX)	F-Number
0	1
1	1.4
2	2
3	2.8
4	4
5	5.6
6	8
7	11
8	16
9	22
10	32

ShutterSpeed Value (APEX)	ExposureTime (second)
-5	30
-4	15
-3	8
-2	4
-1	2
0	1
1	1/2
2	1/4
3	1/8
4	1/15
5	1/30
6	1/60
7	1/125
8	1/250
9	1/500
10	1/1000
11	1/2000

BrightnessValue (APEX)	foot lambert
-2	1/4
-1	1/2
0	1
1	2
2	4
3	8
4	15
5	30

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Appendix D Recommended Implementation Examples

The purpose of this chapter is not to restrict Exif implementations, but to show examples of recommended practices that will increase the level of compatibility among DSC cameras and related systems using general-purpose removable media such as PC Card or Smart Media.

The practices illustrated below are recommended for DSC and other embedded systems when the processing capacity for handling the recording media is limited.

D.1 Recommended Directory Name Usage Examples

Writers

Create a subdirectory "IMxxxxxx" under the root directory, and record the Exif file there. The "xxxxxx" part of the name consists of no more than 6 alphanumerics and cannot contain special characters. "IM" are upper case. Hereafter this is called the Exif directory.

D.2 Recommended File Naming Usage Examples

Readers

An Exif reader plays the files in the Exif directory noted in D.1 above, treating those with the extension "JPG" as Exif compressed files, those with the extension "TIF" as Exif uncompressed files, and those with the extension "WAV" as audio files. On this basis it confirms the mandatory tags or chunk data in the file and plays it as appropriate. No specification is made regarding the handling of files with extensions other than the above.

D.3 Recommended File Operation Usage Examples

Exif compressed files, uncompressed files and audio files can be recorded in the same Exif directory. It is also possible to create two or more Exif directories under the root directory, so long as the stipulations for "IMxxxxxx" (in D.1 above) are observed. A specific usage case is given below.

Usage case

If the recording medium already has an Exif directory (e.g., IMXYZ) recorded by a different model,

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separate from the self-recorded Exif directory (e.g., IMFIDX10), then a self-recorded Exif directory (IMFIDX10) can be created under the root directory and used to record Exif files.

In this case the existing Exif directory (IMXYZ) continues to be preserved on the medium (see Fig. 50).

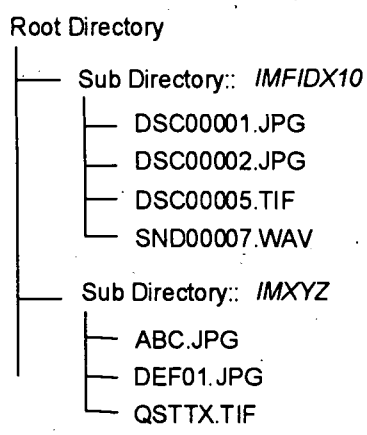


Fig. 50 Directory Structure and File Recording Example

Readers

The reader recognizes an Exif directory "IMxxxxxx" in the root directory (a subdirectory with "IM" as the first two letters of its name) and files in it that meet the naming conventions in section 2.8.3 and section 3.7.1, and plays the file if the contents of the mandatory tags or chunks match the equipment specifications.

When there are multiple Exif directories "IMxxxxxx" under the root directory, it must be possible to recognize the files recorded in those directories.

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Appendix E Color Space Guidelines

These guidelines are given with reference to sRGB[xvii], ITU-R BT.709[xviii], and ITU-R BT.601[xix]. For details see the documents themselves.

E.1 sRGB

The sRGB standard gives strict color space definitions based on standard monitor characteristics and viewing conditions (details are under deliberation in IEC/TC 100 PT 61966). This standard takes the characteristics of typical commercially available displays as its median reference values.

ITU-R BT.709 is a standard specification for cameras, which specifies algorithms for photographing a scene and displaying it on a standard monitor. It does not, however, give a clear specification of the standard monitor characteristics. Accordingly, sRGB can be thought of as a standard that augments and is compatible with ITU-R BT.709.

In actual camera design, the ITU-R BT.709 characteristics can be used as the picture-taking algorithms, presupposing the standard monitor characteristics and viewing conditions given in sRGB, in order to generate images with a standard color space.

E.2 Tone Reproduction (Brightness and Contrast)

Scene reflectance can be nonlinearly converted based on ITU-R BT.709, and recorded using 8-bit quantization.

The ITU-R BT.709 transfer characteristics are as follows.

(1) When R, G, B equal or lager than 0.018

$R' = 1.099R^{0.45}-0.099$

$G' = 1.099G^{0.45}-0.099$

$B' = 1.099B^{0.45}-0.099$

(2) When R, G, B less than 0.018

$R' = 4.5R$

$G' = 4.5G$

$B' = 4.5B$

After this conversion takes place, the data are enlarged by a factor of 255 and recorded using 8-bit

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quantization.

E.3 Luminance/Chrominance and RGB Transformation

Calculation of R, G, B from luminance Y and chrominance Cb and Cr takes place as follows based on ITU-R BT.601.

Y = 0.299R + 0.587G + 0.114B

Cb = (-0.299R - 0.587G + 0.886B) * 0.564 + offset

Cr = (0.701R - 0.587G - 0.114B) * 0.713 + offset

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Appendix F Notes on Conversion to FlashPix

The data recording method in this standard makes it possible to convert from Exif to FlashPix format with no loss of image quality, and retaining all attribute information. A file that is thus designed from the start for conversion to FlashPix is called a FlashPix-Ready (FPXR) file.

There are three main FlashPix-Ready functions:

- All Exif tag information is mapped to the FlashPix Image Info Property Set,
- APP2 extended data can be converted to FlashPix extensions,
- JPEG images can be converted to the FlashPix tile structure without image quality loss, making use of restart markers.

Fig. 51 illustrates the conversion process.

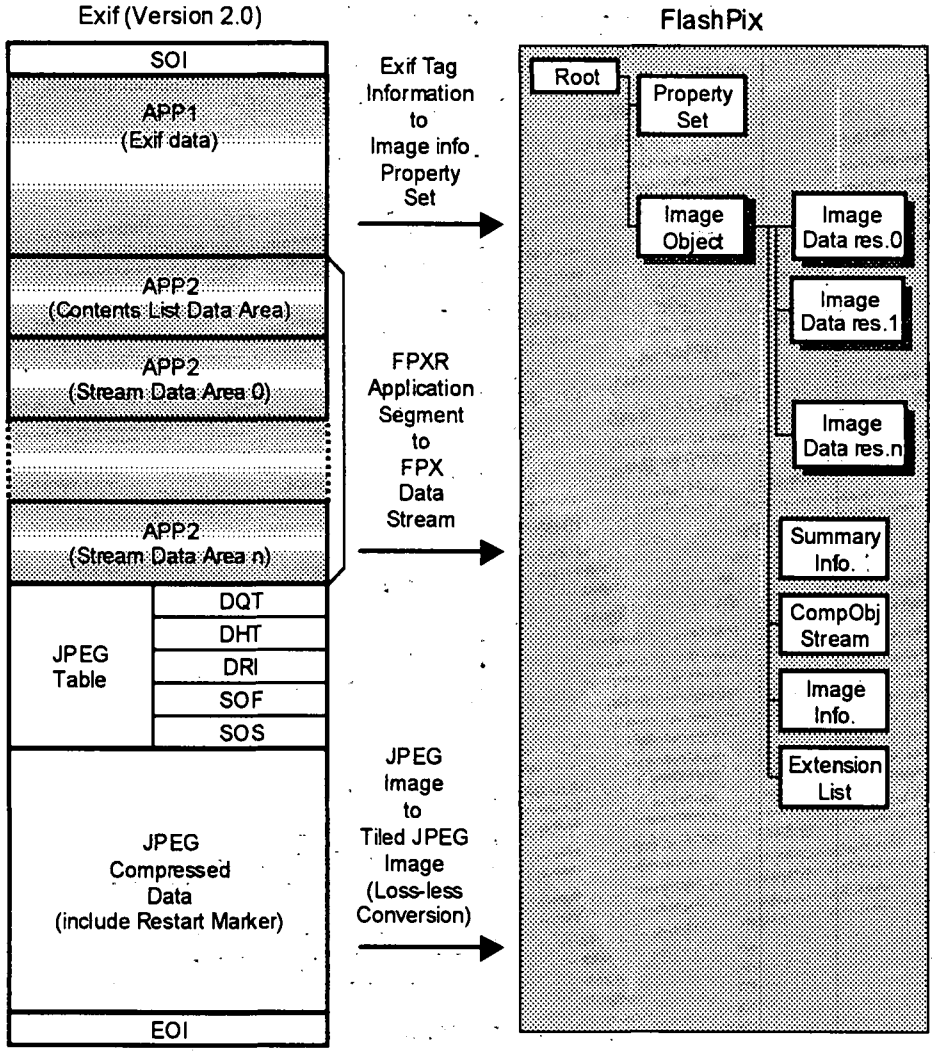


Fig. 51 Conversion from Exif to FlashPix

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F.1 Converting Image Data

FlashPix compressed image data consists of JPEG-compressed 64 x 64-pixel tiles. Converting JPEG images without restart markers to FlashPix images requires that the JPEG data be expanded and re-compressed, which can lead to image quality loss. By inserting restart markers at 64-pixel intervals, FlashPix images of the maximum resolution can be generated simply by rearranging the JPEG-compressed data.

Fig. 52 shows how compressed data is rearranged using restart markers.

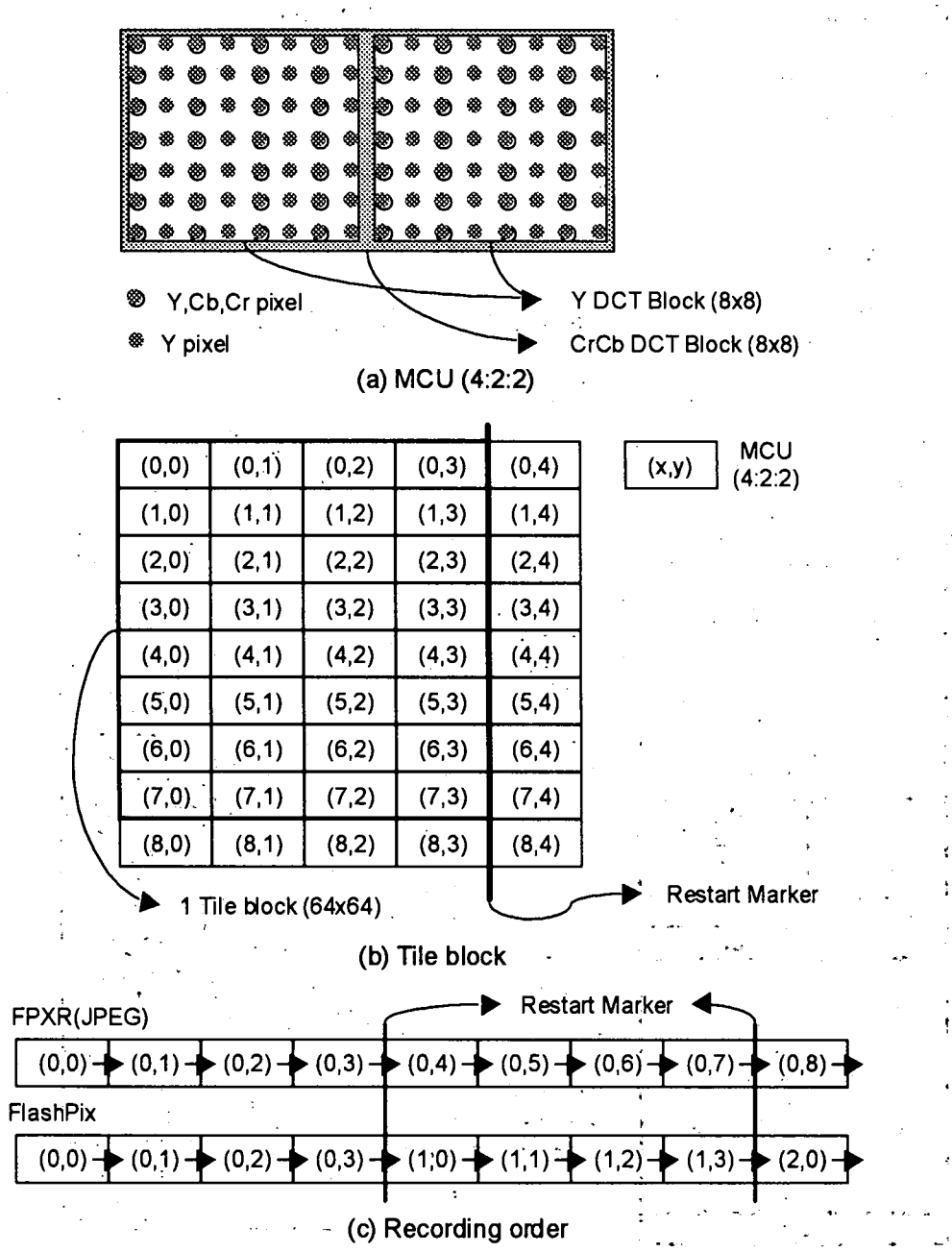


Fig. 52 Conversion to FlashPix Using Restart Markers

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Recording of restart markers is optional, and conversion to FlashPix is possible without them; but conversion without restart markers may result in some image quality loss and require a longer processing time.

In order for restart markers to be inserted at 64-pixel intervals, the image data width must be an exact multiple of 64. Therefore the valid image width is recorded as tag information (*PixelXDimension*), and the JPEG compressed data is recorded with the valid image padded to the right to make it an exact multiple of 64 (see section 2.8.1).

As in the FlashPix standard, padding is used where necessary to achieve exact multiples of 64; and when converting to FlashPix, the padding data on the right can be treated in the same way as valid image data.

If the image height is not an exact multiple of 64, Exif files are not padded; so when converting to FlashPix it is necessary to pad the bottom edge of the image.

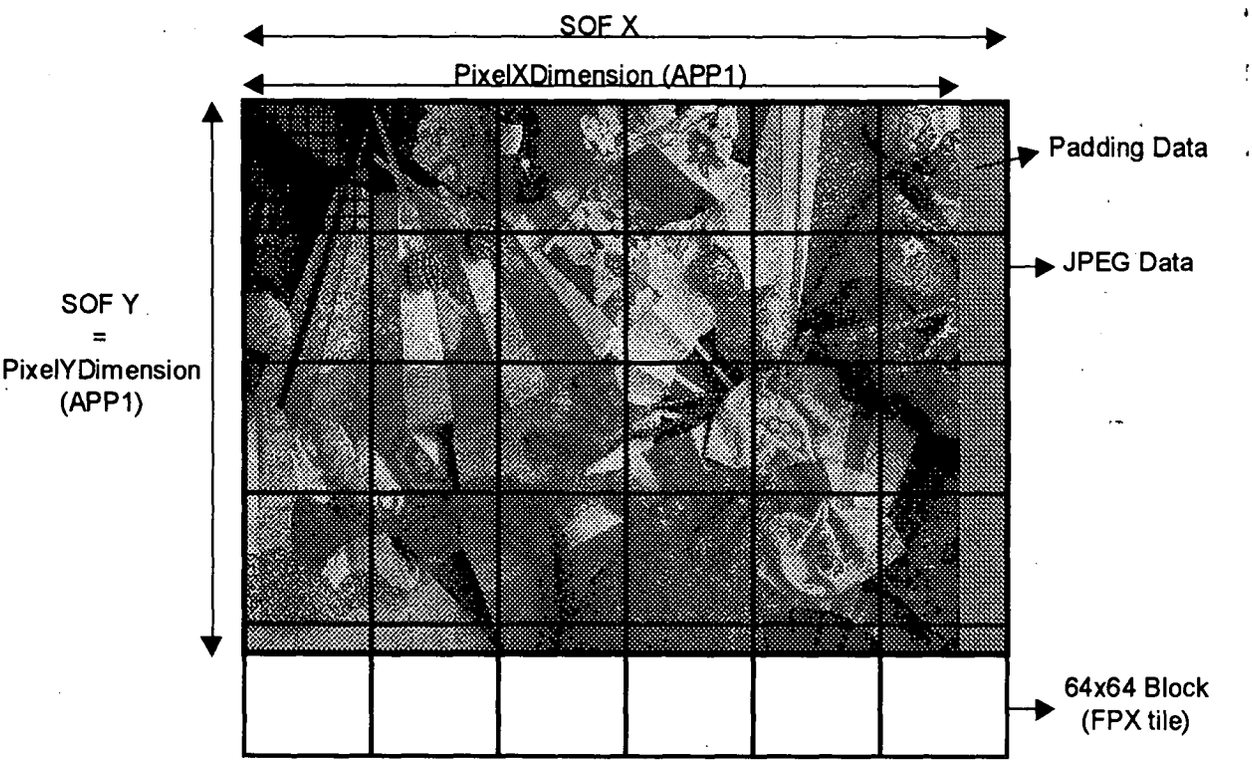


Fig. 53 Image Size Restrictions

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F.2 Converting Tag Data

When Exif attribute information is converted to FlashPix, a one-to-one conversion can be made to the Property Set used to record FlashPix attributes. The rules for converting from each kind of Exif tag to the FlashPix PropertySet are given in the tables below (conversion of GPS Info tags is to be determined later).

Table 48 Conversion between Exif Tags and FlashPix Property Set (1) (TIFF Tags)

Exif			FPX		
Field Name	Tag Code		Property Set	Group	Name
	Dec	Hex			
ImageWidth	256	100	-	-	-
ImageLength	257	101	-	-	-
BitsPerSample	258	102	-	-	-
Compression	259	103	-	-	-
PhotometricInterpretation	262	106	-	-	-
ImageDescription	270	10E	Image Info	Content Description	Caption text
Make	271	10F	Image Info	Camera Information	Camera manufacturer name
Model	272	110	Image Info	Camera Information	Camera model name
StripOffsets	273	111	-	-	-
Orientation	274	112	Transform	-	Spatial Orientation
SamplesPerPixel	277	115	-	-	-
RowsPerStrip	278	116	-	-	-
StripByteCounts	279	117	-	-	-
XResolution	282	11A	Image Contents	Primary description	Default display width
YResolution	283	11B	Image Contents	Primary description	Default display height
PlanarConfiguration	284	11C	-	-	-
ResolutionUnit	296	128	Image Contents	Primary description	Display height/width units
TransferFunction	301	12D	-	-	-
Software	305	131	Image Info	File source	Software Name
DateTime	306	132	Ignore	Ignore	Ignore
Artist	306	13B	Image Info	Intellectual Property	Authorship
WhitePoint	318	13E	-	-	-
PrimaryChromaticities	319	13F	-	-	-
YCbCrCoefficients	529	211	-	-	-
YCbCrSubSampling	530	212	-	-	-
YCbCrPositioning	531	213	Ignore	Ignore	Ignore
ReferenceBlackWhite	532	214	-	-	-
Copyright	33432	8298	Image Info	Intellectual Property	Copyright message
Exif IFD Pointer	34665	8769	-	-	-
GPS Info IFD Pointer	34853	8825	-	-	-

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Table 49 Conversion between Exif Tags and FlashPix Property Set (2) (Exif Private Tags)

Exif			FPX		
Field Name	Tag Code		Property Set	Group	Name
	Dec	Hex			
ExposureTime	33434	829A	Image Info	Per Picture Camera Setting	Exposure time
FNumber	33437	829D	Image Info	Per Picture Camera Setting	F-number
ExposureProgram	34850	8822	Image Info	Per Picture Camera Setting	Exposure program
SpectralSensitivity	34852	8824	Image Info	Digital Camera Characterization	Spectral sensitivity
ISOSpeedRatings	34855	8827	Image Info	Digital Camera Characterization	ISO speed ratings
OECF	34857	8829	Image Info	Digital Camera Characterization	OECF
ExifVersion	36864	9000	-	-	-
DateTimeOriginal	36867	9003	Image Info	Content Description	Date of the original image
			Image Info	Per Picture Camera Setting	Capture date
DateTimeDigitized	36868	9004	Summary Info	-	Create date/time
ComponentsConfiguration	37121	9101	Ignore	Ignore	Ignore
CompressedBitsPerPixel	37122	9102	Ignore	Ignore	Ignore
ShutterSpeedValue	37377	9201	Image Info	Per Picture Camera Setting	Exposure time
ApertureValue	37378	9202	Image Info	Per Picture Camera Setting	F-number
BrightnessValue	37379	9203	Image Info	Per Picture Camera Setting	Brightness value
ExposureBiasValue	37380	9204	Image Info	Per Picture Camera Setting	Exposure bias value
MaxApertureValue	37381	9205	Image Info	Per Picture Camera Setting	Maximum aperture value
SubjectDistance	37382	9206	Image Info	Per Picture Camera Setting	Subject distance
MeteringMode	37383	9207	Image Info	Per Picture Camera Setting	Metering mode
LightSource	37384	9208	Image Info	Per Picture Camera Setting	Scene illuminant
Flash	37385	9209	Image Info	Per Picture Camera Setting	Flash
			Image Info	Per Picture Camera Setting	Flash return
FocalLength	37386	920A	Image Info	Per Picture Camera Setting	Focal length
MakerNote	37500	927C	-	-	-
UserComment	37510	9286	Image Info	Content description	Content description note
SubSecTime	37520	9290	Ignore	Ignore	Ignore
SubSecTimeOriginal	37521	9291	Image Info	Content Description	Date of the original image
			Image Info	Per Picture Camera Setting	Capture date
SubSecTimeDigitized	37522	9292	Summary Info	-	Create date/time
FlashPixVersion	40960	A000	-	-	-
ColorSpace	40961	A001	Image Contents	resolution description	Subimage color
PixelXDimension	40962	A002	Image Contents	Primary description	Highest resolution width
PixelYDimension	40963	A003	Image Contents	Primary description	Highest resolution length
RelatedSoundFile	40964	A004	-	-	-
FlashEnergy	41483	A20B	Image Info	Per Picture Camera Setting	Flash Energy
SpatialFrequencyResponse	41484	A20C	Image Info	Digital Camera Characterization	Spatial frequency response
FocalplaneXResolution	41486	A20E	Image Info	Digital Camera Characterization	Focal plane X resolution
FocalplaneYResolution	41487	A20F	Image Info	Digital Camera Characterization	Focal plane Y resolution
FocalplaneResolutionUnit	41488	A210	Image Info	Digital Camera Characterization	Focal plane resolution unit
SubjectLocation	41492	A214	Image Info	Per Picture Camera Setting	Subject location
ExposureIndex	41493	A215	Image Info	Per Picture Camera Setting	Exposure index
SensingMethod	41495	A217	Image Info	Digital Camera Characterization	Sensing method
FileSource	41728	A300	Image Info	File Source	File source
SceneType	41729	A301	Image Info	File Source	Scene type
CFAPattern	41730	A302	Image Info	Digital Camera Characterization	CFA pattern

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Table 50 Conversion between Exif Tags and FlashPix Property Set (3) (GPS Info Tags)

Exif			FPX		
Field Name	Tag Code		Property Set	Group	Name
	Dec	Hex			
GPSVersionID	0	0	GPS Info extension	-	GPSVersionID
GPSLatitudeRef	1	1	GPS Info extension	-	GPSLatitudeRef
GPSLatitude	2	2	GPS Info extension	-	GPSLatitude
GPSLongitudeRef	3	3	GPS Info extension	-	GPSLongitudeRef
GPSLongitude	4	4	GPS Info extension	-	GPSLongitude
GPSAltitudeRef	5	5	GPS Info extension	-	GPSAltitudeRef
GPSAltitude	6	6	GPS Info extension	-	GPSAltitude
GPSTimeStamp	7	7	GPS Info extension	-	GPSTimeStamp
GPSSatellites	8	8	GPS Info extension	-	GPSSatellites
GPSStatus	9	9	GPS Info extension	-	GPSStatus
GPSMeasureMode	10	A	GPS Info extension	-	GPSMeasureMode
GPSDOP	11	B	GPS Info extension	-	GPSDOP
GPSSpeedRef	12	C	GPS Info extension	-	GPSSpeedRef
GPSSpeed	13	D	GPS Info extension	-	GPSSpeed
GPSTrackRef	14	E	GPS Info extension	-	GPSTrackRef
GPSTrack	15	F	GPS Info extension	-	GPSTrack
GPSImgDirectionRef	16	10	GPS Info extension	-	GPSImgDirectionRef
GPSImgDirection	17	11	GPS Info extension	-	GPSImgDirection
GPSMapDatum	18	12	GPS Info extension	-	GPSMapDatum
GPSDestLatitudeRef	19	13	GPS Info extension	-	GPSDestLatitudeRef
GPSDestLatitude	20	14	GPS Info extension	-	GPSDestLatitude
GPSDestLongitudeRef	21	15	GPS Info extension	-	GPSDestLongitudeRef
GPSDestLongitude	22	16	GPS Info extension	-	GPSDestLongitude
GPSDestBearingRef	23	17	GPS Info extension	-	GPSDestBearingRef
GPSDestBearing	24	18	GPS Info extension	-	GPSDestBearing
GPSDestDistanceRef	25	19	GPS Info extension	-	GPSDestDistanceRef
GPSDestDistance	26	1A	GPS Info extension	-	GPSDestDistance

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F.3 Converting to FlashPix Extensions (APP2)

The extended data recorded in APP2 marker segments can be converted readily to FlashPix extensions.

First of all, Fig. 54 shows the conversion process when APP2 is recorded as one entry per stream of data.

An area with data size of 8000.H, Default value 00.H is allocated to the stream name "/¥005MyPropertySet" (¥005 means 005.H) in the FlashPix file Structured Storage structure, and the stream data recorded in APP2-2 is copied to offset 00000000.H, that is, the start of the allocated area.

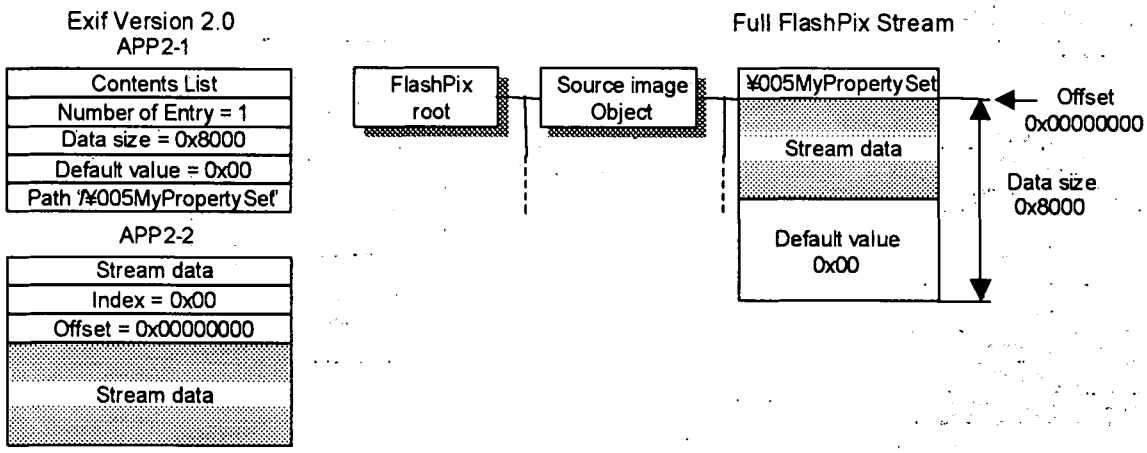


Fig. 54 Conversion to FlashPix Extensions (1)

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Next, Fig. 55 shows the conversion process when one entry per two streams of data is recorded in APP2.

This time an area with data size of 10000.H, Default value 00.H is allocated to the stream name "/¥005MyPropertySet" in the FlashPix file Structured Storage structure, and the stream data recorded in APP2-2 is copied to offset 00000000.H, that is, the start of the allocated area, while the stream data recorded in APP2-3 is copied starting from offset 00008000.H.

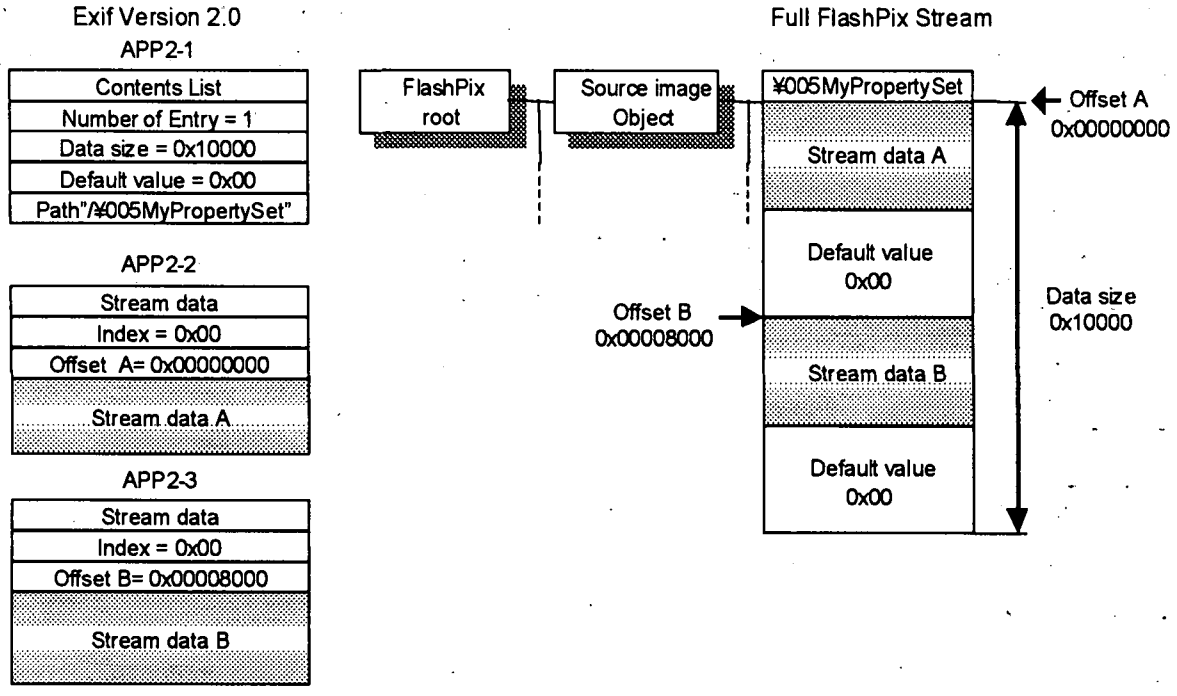


Fig. 55 Conversion to FlashPix Extensions (2)

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Finally, Fig. 56 shows an example of conversion when 2 entries per stream of data are recorded in APP2.

Here a data size of 8000.H, Default value 00.H is allocated to the stream name "MyPropertySet" under the storage name "¥005MyStorage" in the FlashPix file Structured Storage structure, and the stream data recorded in APP2-2 is copied to offset 00000000.H, that is, the start of the allocated area.

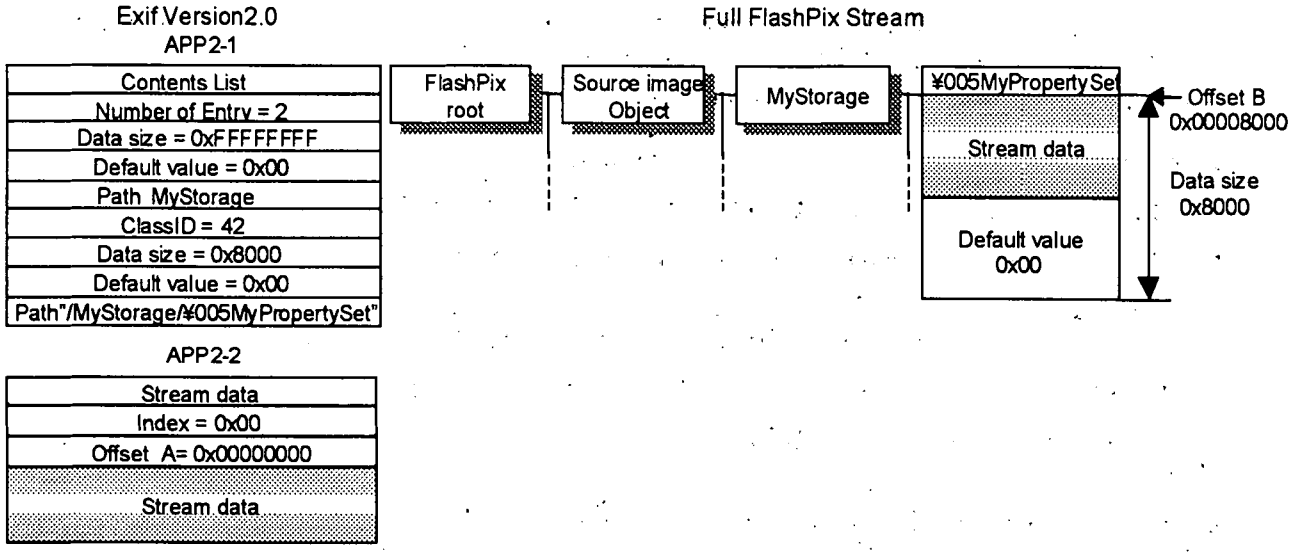


Fig. 56 Conversion to FlashPix Extensions (3)

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References

[i] Digital Still Camera Image File Format Standard (Exif) Version 1.0, October 1995, Japan Electronic Indusutry Development Association.

[ii] Digital Still Camera Image File Format Standard (Exif) Version 1.1, May 1997, Japan Electronic Indusutry Development Association.

[iii] ISO/IEC 10918-1 / ITU-T Recommendation T.81 information technology - Digital compression and coding of continuous-tone still images - Requirements and guide-lines

[iv] TIFF Revision 6.0 Final, June 3, 1992, AldusCorporation.

[v] FlashPix Format Specification Version 1.0, September 11, 1996, Eastman Kodak Compay.

[vi] New Multimedia Data Types and Data Techniques, 1996, Microsoft Corporation.

[vii] ITU-T G.711, Pulse code modulation (PCM) of Voice Frequencies.

[viii] Recommended Practices for Enhancing Digital Audio Compatibility in Multimedia Systems Revision 3.00, October 21, 1992, Interactive Multimedia Association(IMA)

[ix] JIS X 0208:1990 Code of the Japanese graphic character set for information interchange.

[x] ITU-T T.50 (09/92) International Reference Alphabet (IRA) (Formerly International Alphabet No.5 or IA5)

[xi] Unicode Standard, The Unicode Consortium, 1991, Addison-Wesley.

[xii] New Standard Practice for the Electronic Interchange of Color and Appearance Data, ASTM Techinical Committee

[xiii] ISO 12232, Photography-Electronic still picture cameras-Determination of ISO speed.

[xiv] ISO 14524, Photography-Electronic still picture cameras-Methods for measuring the opto-electronic conversion functions.

[xv] ISO 12233, Photography-Electronic still picture cameras-Resolution measure-ments.

[xvi] IMA Digital Audio Doc-Pac, 1992, Interactive Multimedia Association

[xvii] IEC TC100, 100/43/NP: Colour measurement and management in multimedia systems and equipment, Part 2.1 of the approved project 61966: Colour management in multimedia systems - Default RGB colour space - sRGB (Under discussion)

[xviii] ITU-R BT.709, Basic Parameter Values for the HDTV Standard for the Studio and for International Programme Exchange.

[xix] ITU-R.BT.601, Encoding Parameters of Digital Television for Studios.

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Exif SUB WG

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	Hiroshi Suzuki	Japan Electronic Industry Development Association

JEIDA規格

ディジタルスチルカメラ用画像ファイル フォーマット規格 (Exif) Version2.0 日本語版

JEIDA-49-1997

社団法人 日本電子工業振興協会

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規格改訂について

ディジタルスチルカメラおよびこれに関連するシステムで利用される画像ファイルフォーマットとして「ディジタルスチルカメラ用画像ファイルフォーマット規格 Version 1.0 、平成 7 年 10 月」[i]（以下 Exif Version 1.0）が規格として発行されている。また、平成 9 年 5 月には、Version 1.0 の必須規定は踏襲し、オプションの付属情報の追加とともにフォーマット運用に関する規程を追加した Version1.1[ii]が規格として発行された。

ディジタルスチルカメラは近年急速な普及が進んでおり、記録される画像データファイルの規格を統一することへの要求が高まっている。また用途の広がりにより、ファイルに記録できる付属情報に関する要望も出ている。

今回、Exif を実際に製品に応用しているメーカおよび今後製品への応用を検討しているメーカ間で Exif Version 1.x とのバックワード互換性を考慮しながら改良を加え、より使いやすくしたものが Exif Version 2.0 である。

Version 1.1 から Version 2.0 への改訂において、追加・変更した内容は次の通り。

［追加点］

- 音声ファイル規定の追加
- 圧縮サムネイル規定の追加
- 色差サンプリング方式 4:2:0 の追加
- FlashPix 変換用タグの追加
- 各種撮影情報タグの追加
- FlashPix 拡張データ用に APP2 マーカセグメント規定の追加
- 色空間情報の定義

［変更点］

- 「Exif ファイル規定」と「運用規定（Exif-1）」の 2 章構成を一本化
- 圧縮ファイルにおける画素数の制限（8,16 の倍数）を撤廃し運用範囲を拡大

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1. 概要

1.1. 目的

急速な普及発展が見られるパーソナル・コンピュータ（以下 PC）など情報インフラの動向をふまえ、PC カード等の着脱型メモリを記録媒体としたディジタルスチルカメラ（以下 DSC）およびその関連機器にて記録される画像ファイルを規定することで、データの互換性、交換性を確保し、多くのユーザにとって使いやすい環境を提供することを目的とする。

1.2. 適用範囲と規格の略称

本規格は、DSC およびその関連機器において、PC カード等の着脱可能なメモリ（Removable Memory）に記録される画像ファイルに対して適用される。本規格の略称を Exif （Exchangeable image file format）とする。

注意：本規格は、略称である"Exif"の商標使用権等について保証するものではない。

1.3. 規格の構成と特長

本規格は、「Exif 画像ファイル規定」「Exif 音声ファイル規定」から構成される（Fig. 1 参照）。記録媒体についての仕様は、使用する記録媒体それぞれの規格に沿うものとし、ここでは規定しない。ただし、ディレクトリ、ファイル名に関する推奨運用例を付録 Dに示す。

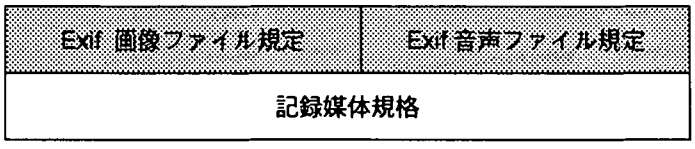


Fig. 1 フォーマット構造

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1.4. Exif 画像ファイル規定

「Exif 画像ファイル規定」はファイルの記録方法に関する規定であり、次の項目についての規定が記載されている。

- ファイルのデータ構造
- 使用するタグ
- フォーマット・バージョンの定義

「Exif 画像ファイル規定」は次のような特長をもつ。

ファイルの記録形式は、既存のフォーマットをベースとする。圧縮ファイルは JPEG（ISO/IEC 10918-1[iii]）にアプリケーション・マーカセグメント（APP1、APP2）を挿入記録し、非圧縮ファイルは TIFF Rev.6.0[iv]で記録する。これは、機器で記録したファイルを市販のアプリケーションで直接読め、表示や加工などの機能を利用できるというメリットを重視したためである。

関連する付属情報は、圧縮ファイル、非圧縮ファイルともに TIFF Rev.6.0 で定義されているタグ情報の形式で記録する。また、TIFF では定義されていない DSC 固有の付属情報は、Exif 専用に登録したプライベートタグに記載する。さらに、Exif 画像ファイル規定ではサムネイル記録の方法を規定する。圧縮ファイルの APP1 内において TIFF Rev.6.0 のタグ形式を使用するのは、Exif の圧縮ファイルと非圧縮ファイル間の付属情報データの交換を容易にするためである。

圧縮ファイルは、64kByte を越える拡張データを複数の APP2 に分割して記録することが可能である。APP2 は、FlashPix[v]の拡張データを記録するために用いる。

Exif 画像ファイルは、PC 等の情報インフラを活用できるように、広く普及している汎用フォーマットとの互換性を持たせていることが特長であり、これにより DSC の普及を促進することがねらいである。

「Exif 画像ファイル規定」の詳細については、本規格資料第2章に記載する。

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1.5. Exif 音声ファイル規定

「Exif 音声ファイル規定」は音声ファイルの記録方法に関する規定であり、次の項目についての規定が記載されている。

- ファイルのデータ構造
- 使用するチャンク
- フォーマット・バージョンの定義

「Exif 音声ファイル規定」は次のような特長をもつ。

ファイルの記録形式は、既存の RIFF WAVE Form Audio File フォーマット[vi]を利用する。また、データの形式は、非圧縮音声データは PCM 及び μ-Law PCM（ITU-T G.711[vii]準拠）、圧縮音声データは IMA-ADPCM[viii]を採用する。これは、画像ファイル規定と同様に、機器で記録したファイルを市販のアプリケーションで直接読め、再生や加工などの機能を利用できるというメリットを重視したためである。

関連する付属情報は、一般の付属情報を INFO リストに、Exif 固有の付属情報を Exif 固有のチャンクに記録する。Exif 固有のチャンクは、チャンクの拡張性を利用して必要な情報を追加できるように新設する。Exif 固有のチャンクのデータ記載方法は INFO リストに倣っている。

Exif 音声ファイルも画像ファイルと同様、PC 等の情報インフラを活用できるように、広く普及している汎用フォーマットとの互換性を持たせていることが特長であり、これにより DSC の普及を促進することがねらいである。

「Exif 音声ファイル規定」の詳細については、本規格資料第3章に記載する。

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1.6. 画像ファイル規定と音声ファイル規定について

本規格では、画像ファイルのフォーマットに関する規定の他に、付加機能として音声を記録することも可能なように、音声ファイルフォーマットを規定する。

本規格では、画像ファイルと音声ファイルの関連を示す関連情報についても規定する。

画像ファイルと音声ファイルの関連づけの方法には様々なパターンがあるが、本規格では最も単純な関連付けについてのみ規定し、その他については個別の運用に任せることとする。

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1.7. システムと互換性

下記の三つの要素からなる画像システムを想定している。

- 機器　　：画像関連機器（カメラ、プリンタ、ファイル装置など）
- 市販ソフトウェア　：PC 上で動作する市販の画像ソフトウェア
- 専用ソフトウェア　：PC 上で動作する機器専用の画像ソフトウェア

このシステムにおける画像ファイルの互換性は次のように確保される。DSC などの記録機器は、本規格にて定義される形式に沿ってファイルを書く。また再生機能を備える機器の場合は、少なくとも機器自身で記録したファイルを読めることを基本条件とする。一方、PC の環境においては、専用ソフトウェアは、本規格に沿って記録されたすべてのファイルの画像、音声及びその付属情報を読めることを基本条件とする（Fig. 2 参照)。

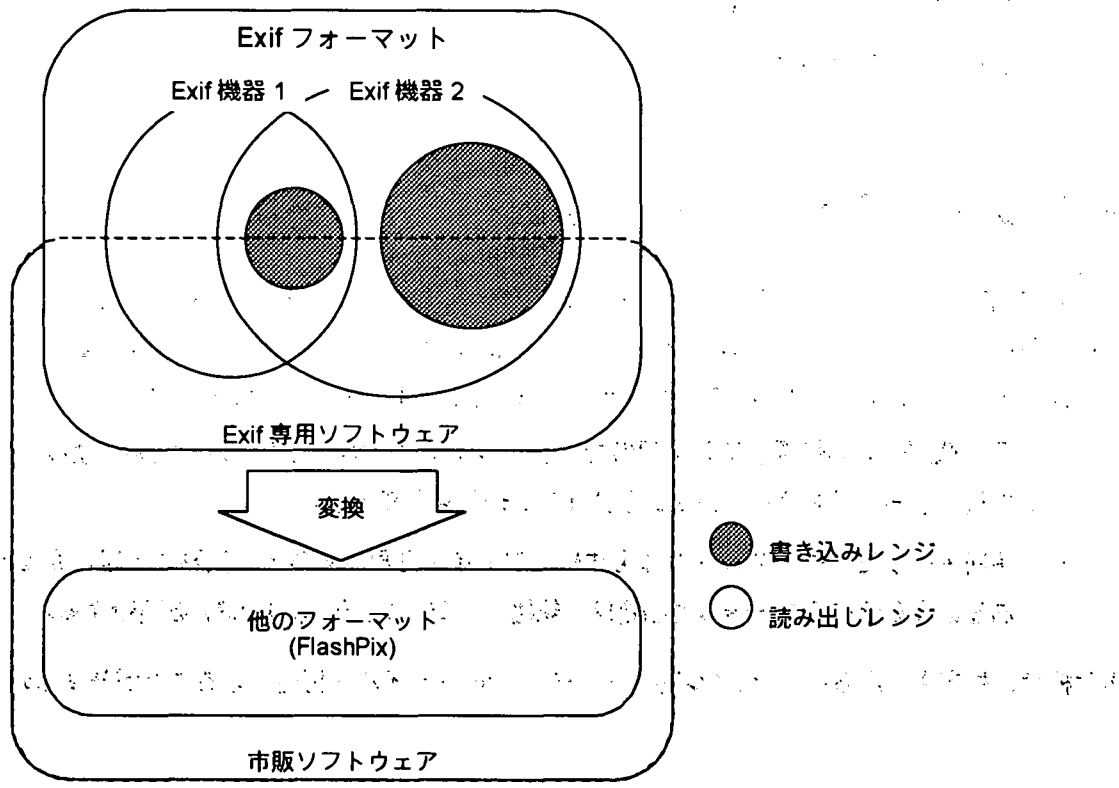


Fig. 2 互換性の概念

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2. Exif 画像ファイル規定

2.1. Exif 画像ファイル規定の概要

本章では、画像ファイルの記録方法を規定し、以下の項目について記載する。

- フォーマットバージョンの定義
- 画像データに関する規定
- 画像データの基本構造
- 使用するタグ
- 使用する JPEG マーカセグメント
- データの記載に関する規定

2.2. フォーマットバージョン

本規格で規定するフォーマットのバージョンは 4Byte で記述する（2.6.5章参照)。記録するアドレスの若い方から各バイトを、A1, A2, B1, B2 とし、A1, A2 を規格バージョン上位 、 B1, B2 を規格バージョン下位とする。今後本規格のバージョンを更新する場合は、以下の基準で実施する。

- 再生機が従来の情報を正しく認識でき、かつ新たに追加した書き方や情報を読み飛ばすことが期待できる時は規格バージョン下位（B1, B2）を更新する。
- 更新前の規格に従って動作する再生機でファイルを再生すると、誤動作を起こさせる可能性があるような仕様変更を伴った場合は、規格バージョン上位（A1, A2）を更新する。

再生機は、対応する規格バージョン以前のバージョンのファイルを再生できることが望ましい。

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2.3. 用語の定義

本規格では、以下のように定義している。

- 「タグ」を「フィールド」と同義語として用いている。
- 後尾に"H"が付加されている数値は16進数を意味している。
- その他特に記載がない場合は10進数を意味している。
- ファイル上で最初に記載される IFD は「0th IFD」、それに続く IFD は「1st IFD」と呼ぶ。
- 主たるデータとして記録する画像を「主画像」と呼び、その見出し用小画像を「サムネイル」と呼ぶ。
- JPEG 規格における「エントロピー符号化データ」を本規格では「圧縮データ」と呼ぶ。

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2.4. 画像データに関する規定

2.4.1. 画素数

主画像は、非圧縮データまたはJPEG圧縮データとして記録する場合、ともに画素数の制限を受けない。ただし、Number of lines (ImageLength)、Number of samples / line (ImageWidth) が8または16の倍数でない画像をJPEG圧縮データとして記録する場合の記録方法を2.8.1章にて規定する。以上の規定は、サムネイルについても同様に規定する。

2.4.2. 画素アスペクト

記録する画像データは、画素アスペクト比 1:1 の正方画素とする。以上の規定は、サムネイルについても同様に規定する。

2.4.3. 構成要素と画素サンプリング

画素データの構成要素と画素サンプリングの組み合わせは、必ず RGB 4:4:4、YCbCr4:2:2 または YCbCr4:2:0 のいずれかでなければならない。また、画像データの構成要素は各々 8bit でなければならない。以上の規定は、サムネイルについても同様に規定する。

画素を構成する要素のサンプル点は Y と CbCr サンプリング点の一致・中心を許す。画像の幅 w、高さ h 画素サンプリング例をFig. 3 に示す。YCbCr 4:2:2 の場合は、TV 系における再生画質改善のために空間的に一致とすることを推奨する。YCbCr 4:2:0 の場合は、PC 上のアプリケーションで最も多く使われ、また、TIFF のデフォルトでもある空間的に中心とすることを推奨する。

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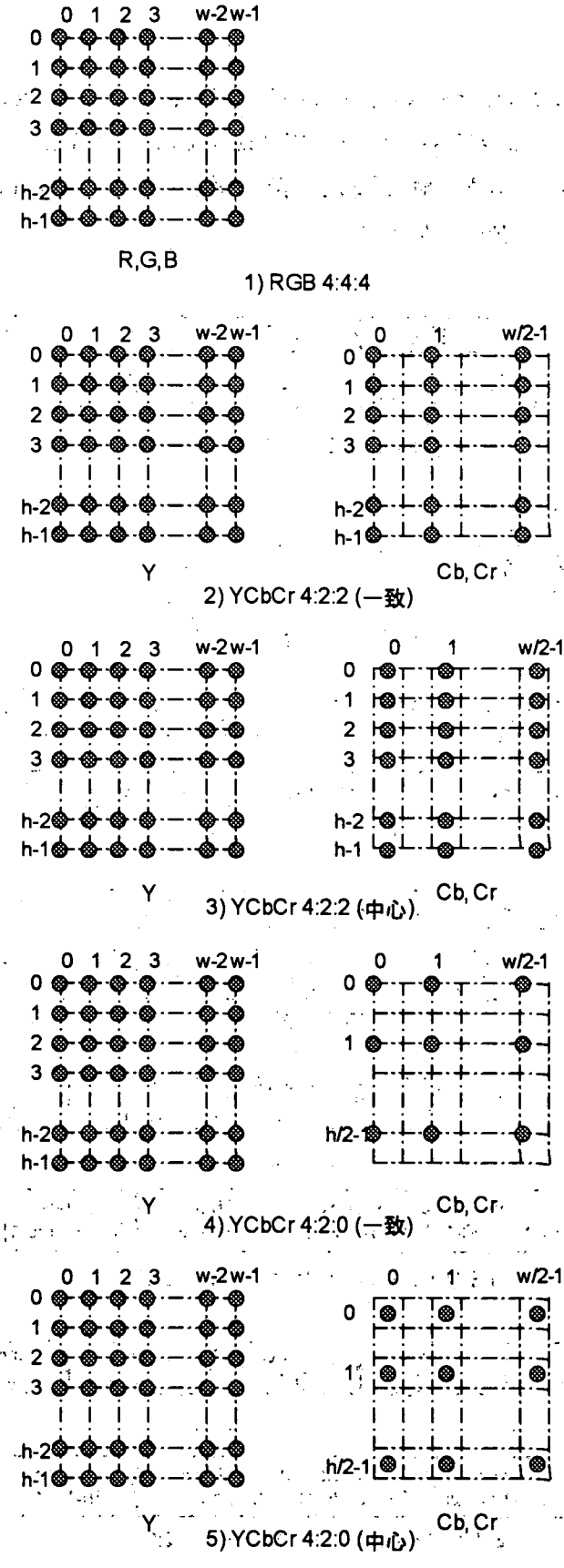


Fig. 3 構成要素と画素サンプリング

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2.4.4. データの並び

画像データの並びは以下でなければならない。非圧縮データは、1 ラインは左から右に走査された画素で構成され、1 画面は上から下に走査されたラインで構成される。JPEG 圧縮データは、ブロックを単位として同様な順序で走査された画素で構成される。画像の幅 w 画素、高さ h 画素としたときにファイルに記録する各種データの並びをFig. 4 に示す。



Fig. 4 データの並び

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2.5. 画像データの基本構造

2.5.1. 主画像データの基本構造

本規格では、画像データの形式に応じて次のような既存の画像フォーマットで記載する。

- RGB 非圧縮データ　　: Baseline TIFF Rev.6.0 RGB Full Color Images [iv]
- YCbCr 非圧縮データ　　: TIFF Rev.6.0 Extensions YCbCr Images [iv]
- JPEG 圧縮データ　　: JPEG Baseline ADCT [iii]

圧縮データの場合は、DSC アプリケーションで必要とされる付属情報を APP1 へ記録する。APP1 内部のデータの記載は TIFF に倣っている。これは、圧縮データと非圧縮データで付属情報の記述を共通化することによりフォーマットの簡素化をはかれること、また必要な情報をプライベートタグに追加できるというタグの拡張性を利用することがねらいである。

2.5.2. RGB 非圧縮データの基本構造

RGB 非圧縮データは、「Baseline TIFF Rev.6.0 RGB Full Color Images [iv]」に準拠して記載する。

付属情報は、TIFF Rev.6.0 にて定められたタグで記載する。Exif 固有の付属情報は、本規格用として TIFF で予約されたプライベートタグを用いて記載する。このプライベートタグは、これら付属情報の集まり（Exif IFD）を指す。

ファイルは以下の構成とする（Fig. 5 参照）。TIFF 規格と同様、各 IFD の Value の記録位置については規定しない。

- File Header
- 0th IFD
- 0th IFD の Value
- 1st IFD
- 1st IFD の Value
- 1st （thumbnail） Image Data
- 0th （primary） Image Data

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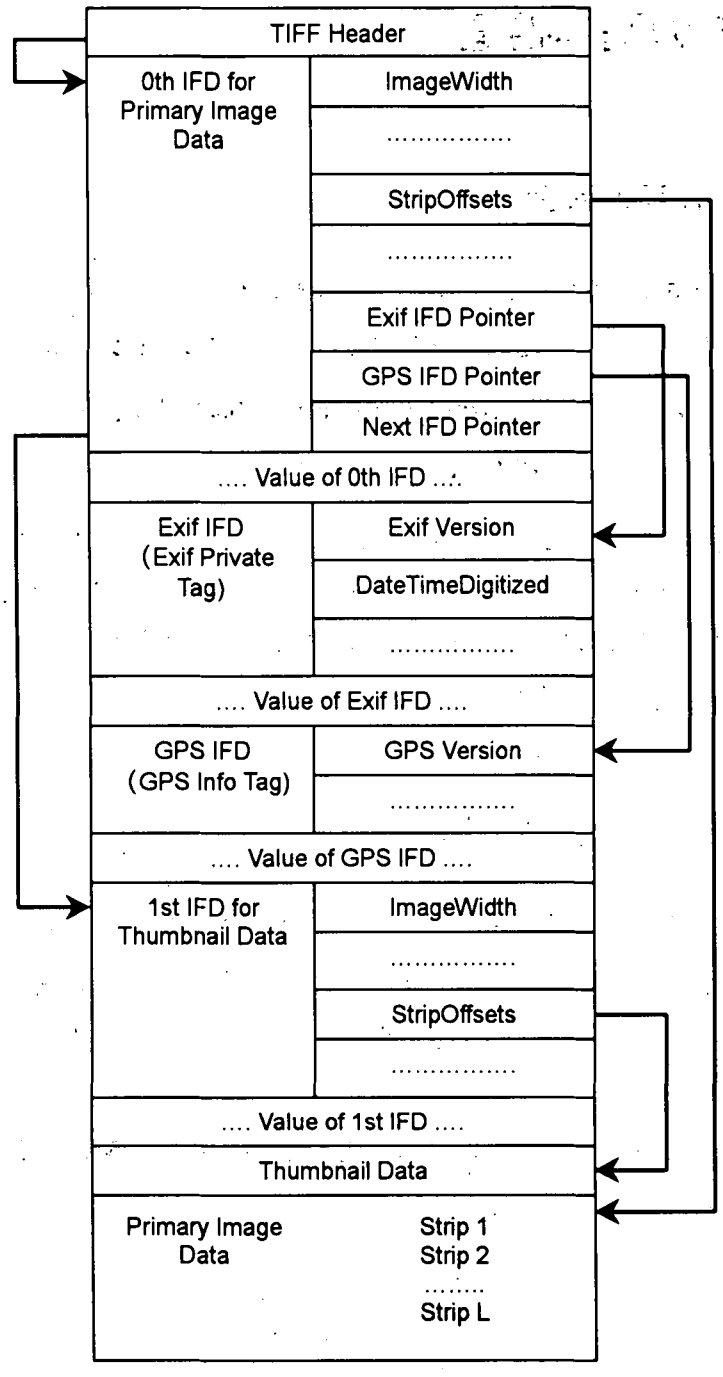


Fig. 5 非圧縮データファイルの基本構造

File Header は、TIFF 規格に定義されている 8byte であり、Offset of IFD は 0th IFD の先頭アドレスを指している（Table 1 参照）。

0th IFD の Offset of Next IFD は、1st IFD（サムネイル画像）の先頭番地を指す。1st IFD を記録しない場合は、0th IFD の Offset of Next IFD は 00000000.H で終端する。

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IFD の記載方法は、2.6.2章を参照のこと。

Table 1 TIFF のヘッダ

Name	Size （Byte）	Value
Byte Order	2	記録するマシンの CPU に合わせて、"II"（4949.H）（リトルエンディアン形式）、または"MM"（4D4D.H）（ビッグエンディアン形式）を書く。
42	2	002A.H（固定）
Offset of IFD	4	0th IFD へのオフセット。TIFF ヘッダの直後に 0th IFD が続く場合には 00000008.H と記載する。

2.5.3. YCbCr 非圧縮データの基本構造

YCbCr 非圧縮データは、「TIFF Rev.6.0 Extensions YCbCr Images [iv]」に準拠して記載する。YCbCr 非圧縮データでは、RGB 非圧縮データの付属情報の他に次の情報を記載するタグが用意されている。

- RGB-YCbCr の色変換マトリクス係数（YCbCrCoefficients）
- 色差のサブサンプル情報（YCbCrSubSampling）
- 色差と輝度サンプルの一致／不一致情報（YCbCrPositioning）

その他の付属情報の記載方法については、RGB 非圧縮データと同様である（2.5.2章参照）。

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2.5.4. JPEG 圧縮データの基本構造

圧縮データファイルは、「ISO/IEC 10918-1 [iii]」に規定される JPEG Baseline DCT フォーマットに準拠して記録し、これにアプリケーション・マーカセグメント（APP1）を挿入する。APP1 はファイルの始まりを示す SOI マーカの直後に記載することとする（Fig. 6 参照)。APP2 は必要に応じて複数個連続して記録し、記録位置は APP1 の直後からとする。Exif 規格では APP1、APP2 以外の APPn マーカ、COM マーカは使用しないが、Exif リーダーは Exif にて未定義のマーカは読み飛ばすことを推奨する。

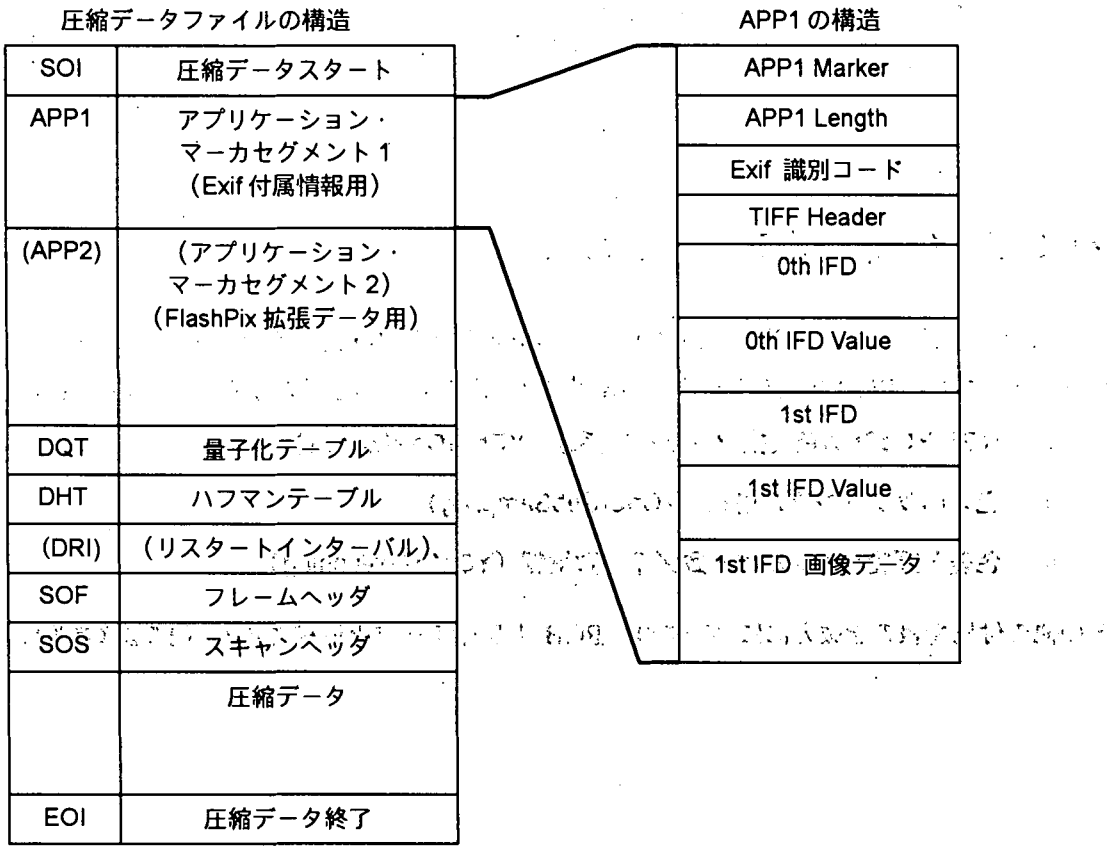


Fig. 6 圧縮データファイルの基本構造

APP1 の内部は、APP1 マーカ、Exif の識別コード、および付属情報本体から構成される。これら全てを含む APP1 の大きさは、JPEG の規格により 64kByte を越えてはならない。

付属情報は File Header を含む TIFF の構造をとり、最大二つの IFD （0th IFD, 1st IFD） を記録できる。0th IFD には、圧縮されている画像（主画像）に関する付属情報を記録する。1st IFD には、サムネイル画像を記録することができる。詳細は、2.7.2 章を参照のこと。

APP2 の内部は、APP2 マーカ、FPXR（FlashPix Ready）の識別コード、および FlashPix 用拡張データ記録のためのコンテンツ・リストまたはストリーム・データから構成される。64kByte を越えるデータを記録する際に、APP2 は複数個を連続して記録する。詳細は 2.7.3 章を参照のこと。

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2.5.5. サムネイルデータの基本構造

サムネイルデータも主画像と同じ2つの既存画像フォーマットで 1st IFD に記載する。

サムネイルの画像サイズに制限はない。サムネイルは記録しなくても良いが、ハードウェア等の制限がない場合は、できるかぎり記録することを推奨する。

サムネイルデータは、主画像のデータ構造と必ずしも同一のデータ構造を取る必要はない。なお、主画像が RGB 非圧縮データもしくは YCbCr 非圧縮データの場合は、サムネイルは JPEG 圧縮では記録できない (Table 2 参照)。

Table 2 主画像とサムネイルの対応

		主画像	
		非圧縮	圧縮
サムネイル	非圧縮	○	○
	圧縮	×	○

○：本規格で記録可能
×：〃　記録不可

非圧縮形式のサムネイルを記録する場合は、「Baseline TIFF Rev.6.0 RGB Full Color Images」または「TIFF Rev.6.0 Extensions YCbCr Images」に従って 1st IFD に記録する。

圧縮形式のサムネイルを記録する場合は、Exif 固有の記録方法を採る。

Compression タグに "6" をセットし、1st IFD 中のタグ（JPEGInterchangeFormat、JPEGInterchangeFormatLength）によって位置とサイズを指定する。指定された位置に JPEG Baseline DCT フォーマットに準拠する JPEG ストリーム（SOI から EOI まで）の形式で記録する。JPEG ストリーム中に APPn マーカ、COM マーカ、リスタートマーカは記録しない（Fig. 7参照)。また、TIFF の画像を指すタグおよび JPEG マーカ・セグメントとして別途記載されている情報については、二重定義をさけるため 1st IFD には記載しない。

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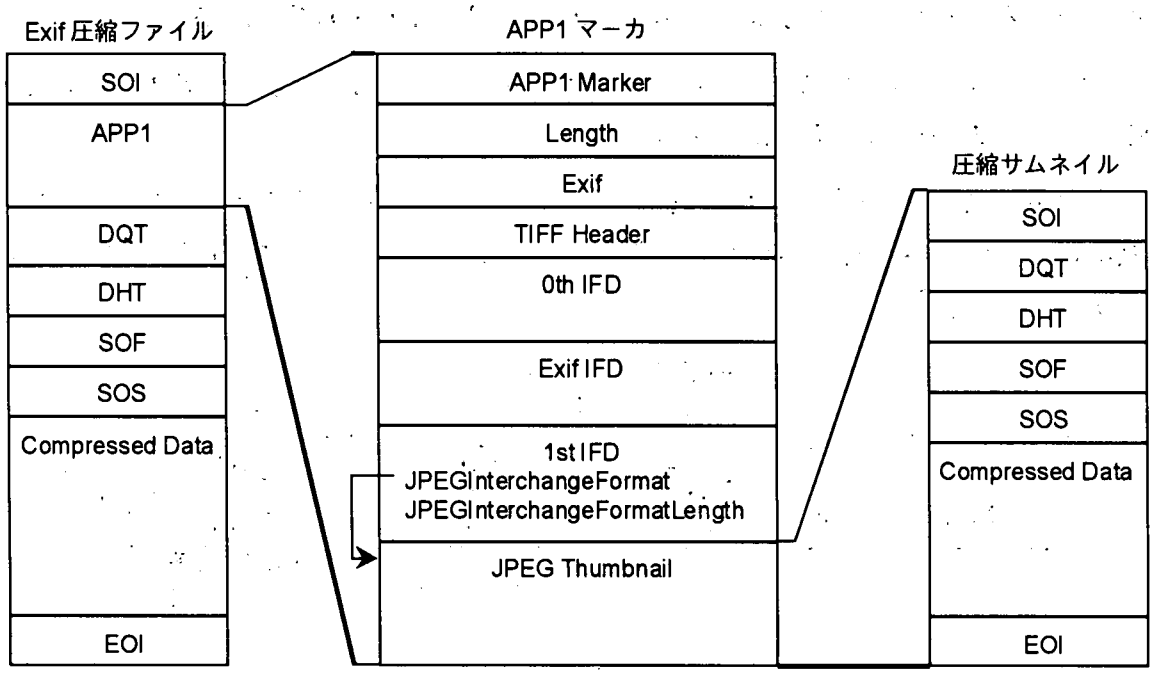


Fig. 7 圧縮サムネイルを持つ Exif ファイルの構造

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2.6. 使用するタグ

2.6.1.付属情報の特長

RGB データは Baseline TIFF Rev.6.0 RGB Full Color Images に、YCbCr データは TIFF Rev.6.0 Extensions YCbCr Images にそれぞれ準拠している。したがって、TIFF 構造に倣っている部分の記載は TIFF 規格に従わなければならない。これらの標準において必須とされる付属情報に加えて、本規格では DSC などのシステムで利用できる TIFF のオプションタグと、DSC 固有の付属情報を記録するための固有タグ、位置情報を記録するための GPS タグを追加する。また、サムネイルの圧縮記録については、TIFF 規格には無い Exif 特有の規定を定める。

圧縮データを記録する場合は、以下の点で非圧縮データと異なる。

- 主画像データを圧縮記録する場合、主画像本体、及びそのアドレス（ポインタ）を示すタグはない。
- サムネイルデータを圧縮記録する場合、固有のタグを用いてアドレスとサイズを指定する。
- JPEG Baseline に定められている情報と重複するタグは記載しない（主画像、サムネイル共通）
- 所定のタグを用いて、圧縮に関連する情報を記載できる。

2.6.2. IFD の構造

本規格で用いる IFD は TIFF Revision6.0 に従い、2 バイトのカウント（フィールドの数）、12 バイト単位のフィールドエントリ列、そして 4 バイトの次の IFD へのオフセットで構成する。

12 バイトの各々のフィールドエントリは、次の 4 つの要素で構成する。

0-1 バイト　タグ（Tag）
2-3 バイト　タイプ（Type）
4-7 バイト　カウント（Count）
8-11 バイト　値へのオフセット（Value Offset）

以下にそれぞれの要素の説明を簡単に行う。詳細については、TIFF Revision 6.0 を参照のこと。

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タグ（Tag）

フィールドを識別するため、各タグには2バイトの固有の番号が振られている。Exifの0th IFD、1st IFDのタグ番号は、すべてTIFFのタグ番号と共通である。

タイプ（Type）

Exifで用いるタイプは以下の通りである。

1 = BYTE	8ビット符号無し整数。
2 = ASCII	一つの7ビットASCIIコードを納めた8ビットバイト。最後のバイトはNULLで終端する。ASCIIのカウントはNULLも含めた値とする。
3 = SHOT	16ビット（2バイト）符号無し整数。
4 = LONG	32ビット（4バイト）符号無し整数。
5 = RATIONAL	LONG2個。最初のLONGは分子、2個目のLONGは分母を表す。
7 = UNDEFINED	フィールドの定義により、どんな値をとっても良い8ビットバイト。
9 = SLONG	32ビット（4バイト）符号付き整数（2の補数表現）。
10 = SRATIONAL	SLONG2個。最初のSLONGは分子、2個目のSLONGは分母を表す。

カウント（Count）

値の個数。カウントはバイト数の合計ではないので注意が必要である。たとえばSHORT（16ビット）の値ひとつの場合には、2バイトであるがカウントは'1'である。

値へのオフセット（Value Offset）

TIFFヘッダの先頭から値本体の記録位置へのオフセットを記録する。ただし、値が4バイトに納まる場合には、値そのものを記録する。値が4バイトより小さいときは、4バイトのエリアに左詰で、つまりバイトオフセットの小さい領域から値を納める。たとえば、ビッグエンディアン形式でタイプがSHORT、値が1の場合には、00010000.Hを記録する。

なお、フィールドエントリは、タグ番号の小さいものから順番に並べて記録しなければならない。タグの値（Value）の記録順序、記録位置については特に規定しない。

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2.6.3. Exif 固有の IFD

A. Exif IFD

Exif IFD は、Exif 固有の付属情報を記載するためのタグの集まりであり、Exif プライベートタグの値で示される TIFF ヘッダからのオフセット（Value Offset）でポイントされる。

Exif IFD へのポインタ ***Exif IFD Pointer***

Tag = 34665 (8769.H)
Type = LONG
Count = 1
Default =なし

Exif IFD の内部は、TIFF で定められる IFD 構造と同様である。ただし、通常の TIFF のように画像データを持たないのが特長である。

B. GPS IFD

GPS IFD は、GPS 情報を記載するためのタグの集まりであり、GPS プライベートタグの値で示される TIFF ヘッダからオフセット（Value Offset）でポイントされる。

GPS IFD へのポインタ ***GPS Info IFD Pointer***

Tag = 34853 (8825.H)
Type = LONG
Count = 1
Default =なし

GPS Info IFD の内部構造は、Exif IFD と同様に、画像データを持たない。

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2.6.4. TIFF Rev.6.0 の付属情報

Exif で用いられる「Baseline TIFF Rev.6.0 RGB Full Color Images」および「TIFF Rev.6.0 Extensions YCbCr Images」において必須とされる付属情報と DSC 他のシステムで利用できる TIFF のオプションタグ一覧は Table 3 のとおりである。これらの内容について以下に説明する。

Table 3　Exif で用いる TIFF Rev.6.0 の付属情報一覧

分類	タグ名称	Field Name	タグ番号 Dec	タグ番号 Hex	タイプ	カウント
A.画像データの構成に関するタグ						
	画像の幅	ImageWidth	256	100	SHORT or LONG	1
	画像の高さ	ImageLength	257	101	SHORT or LONG	1
	画像のビットの深さ	BitsPerSample	258	102	SHORT	3
	圧縮の種類	Compression	259	103	SHORT	1
	画素構成	PhotometricInterpretation	262	106	SHORT	1
	画像方向	Orientation	274	112	SHORT	1
	コンポーネント数	SamplesPerPixel	277	115	SHORT	1
	画像データの並び	PlanarConfiguration	284	11C	SHORT	1
	YCC の画素構成（C の間引き率	YCbCrSubSampling	530	212	SHORT	2
	YCC の画素構成（Y と C の位置	YCbCrPositioning	531	213	SHORT	1
	画像の幅の解像度	XResolution	282	11A	RATIONAL	1
	画像の高さの解像度	YResolution	283	11B	RATIONAL	1
	画像の幅と高さの解像度の単位	ResolutionUnit	296	128	SHORT	1
B. 画像の記録位置に関するタグ						
	画像データのロケーション	StripOffsets	273	111	SHORT or LONG	*S
	ストリップ中のライン数	RowsPerStrip	278	116	SHORT or LONG	1
	ストリップのデータ量	StripByteCounts	279	117	SHORT or LONG	*S
	JPEG の SOI へのオフセット	JPEGInterchangeFormat	513	201	LONG	1
	JPEG データのバイト数	JPEGInterchangeFormatLength	514	202	LONG	1
C. 画像データの特性に関するタグ						
	再生階調カーブ特性	TransferFunction	301	12D	SHORT	3 * 256
	参照白色点の色度座標値	WhitePoint	318	13E	RATIONAL	2
	原色の色度座標値	PrimaryChromaticities	319	13F	RATIONAL	6
	色変換マトリクス係数	YCbCrCoefficients	529	211	RATIONAL	3
	参照黒色点値と参照白色点値	ReferenceBlackWhite	532	214	RATIONAL	6
D. その他のタグ						
	ファイル変更日時	DateTime	306	132	ASCII	20
	画像タイトル	ImageDescription	270	10E	ASCII	Any
	画像入力機器のメーカー名	Make	271	10F	ASCII	Any
	画像入力機器のモデル名	Model	272	110	ASCII	Any
	使用ソフトウェア名	Software	305	131	ASCII	Any
	作者名	Artist	315	13B	ASCII	Any
	撮影著作権者/編集著作権者	Copyright	3432	8298	ASCII	Any

*S　　点順次：　StripPerImage

面順次：　SamplePerImage × StripPerImage

StripsPerImage = floor（(ImageLength + RowPerStrip -1）/ RowPerStrip）

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A. 画像データの構成に関するタグ

画像の幅 *ImageWidth*

画像データの列の数、即ち行中の画素の数。JPEG 圧縮データでは JPEG マーカで代用されるので書かない。

Tag = 256 (100.H)
Type = SHORT or LONG
Count = 1
Default = なし

画像の高さ *ImageLength*

画像データの行の数。JPEG 圧縮データでは JPEG マーカで代用されるので書かない。

Tag = 257 (101.H)
Type = SHORT or LONG
Count = 1
Default = なし

画素のビットの深さ *BitsPerSample*

1 コンポーネント当たりのビット数。本規格では画像の各コンポーネントは 8bit なので 8 が書かれる。SamplesPerPixel も参照されたい。JPEG 圧縮データでは JPEG マーカで代用されるので書かない。

Tag = 258 (102.H)
Type = SHORT
Count = 3
Default = 8

圧縮の種類 *Compression*

その画像データに使用された圧縮方法。主画像が JPEG 圧縮データでは不要なため記録しない。サムネイルが JPEG 圧縮データの場合は 6 を記録する。

Tag = 259 (103.H)
Type = SHORT
Count = 1
Default = なし
1 = 非圧縮
6 = JPEG 圧縮（サムネイルのみ）
その他 = 予約

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画素構成 *PhotometricInterpretation*

画素の構成。JPEG 圧縮データでは JPEG マーカで代用されるので書かない。

Tag = 262 (106.H)
Type = SHORT
Count = 1
Default = なし
2 = RGB
6 = YCbCr
その他 = 予約

画像方向 *Orientation*

行と列の観点から見た、画像の方向。

Tag = 274 (112.H)
Type = SHORT
Count = 1
Default = 1
1 = 0 番目の行が目で見たときの画像の上 (visual top)、0 番目の列が左側 (visual left-hand side) となる。
2 = 0 番目の行が目で見たときの画像の上、0 番目の列が右側 (visual right-hand side) となる。
3 = 0 番目の行が目で見たときの画像の下 (visual bottom)、0 番目の列が右側となる。
4 = 0 番目の行が目で見たときの画像の下、0 番目の列が左側となる。
5 = 0 番目の行が目で見たときの画像の左側、0 番目の列が上となる。
6 = 0 番目の行が目で見たときの画像の右側、0 番目の列が上となる。
7 = 0 番目の行が目で見たときの画像の右側、0 番目の列が下となる。
8 = 0 番目の行が目で見たときの画像の左側、0 番目の列が下となる。
その他 = 予約

コンポーネント数 *SamplesPerPixel*

1 画素当たりのコンポーネントの数。本規格は RGB 画像または YCbCr 画像を対象としているので 3 が書かれる。JPEG 圧縮データでは JPEG マーカで代用されるので書かない。

Tag = 277 (115.H)
Type = SHORT
Count = 1
Default = 3

画像データの並び *PlanarConfiguration*

各画素のコンポーネントが点順次、面順次のどちらで記録されているかを示す。JPEG 圧縮ファイルで

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はJPEGマーカで代用されるため書かない。このフィールドがない時はTIFFのデフォルト1（点順次）に従う。

Tag = 284 (11C.H)
Type = SHORT
Count = 1
1 = 点順次（chunky）フォーマット
2 = 面順次（planar）フォーマット
その他 = 予約

画素構成 *YCbCrSubSampling*

輝度サンプルに対する、クロマサンプルのサブサンプル比率を特定する。JPEG圧縮データではJPEGマーカで代用されるので書かない。

Tag = 530 (212.H)
Type = SHORT
Count = 2
[2, 1] = YCbCr4:2:2
[2, 2] = YCbCr4:2:0
その他 = 予約

画素構成 *YCbCrPositioning*

輝度サンプルに対する、クロマサンプルの相対的配置を特定する。このフィールドはJPEG圧縮データまたは非圧縮YCbCrデータ記録時だけに書かれる。TIFFの定めるデフォルト値は1（中心）であるが、YCbCr4:2:2の場合、TV系の画質改善を目的に本規格では2（一致）の形式のデータを記録することを推奨する。このフィールドがない時、リーダーはTIFFのデフォルトに従う。一方、YCbCr4:2:0の場合はTIFFのデフォルト（中心）を推奨する。リーダーの能力が限定されYCbCrPositioningの両方の値に対応できない場合は、このフィールドの値に関わらずTIFFのデフォルト1で再生することとする。リーダーは一致、中心ともに再生できることが望ましい。

Tag = 531 (213.H)
Type = SHORT
Count = 1
Default = 1
1 = 中心
2 = 一致（cosited）
その他 = 予約

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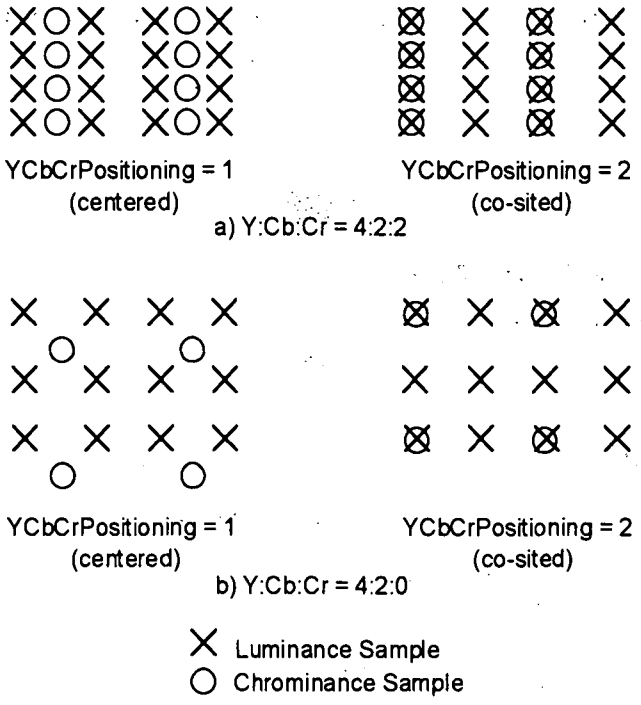


Fig. 8 YCbCrPositioning

画像の幅の解像度 ***XResolution***

ImageWidth 方向の 1 ResolutionUnit あたりの画素数。画像の解像度が不明の時には 72[dpi] が書かれる。

Tag = 282 (11A.H)
Type = RATIONAL
Count = 1
Default = 72

画像の高さの解像度 ***YResolution***

ImageLength 方向の 1 ResolutionUnit あたりの画素数。XResolution と同じ値が書かれる。

Tag = 283 (11B.H)
Type = RATIONAL
Count = 1
Default = 72

画像の幅と高さの解像度の単位 ResolutionUnit

XResolution と YResolution の単位系。XResolution、YResolution と一緒に用いる。画像の解像度が不明の時には 2 (インチ) が書かれる。

Tag = 296 (128.H)
Type = SHORT

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Count = 1

Default = 2

2 = インチ

3 = センチメートル

その他 = 予約

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B. 画像の記録位置に関するタグ

ストリップのバイトオフセット ***StripOffsets***

各ストリップに対して、そのストリップのバイトオフセット。ストリップのバイト数は 64KByte を越えないように選定して書くことを推奨する。JPEG 圧縮データでは不要なため書かない。RowsPerStrip、StripByteCounts も参照されたい。

Tag = 273 (111.H)
Type = SHORT or LONG
Count = StripsPerImage...PlanarConfiguration = 1 の時
= SamplesPerPixel × StripsPerImage...PlanarConfiguration = 2 の時
Default = なし

1 ストリップあたりの行の数 ***RowsPerStrip***

1 ストリップあたりの行の数。画像をストリップに分割して書く場合の 1 ストリップ当たりの画像の行数である。JPEG 圧縮データでは不要なため書かない。

Tag = 278 (116.H)
Type = SHORT or LONG
Count = 1
Default = なし

ストリップの総バイト数 ***StripByteCounts***

各ストリップに対して、そのストリップの総バイト数。JPEG 圧縮データでは不要なため書かない。

Tag = 279 (117.H)
Type = SHORT or LONG
Count = StripsPerImage (PlanarConfiguration = 1 の時)
SamplesPerPixel × StripsPerImage (PlanarConfiguration = 2 の時)
Default = なし

JPEG の SOI へのオフセット ***JPEGInterchangeFormat***

JPEG 圧縮サムネイルデータの先頭バイト (SOI) へのバイトオフセット。サムネイルが JPEG 圧縮の場合にのみ用いる。主画像の JPEG データには用いない。

Tag = 513 (201.H)
Type = LONG
Default = なし

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JPEGデータのバイト数 *JPEGInterchangeFormatLength*

JPEG 圧縮サムネイルデータのバイト数を記録する。主画像の JPEG データには用いない。JPEG サムネイルは、SOI から EOI まで全ての JPEG ストリームを連続して記録し分割しない。APPn、COM マーカは記録しない。圧縮サムネイルのバイト数は、他に APP1 に記録するすべてのデータを含めて 64kByte を越えないように記録しなければならない。

Tag = 513 (201.H)

Type = LONG

Default = なし

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C. 画像データの特性に関するタグ

再生階調カーブ特性 *TransferFunction*

画像の変換関数をテーブル形式で表現したもの。通常は、色空間情報タグで色空間を規定するため、本タグを使用する必要はない。

Tag = 301 (12D.H)
Type = SHORT
Count = 3 * 256
Default = なし

参照白色点の色度座標値 *WhitePoint*

画像のホワイトポイントのクロマ。通常は、色空間情報タグで色空間を規定するため、本タグを使用する必要はない。

Tag = 318 (13E.H)
Type = RATIONAL
Count = 2
Default = なし

原色の色度座標値 *PrimaryChromaticities*

画像の 3 原色のクロマ。通常は、色空間情報タグで色空間を規定するため、本タグを使用する必要はない。

Tag = 319 (13F.H)
Type = RATIONAL
Count = 6
Default = なし

色変換マトリックス係数 YCbCrCoefficients

RGB から YCbCr 画像データへの色変換マトリクス係数。TIFF ではデフォルトの記載がないが、付録 E「色空間ガイドライン」に示される値をデフォルトとする。色空間情報タグで色空間宣言し、この条件に最適な特性を持つ画像を記録する場合はデフォルト値となる。

Tag = 529 (211.H)
Type = RATIONAL
Count = 3
Default = 付録 E 参照

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参照黒色点値と参照白色点値 *ReferenceBlackWhite*

参照黒色点値と参照白色点値。TIFF ではデフォルトの記載がないが、以下の値をデフォルトとする。色空間情報タグで色空間を規定し、この条件に最適な特性を持つ画像を記録する場合はデフォルト値となる。

Tag	=	532 (214.H)	
Type	=	RATIONAL	
Count	=	6	
Default	=	[0, 255, 0, 255, 0, 255]	(PhotometricInterpretation が RGB の場合)
		[0, 255, 0, 128, 0, 128]	(PhotometricInterpretation が YCbCr の場合)

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D. その他のタグ

ファイル変更日時 *DateTime*

画像の作成された日付と時間。 本規格では、ファイル変更日時として用いる。フォーマットは "YYYY:MM:DD HH:MM:SS"。時間は 24 時間表示し、日付と時間の間に空白文字を 1 つ埋める。日時不明の場合は、コロン ":" 以外の日付・時間の文字部を空白文字［20.H］で埋めても良いし、すべてを空白文字で埋めても良い。文字列の長さは、NULL を含み 20 バイトである。記載が無いときは不明として扱う。

Tag = 306 (132.H)
Type = ASCII
Count = 20
Default = なし

画像タイトル *ImageDescription*

画像の題を表す文字列。例えば、画像に"1988 company picnic"などのコメントを付加することができる。2 バイトコードは記録できない。2 バイトコードの記録が必要な場合には、Exif Private タグの UserComment を使用する。

Tag = 270 (10E.H)
Type = ASCII
Count = Any
Default = なし

画像入力機器のメーカ名 *Make*

記録器の製造業者。DSC、スキャナー、ビデオデジタイザー、その他の画像生成用機器の製造業者。記載が無いときは不明として扱う。

Tag = 271 (10F.H)
Type = ASCII
Count = Any
Default = なし

画像入力機器のモデル名 *Model*

記録器のモデル名、またはモデル番号。DSC、スキャナー、ビデオデジタイザー、その他の画像生成用機器のモデル名、またはモデル番号。記載が無いときは不明として扱う。

Tag = 272 (110.H)
Type = ASCII
Count = Any

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Default = なし

ソフトウェア *Software*

このタグは、画像を生成するのに使用されたカメラまたは画像入力機器のソフトウェアまたはファームウェアの名前とバージョンを記録する。書式の詳細は規定しないが、以下の例のように記述することを推奨する。記載が無いときは不明として扱う。

例） "Exif Software Version 1.00a"

Tag = 305 (131h)

Type = ASCII

Count = Any

Default = なし

アーティスト *Artist*

このタグはカメラの所有者、写真家または画像の作成者の名前を記録する。書式の詳細は規定しないが、以下の例のように内容が明快に判読できるように記述することを推奨する。記載が無いときは不明として扱う。

例）"Camera owner,John Smith:Photographer, Michael Brown:Image creator, Ken James"

Tag = 315 (13Bh)

Type = ASCII

Count = Any

Default = なし

撮影著作権者／編集著作権者 *Copyright*

著作権表示。本規格では、撮影著作権者と編集著作権者双方の表示に用いる。その画像に対して著作権を主張する人または組織の著作権表示。日付と権利の宣言を含む全ての著作権表示文はこのフィールドに書くべきである。例えば、"Copyright, John Smith, 19xx. All rights reserved."。本規格では、撮影著作権者と編集著作権者双方の表示に用い、各々を別の文字列として記録する。撮影著作権者と編集著作権者が明確に分かるときは、撮影著作権者、編集著作権者の順序で間に NULL を入れてそのコピーライトを記述する（この場合文字列の最後にも NULL を入れるため 2 つの NULL コードが書かれることになる）（例 1 参照)。撮影著作権者のみを記述する場合は 1 つの NULL コードで終端し（例 2 参照)、編集著作権者のみを記述する際は撮影著作権者を 1 つのスペースコードで埋めて NULL コードで終端した後に編集著作権者を記述する（例 3 参照)。記載が無いときは不明として扱う。

例 1）撮影著作権者と編集著作権者を記載する場合

撮影著作権者 + NULL［00.H］ + 編集著作権者 + NULL［00.H］

例 2）撮影著作権者のみを記載する場合

撮影著作権者 + NULL［00.H］

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例 3) 編集著作権者のみを記載する場合

Space［20.H］+ NULL［00.H］ + 編集著作権者 + NULL［00.H］

Tag = 33432 (8298.H)

Type = ASCII

Count = Any

Default = なし

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2.6.5. Exif IFD の付属情報

以下に、Exif IFD に記録される付属情報（フィールド名、コード）一覧を Table 4、Table 5に示す。また、これらの内容を以下に説明する。

Table 4 Exif IFD の付属情報 (1)

分類	タグ名称	Field Name	タグ番号 Dec	タグ番号 Hex	タイプ	カウント
A. バージョンに関するタグ						
	Exif バージョン	Exif Version	36864	9000	UNDEFINED	4
	対応フラッシュピックスバージョン	FlashPixVersion	40960	A000	UNDEFINED	4
B. 画像データの特性に関するタグ						
	色空間情報	ColorSpace	40961	A001	SHORT	1
C. 構造に関するタグ						
	各コンポーネントの意味	ComponentsConfiguration	37121	9101	UNDEFINED	4
	画像圧縮モード	CompressedBitsPerPixel	37122	9102	RATIONAL	1
	実効画像幅	PixelXDimension	40962	A002	SHORT or LONG	1
	実効画像高さ	PixelYDimension	40963	A003	SHORT or LONG	1
D. ユーザー情報に関するタグ						
	メーカーノート	MakerNote	37500	927C	UNDEFINED	Any
	ユーザーコメント	UserComment	37510	9286	UNDEFINED	Any
E. 関連ファイル情報に関するタグ						
	関連音声ファイル	RelatedSoundFile	40964	A004	ASCII	13
F. 日時に関するタグ						
	原画像データの生成日時	DateTimeOriginal	36867	9003	ASCII	20
	ディジタルデータの作成日時	DateTimeDigitized	36868	9004	ASCII	20
	DateTime のサブセック	SubSecTime	37520	9290	ASCII	Any
	DateTimeOriginal のサブセック	SubSecTimeOriginal	37521	9291	ASCII	Any
	DateTimeDigitized のサブセック	SubSecTimeDigitized	37522	9292	ASCII	Any

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Table 5 Exif IFD の付属情報 (2)

G. 撮影条件に関するタグ					
露出時間	ExposureTime	33434	829A	RATIONAL	1
F ナンバー	FNumber	33437	829D	RATIONAL	1
露出プログラム	ExposureProgram	34850	8822	SHORT	1
スペクトル感度	SpectralSensitivity	34852	8824	ASCII	Any
ISO スピードレート	ISOSpeedRatings	34855	8827	SHORT	Any
光電変換関数	OECF	34856	8828	UNDEFINED	Any
シャッタースピード	ShutterSpeedValue	37377	9201	SRATIONAL	1
絞り値	ApertureValue	37378	9202	RATIONAL	1
輝度値	BrightnessValue	37379	9203	SRATIONAL	1
露光補正値	ExposureBiasValue	37380	9204	SRATIONAL	1
レンズ最小F値	MaxApertureValue	37381	9205	RATIONAL	1
被写体距離	SubjectDistance	37382	9206	RATIONAL	1
測光方式	MeteringMode	37383	9207	SHORT	1
光源	LightSource	37384	9208	SHORT	1
フラッシュ	Flash	37385	9209	SHORT	1
レンズ焦点距離	FocalLength	37386	920A	RATIONAL	1
フラッシュ強度	FlashEnergy	41483	A20B	RATIONAL	1
空間周波数応答	SpatialFrequencyResponse	41484	A20C	UNDEFINED	Any
焦点面の幅の解像度	FocalPlaneXResolution	41486	A20E	RATIONAL	1
焦点面の高さの解像度	FocalPlaneYResolution	41487	A20F	RATIONAL	1
焦点面解像度単位	FocalPlaneResolutionUnit	41488	A210	SHORT	1
被写体位置	SubjectLocation	41492	A214	SHORT	2
露出インデックス	ExposureIndex	41493	A215	RATIONAL	1
センサー方式	SensingMethod	41495	A217	SHORT	1
ファイルソース	FileSource	41728	A300	UNDEFINED	1
シーンタイプ	SceneType	41729	A301	UNDEFINED	1
CFA パターン	CFAPattern	41730	A302	UNDEFINED	Any

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A. バージョンに関するタグ

Exif バージョン *Exif Version*

本規格での対応バージョンを示す。このフィールドが存在しなければ、本規格に準拠していないと判断される（2.2 章参照）。本規格に準拠する場合には、4Byte の ASCII "0200"を記録する。Type が UNDEFINED のため最後に NULL は記録しない。

Tag = 36864 (9000.H)
Type = UNDEFINED
Count = 4
Default = "0200"

対応 FlashPix バージョン *FlashPix Version*

FPXR ファイルの FlashPix フォーマットへの対応バージョンを示す。FPXR の機能が FlashPix フォーマット Ver.1.0 に対応するときは ExifVersion と同様に 4Byte の ASCII "0100"を記録する。Type が UNDEFINED のため最後に NULL は記録しない。

Tag = 40960 (A000.H)
Type = UNDEFINED
Count = 4
Default = "0100"
0100 = FlashPix Format Version 1.0
その他 = 予約

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B. 画像データの特性に関するタグ

色空間情報 ***ColorSpace***

色空間を示す情報として、(ColorSpace) 色空間情報タグを必ず記録する。

本規格では、PC モニタによる観察条件から色空間を規定した sRGB (=1) を使用する。やむを得ぬ理由で sRGB 以外の色空間を使用する場合は、Uncalibrated (=FFFF.H) を記録する。Uncalibrated として記録された画像データは、後に FlashPix に変換する際には sRGB と見なしてよい。sRGB については付録 E を参照のこと。

Tag = 40961 (A001.H)
Type = SHORT
Count = 1
1 = sRGB
FFFF.H = Uncalibrated
その他 = 予約

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C. 画像データの構成に関するタグ

実効画像幅 *PixelXDimension*

圧縮データ固有の情報。圧縮ファイルを記録する場合には、パディングデータの有無、リスタートマーカの有無に関わらず、有意な画像の幅をこの実効画像幅タグに必ず記録する。非圧縮ファイルでは書かない。詳細は2.8.1章及び付録 F を参照のこと。

Tag = 40962 (A002.H)
Type = SHORT or LONG
Count = 1
Default = なし

実効画像高さ *PixelYDimension*

圧縮データ固有の情報。圧縮ファイルを記録する場合には、パディングデータの有無、リスタートマーカの有無に関わらず、有意な画像の高さをこの実効画像高さタグに必ず記録する。非圧縮ファイルでは書かない。詳細は2.8.1章及び付録 Fを参照のこと。実際には、垂直方向のデータのパディングは不要であるため、実効画像高さタグと SOF に記述されたライン数は一致する。

Tag = 40963 (A003.H)
Type = SHORT or LONG
Count = 1

各コンポーネントの意味 *ComponentsConfiguration*

圧縮データ固有の情報。各コンポーネントのチャネルを、第 1 コンポーネントから第 4 コンポーネントの順に示す。非圧縮データでは PhotometricInterpretation でデータ並びを表現する。しかし、PhotometricInterpretation では YCbCr の順序しか表現できないので、圧縮データが Y,Cb,Cr 以外のコンポーネントやそれらの順番を多様に記載可能とするため定義する。

Tag = 37121 (9101.H)
Type = UNDEFINED
Count = 4
Default = 4 5 6 0 (RGB 非圧縮の場合)
1 2 3 0 (その他の場合)

0 = 存在しない
1 = Y
2 = Cb
3 = Cr
4 = R
5 = G
6 = B

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その他　＝　予約

画像圧縮モード *CompressedBitsPerPixel*

圧縮データ固有の情報。画像圧縮時に設定された圧縮モードを単位 bit/pel で示す。

Tag　＝　37122　(9102.H)

Type　＝　RATIONAL

Count　＝　1

Default　＝　なし

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D. ユーザ情報に関するタグ

メーカノート ***MakerNote***

Exif ライターのメーカが個別の情報を記入するためのタグ。内容については各メーカの運用に任せる。

Tag = 37500 (927C.H)
Type = UNDEFINED
Count = Any
Default = なし

ユーザコメント ***UserComment***

ImageDescription 以外に画像に対して Exif ユーザがキーワードやコメントを書き込むためのタグ。

Tag = 37510 (9286.H)
Type = UNDEFINED
Count = Any
Default = なし

UserComment に書かれる文字コードを判別するために、識別コードをタグのデータ領域先頭に 8 バイト固定で記入し、余った領域には NULL ("00.H") でパディングすることとする。識別コードについては登録制としコードを割り振る。各文字コードのリファレンスをTable 6 に示す。また、Count 数 N については、文字コード領域 8 バイトとユーザコメント欄のバイト数により決定される。なお、TYPE は ASCII ではないため NULL で終端する必要はない (Fig. 9参照)。

Table 6、文字コードと文字コード欄記入方法

文字コード	コード記入方法 (8Byte)	リファレンス
ASCII	41.H, 53.H, 43.H, 49.H, 49.H, 00.H, 00.H, 00.H	ITU-T T.50 IA5[ix]
JIS	4A.H, 49.H, 53.H, 00.H, 00.H, 00.H, 00.H, 00.H	JIS X0208-1990[x]
Unicode	55.H, 4E.H, 49.H, 43.H, 4F.H, 44.H, 45.H, 00.H	Unicode Standard [xi]
Undefined	00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H	Undefined

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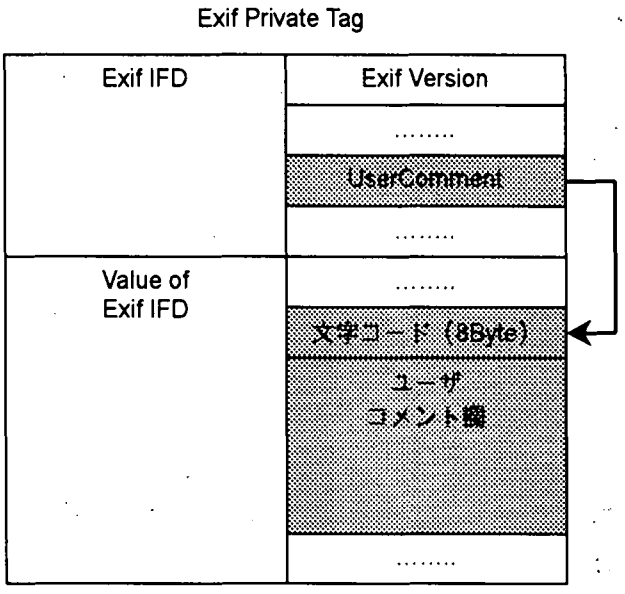


Fig. 9　ユーザコメントタグの構成

UserCommentエリアの識別コードはJISコードやASCIIコード等のDefinedのものと、Undefinedのものがある。Undefinedの名称は、UndefinedTextとし、識別コードは8バイト全て"NULL"（"00.H"）で埋める。UserCommentタグを読むExifのリーダーは識別コードを判別する機能を必ず持つものとする。なお、UserCommentタグを使用しないExifリーダーは判別する機能を持つ必要はない（Table 7 参照）。

Table 7　Defined系文字コードとUndefinedの運用の違い

識別コード	Exif リーダーの運用
Defined系 （JIS、ASCII 等）	識別コードを判別し、リーダーの能力に合わせて表示する。
Undefined系 （すべてNULL）	各国のPCに依存する（日本における Shift-JIS のように明確な仕様書がない文字コードを使用する場合にはUndefinedを使用する）。 文字化けの可能性があるが、表示は各リーダーの運用に任せる。

UserCommentエリアの領域確保をする場合は識別コードをASCIIとし、続くユーザコメント欄は空白文字［20.H］で埋めることを推奨する。

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E. 関連ファイルに関するタグ

関連音声ファイル RelatedSoundFile

画像データに関連する音声ファイル名を記録する。関連情報として、相手先である Exif 音声ファイルのファイル名と拡張子（8 文字+'.'+ 3 文字の ASCII 文字列とする）を一つだけ記録する。パスは記述しない。音声に関する規定は 3.6.3章 erel を参照のこと。また、ファイル名称の記載方法については、3.7.1章を参照のこと。

本タグを使用する場合、音声ファイルは Exif 音声フォーマット規定に従って記録されたものでなければならない。ただし、APP2 に FlashPix 拡張データとして音声のようなデータを記録ことは可能である。

Exif 画像ファイルと Exif 音声ファイルの対応関係はTable 8に示すように 3 通りある。Table 中 [2]又は[3]のように、1 つのファイルに複数のファイルが対応しているような場合でも、上に述べた規定に従い相手先のファイル名は 1 つだけ記録するものとする。複数の相手先ファイルが存在する場合、その中で最初に記録されたファイルのファイル名を記録するものとする。

たとえば、Table 8 中の [3]では、Exif 画像ファイル"DSC00001.JPG"は、関連する Exif 音声ファイルとして"SND00001.WAV"のみ示す。

逆に 3 つの Exif 音声ファイル"SND00001.WAV"、"SND00002.WAV"、"SND00003.WAV"は、それぞれ相手先の Exif 画像ファイル名"DSC00001.JPG"を示す。これら複数の関連情報を組み合わせることによって多様な再生を行うこともできる。関連情報の利用の仕方については、再生側の運用に任せる。この情報は ASCII 文字列なので、NULL 終端すること。

Table 8 画像ファイルと音声ファイルの関連付け

	対応関係	Exif 画像ファイル	Exif 音声ファイル
[1]	1 対 1	DSC00001.JPG	SND00001.WAV
[2]	多対 1	DSC00001.JPG DSC00002.JPG DSC00003.JPG	SND00001.WAV
[3]	1 対多	DSC00001.JPG	SND00001.WAV SND00002.WAV SND00003.WAV

本タグを用いて音声ファイルと関連づけを行う場合には、必ず関連付けされた音声ファイル側にも画像への関連情報を記録しなければならない。

Tag = 40964 (A004.H)

Type = ASCII

Count = 13

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Default = なし

F. 日時に関するタグ

原画像データの生成日時 DateTimeOriginal

原画像データの生成された日付と時間。DSC では撮影された日付と時間を記載する。フォーマットは "YYYY:MM:DD HH:MM:SS"。時間は 24 時間表示し、日付と時間の間に空白文字［20.H］を 1 つ埋める。日時不明の場合は、コロン ":" 以外の日付・時間の文字部を空白文字で埋めても良いし、すべてを空白文字で埋めても良い。文字列の長さは、NULL を含めて 20 バイトである。記載が無いときは不明として扱う。

Tag = 36867 (9003.H)
Type = ASCII
Count = 20
Default = なし

ディジタルデータ作成日時 *DateTimeDigitized*

画像がディジタルデータ化された日付と時間。例えば、DSC により撮影され、同時にファイルが記録される場合、DateTimeOriginal と DateTimeDigitized は同じ内容となる。フォーマットは "YYYY:MM:DD HH:MM:SS"。時間は 24 時間表示し、日付と時間の間に空白文字［20.H］を一つ挿入する。日時不明の場合は、コロン ":" 以外の日付や時間の文字部を空白文字で埋めても良いし、すべてを空白文字で埋めても良い。文字列の長さは、NULL を含み 20 バイトである。記載が無いときは不明として扱う。

Tag = 36868 (9004.H)
Type = ASCII
Count = 20
Default = なし

DateTime のサブセック *SubsecTime*

DateTime タグに関連して時刻を少数点以下の秒単位まで記録するためのタグ。

Tag = 37520 (9290.H)
Type = ASCII
Count = Any
Default = なし

DateTimeOriginal のサブセック *SubsecTimeOriginal*

DateTimeOriginal タグに関連して時刻を少数点以下の秒単位まで記録するためのタグ。

Tag = 37521 (9291.H)

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Type = ASCII

N = Any

Default = なし

DateTimeDigitized のサブセック *SubsecTimeDigitized*

DateTimeDigitized タグに関連して時刻を少数点以下の秒単位まで記録するためのタグ。

Tag = 37522 (9292.H)

Type = ASCII

N = Any

Default = なし

注記：サブセックデータ（SubsecTime, SubsecTimeOriginal, SubsecTimeDigitized）の記録方法

タグタイプは ASCII で文字列の長さは NULL を含めて可変長とする。有効数字が小数点以下 2 位までの時は Value の位置にサブセックの値を記入し、小数点以下 4 位以上まである時はアドレスの値を記入し、そのアドレスが示す場所にサブセックの値を記入する。(ASCII タイプのフィールドエントリーのカウントは NULL を含めた値を記入するため、有効数字が小数点以下 4 位まであるときはカウントが 5 となり値のオフセット（Value Offset）フィールドにはオフセット値を記入する。2.6.2章参照。）また、サブセックタグは DateTime 等の TIFF Rev 6.0 定義済タグとは異なり、いずれも Exif IFD 内に記録する。

例：1998 年 9 月 1 日 9 時 15 分 30.130 秒

（有効数字が少数点以下第 3 位までのとき）

DateTime 1996:09:01 09:15:30 [NULL]

SubSecTime 130 [NULL]

文字列の長さが有効数字よりも多い場合には、数字を先頭詰めで記録し残りのエリアは空白文字［20.H］で埋める。サブセックデータが不明な場合は、すべてを空白文字で埋めて良い。

サブセックデータが 0.130 秒の場合の実現例）

例 1) '1','3','0',[NULL]

例 2) '1','3','0',[20.H],[NULL]

例 3) '1','3','0', [20.H], [20.H], [20.H], [20.H], [20.H], [NULL]

サブセックデータ不明として扱う例）

例 4) [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [NULL]

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G. 撮影条件に関するタグ

露出時間 *ExposureTime*

露出時間を示す。単位は秒（sec）である。

Tag = 33434 (829A.H)
Type = RATIONAL
Count = 1
Default = なし

シャッタースピード *ShutterSpeedValue*

シャッタースピードを示す。単位はAPEX（Additive System of Photographic Exposure）値（付録 C 参照）である。

Tag = 37377 (9201.H)
Type = SRATIONAL
Count = 1
Default = なし

絞り値 *ApertureValue*

レンズの絞り値を示す。単位はAPEX値である。

Tag = 37378 (9202.H)
Type = RATIONAL
Count = 1
Default = なし

輝度値 (BV) *BrightnessValue*

輝度値を示す。単位はAPEX値である。一般的な記載範囲は-99.99から99.99である。

Tag = 37379 (9203.H)
Type = SRATIONAL
Count = 1
Default = なし

露光補正値 *ExposureBiasValue*

露光補正値を示す。単位はAPEX値である。一般的な記載範囲は-99.99から99.99である。

Tag = 37380 (9204.H)
Type = SRATIONAL
Count = 1

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Default = なし

レンズ最小F値 *MaxApertureValue*

レンズの最小F値を示す。単位はAPEX値である。一般的な記載範囲は00.00から99.99であるが、特にこの範囲に限定しない。

Tag = 37381 (9205.H)
Type = RATIONAL
Count = 1
Default = なし

被写体距離 *SubjectDistance*

被写体距離を示す。単位は m である。

Tag = 37382 (9206.H)
Type = RATIONAL
Count = 1
Default = なし

測光方式 *MeteringMode*

測光方式示す。

Tag = 37383 (9207.H)
Type = SHORT
Count = 1
Default = 0
0 = 不明
1 = 平均 (Average)
2 = 中央重点 (CenterWeightedAverage)
3 = スポット (Spot)
4 = マルチスポット (MutiSpot)
5 = 分割測光 (Pattern)
6 = 部分測光 (Partial)
7～254 = 予約
255 = その他

光源 *LightSource*

光源の種類を示す。

Tag = 37384 (9208.H)
Type = SHORT

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Count = 1

Default = 0

0 = 不明

1 = 昼光

2 = 蛍光灯

3 = タングステン

17 = 標準光 A

18 = 標準光 B

19 = 標準光 C

20 = D55

21 = D65

22 = D75

23～254 = 予約

255 = その他

フラッシュ ***Flash***

このタグはストロボを使用して画像が取り込まれた時に記録される。このタグのビット 0 はストロボの状態、ビット 1 および 2 はストロボのリターン状態を表わす（Fig. 10 参照）。

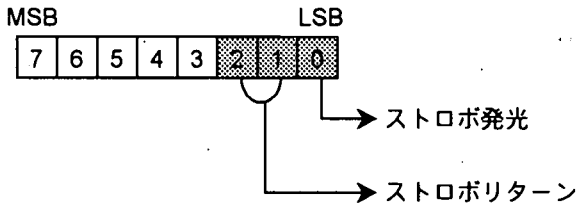


Fig. 10 フラッシュのビット表現

Tag = 37385 (9209.H)

Type = SHORT

Count = 1

ストロボ発光状態ビット（bit0）の値は以下のとおり。

0b = ストロボ発光せず

1b = ストロボ発光

ストロボのリターン状態の値（bit1,2）は以下のとおり。

00b = ストロボのリターン検出機能なし

01b = 予約

10b = ストロボのリターン検出されず

11b = ストロボのリターン検出

従って Flash タグの値は以下のようになる。

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0000.H = ストロボ発光せず

0001.H = ストロボ発光

0005.H = ストロボ発光、リターン検出されず

0007.H = ストロボ発光、リターン検出

その他 = 予約

レンズ焦点距離 *FocalLength*

撮影レンズの実焦点距離を示す。単位は mm である。35mm フィルムカメラの焦点距離には換算しない。

Tag = 37386 (920A.H)

Type = RATIONAL

Count = 1

Default = なし

F ナンバー *FNumber*

F ナンバーを示す。

Tag = 33437 (829D.H)

Type = RATIONAL

Count = 1

Default = なし

露出プログラム *ExposureProgram*

このタグは撮影時にカメラが使用した露出プログラムのクラスを示す。このタグの値は以下の通り。

Tag = 34850 (8822.H)

Type = SHORT

Count = 1

Default = 0

0 = 未定義

1 = マニュアル

2 = ノーマルプログラム

3 = 露出優先

4 = シャッター優先

5 = creative プログラム（被写界深度方向にバイアス）

6 = action プログラム（シャッタースピード高速側にバイアス）

7 = ポートレイトモード（クローズアップ撮影、背景はフォーカス外す）

8 = ランズケープモード（landscape 撮影、背景はフォーカス合う）

9～255 = 予約

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スペクトル感度 *SpectralSensitivity*

このタグは撮影に用いたカメラの各チャネルのスペクトル感度を表す。タグの値は ASTM Technical committee で開発された規格[xii]と互換性がある ASCII 文字列である。

Tag = 34852 (8824.H)

Type = ASCII

Count = Any

Default = なし

ISO スピードレート *ISOSpeedRatings*

このタグは ISO 12232[xiii]で規定されるカメラまたは入力機器の ISO Speed および ISO Latitude を示す。

Tag = 34855 (8827.H)

Type = SHORT

Count = Any

Default = なし

光電変換関数 *OECF*

このタグは ISO 14524[xiv]で規定される光電変換関数（OECF）を表す。OECF は DSC の光学的入力と画像データ値の関係を示すものである。

Tag = 34856 (8828.H)

Type = UNDEFINED

Count = ANY

Default = なし

m 行 n 列の光電変換関数をタグに記録する場合、その値はFig. 11のようになる。

Length	Type	意味
2	SHORT	列数 = n
2	SHORT	行数 = m
Any	ASCII	0 行目の項目名（NULL 終端）
:	:	:
Any	ASCII	n-1 行目の項目名（NULL 終端）
8	RATIONAL	OECF 値 [0,0]
:	:	:
8	RATIONAL	OECF 値 [n-1,0]
8	RATIONAL	OECF 値 [0,m-1]
:	:	:
8	RATIONAL	OECF 値 [n-1,m-1]

Fig. 11 光電変換関数の記録方法

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Table 9に非常に簡単な例を示す。

Table 9 露出と RGB 出力レベル例

カメラ log 露出	R 出力レベル	G 出力レベル	B 出力レベル
-3.0	10.2	12.4	8.9
-2.0	48.1	47.5	48.3
-1.0	150.2	152.0	149.8

フラッシュ強度 ***FlashEnergy***

画像が取り込まれた時に使用されたストロボのエネルギーを示す。測定単位は、Beam Candle Power Seconds（BCPS）である。

Tag = 41483（A20B.H）

Type = RATIONAL

Count = 1

Default = なし

空間周波数応答 ***SpatialFrequencyResponse***

このタグは ISO 12233[xv]で規定される空間周波数応答（SFR）に従い、カメラまたは入力機器の空間周波数テーブル、画像の幅方向（水平）の SFR 値、画像の高さ方向（垂直）の SFR 値、対角線方向の SFR 値を記録する。

Tag = 41484（A20CH）

Type = UNDEFINED

Count = ANY

Default = なし

m 行 n 列の空間周波数応答をタグに記録する場合、その値はFig. 12のようになる。

Length	Type	意味
2	SHORT	列数 = n
2	SHORT	行数 = m
Any	ASCII	0 行目の項目名（NULL 終端）
:	:	:
Any	ASCII	n-1 行目の項目名（NULL 終端）
8	RATIONAL	SFR 値 [0,0]
:	:	:
8	RATIONAL	SFR 値 [n-1,0]
8	RATIONAL	SFR 値 [0,m-1]
:	:	:
8	RATIONAL	SFR 値 [n-1,m-1]

Fig. 12 空間周波数応答の記録方法

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Table 10に簡単な例を示す。

Table 10 空間周波数応答の例

空間周波数（lw/ph）	画像の幅方向（水平）	画像の高さ方向（垂直）
	1.00	1.00
0.2	0.90	0.95
0.3	0.80	0.85

焦点面の幅の解像度 ***FocalPlaneXResolution***

このタグはカメラのフォーカルプレーン上での FocalPlaneResolutionUnit あたりの画像幅（X）方向の画素数を示す。

Tag = 41486 (A20E.H)
Type = RATIONAL
Count = 1
Default = なし

焦点面の高さの解像度 ***FocalPlaneYResolution***

このタグはカメラのフォーカルプレーン上での FocalPlaneResolutionUnit あたりの画像高さ（Y）方向の画素数を示す。

Tag = 41487 (A20F.H)
Type = RATIONAL
Count = 1
Default = なし

焦点面解像度単位 ***FocalPlaneResolutionUnit***

このタグは FocalPlaneXResolution と FocalPlaneYResolution に対する測定単位を示す。値は ResolutionUnit と同様である。

Tag = 41488 (A210.H)
Type = SHORT
Count = 1
Default = 2 (inch)

注記：焦点面の解像度に関連するタグの使用方法

カメラの持つ撮像素子の解像度を記録するのではなく、ファイルとして記録する主画像の焦点面における解像度を記録する。撮像素子から得られるデータをリサンプリング処理する場合には注意が必要である。これらのタグを FocalLength タグと同時に使用すれば、記録画像の画角を正確に計算することができる。

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被写体位置 *SubjectLocation*

このタグはシーンにおける主要被写体のおおよその位置を示す。このタグの値は主要被写体の中央に相当する画素を Rotation タグによる回転処理前の画像の左肩を原点として表現する。最初の値は X 座標値を表し、次の値は Y 座標値を表す。

Tag = 41492 (A214.H)
Type = SHORT
Count = 2
Default = なし

露出インデックス *ExposureIndex*

このタグは画像が取り込まれた時、カメラまたは入力機器が選択した露出のインデックスを示す。

Tag = 41493 (A215.H)
Type = RATIONAL
Count = 1
Default = なし

センサ方式 *SensingMethod*

このタグは、カメラまたは入力機器で使用される画像センサのタイプを示す。このタグの値は以下の通り。

Tag = 41495 (A217.H)
Type = SHORT
Count = 1
Default = なし

1	=	未定義
2	=	単板カラーセンサ
3	=	2版カラーセンサ
4	=	3版カラーセンサ
5	=	色順次カラーセンサ
7	=	3線リニアセンサ
8	=	色順次リニアセンサ
その他	=	予約

ファイルソース *FileSource*

このタグは画像のソースを示す。DSC で記録する場合にはこのタグの値は常に 3 でなければならない。この値は DSC で記録された映像であることを表わす。

Tag = 41728 (A300.H)
Type = UNDEFINED

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Count = 1

Default = 3

3 = DSC

その他 = 予約

シーンタイプ *SceneType*

このタグは画像のシーンのタイプを示す。DSC で記録する場合にはこのタグの値は常に 1 でなければならない。この値は直接撮影された画像であることを表わすコードである。

Tag = 41729 (A301.H)

Type = UNDEFINED

Count = 1

Default = 1

1 = 直接撮影された画像

その他 = 予約

CFA パターン *CFAPattern*

このタグは単板カラーセンサ使用時のセンサの CFA (color filter array) の幾何学的パターンを示す。このタグは全ての sensing method には対応していない。

Tag = 41730 (A302.H)

Type = UNDEFINED

Count = ANY

縦 m ×横 n 画素単位でカラーフィルタ配列が反復する単板カラーセンサの CFA パターンはFig. 13のように記録する。

Length	Type	意味
2	SHORT	横方向の反復画素単位 = n
2	SHORT	縦方向の反復画素単位 = m
1	WORD	CFA 値 [0.0]
:	:	:
1	WORD	CFA 値 [n-1.0]
1	WORD	CFA 値 [0.m-1]
:	:	:
1	WORD	CFA 値 [n-1.m-1]

Fig. 13 CFA パターンの記録方法

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カラーフィルタ色と CFA 値の対応をTable 11に示す。

Table 11 カラーフィルタ色と CFA 値の対応

フィルタ色	CFA 値
RED	00.H
GREEN	01.H
BLUE	02.H
CYAN	03.H
MAGENTA	04.H
YELLOW	05.H
WHITE	06.H

たとえば CFA パターンタグ値が {0002.H, 0002.H, 01.H, 00.H, 02.H, 01.H} の場合、Fig. 14のようなカラーフィルタ配列を表す。

G	R	G	R	.....
B	G	B	G	.....
G	R	G	R	.....
B	G	B	G	.....
:	:	:	:	

Fig. 14 カラーフィルタ配列例

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2.6.6. GPS に関する付属情報

以下に、GPS info IFD に記録される付属情報（フィールド名、コード）一覧をTable 12に示す。また、これらの内容を以下に説明する。

Table 12 GPS に関する付属情報一覧

分類	タグ名称	Field Name	タグ番号		タイプ	カウント
			Dec	Hex		
A. GPS に関するタグ						
	GPS タグのバージョン	GPSVersionID	0	0	BYTE	4
	北緯(N)or 南緯(S)	GPSLatitudeRef	1	1	ASCII	2
	緯度（数値）	GPSLatitude	2	2	RATIONAL	3
	東経(E)or 西経(W)	GPSLongitudeRef	3	3	ASCII	2
	経度（数値）	GPSLongitude	4	4	RATIONAL	3
	高度の単位	GPSAltitudeRef	5	5	BYTE	1
	高度（数値）	GPSAltitude	6	6	RATIONAL	1
	GPS 時間（原子時計の時間）	GPSTimeStamp	7	7	RATIONAL	3
	測位に使った衛星信号	GPSSatellites	8	8	ASCII	Any
	GPS 受信機の状態	GPSStatus	9	9	ASCII	2
	GPS の測位方法	GPSMeasureMode	10	A	ASCII	2
	測位の信頼性	GPSDOP	11	B	RATIONAL	1
	速度の単位	GPSSpeedRef	12	C	ASCII	2
	速度（数値）	GPSSpeed	13	D	RATIONAL	1
	進行方向の単位	GPSTrackRef	14	E	ASCII	2
	進行方向（数値）	GPSTrack	15	F	RATIONAL	1
	撮影した画像の方向の単位	GPSImgDirectionRef	16	10	ASCII	2
	撮影した画像の方向（数値）	GPSImgDirection	17	11	RATIONAL	1
	測位に用いた地図データ	GPSMapDatum	18	12	ASCII	Any
	目的地の北緯(N)or 南緯(S)	GPSDestLatitudeRef	19	13	ASCII	2
	目的地の緯度（数値）	GPSDestLatitude	20	14	RATIONAL	3
	目的地の東経(E)or 西経(W)	GPSDestLongitudeRef	21	15	ASCII	2
	目的地の経度（数値）	GPSDestLongitude	22	16	RATIONAL	3
	目的地の方角の単位	GPSDestBearingRef	23	17	ASCII	2
	目的の方角（数値）	GPSDestBearing	24	18	RATIONAL	1
	目的地までの距離の単位	GPSDestDistanceRef	25	19	ASCII	2
	目的地までの距離（数値）	GPSDestDistance	26	1A	RATIONAL	1

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A. GPS に関するタグ

GPS タグのバージョン *GPSVersionID*

GPSInfoIFD のバージョンを示す。バージョンは 2.0.0.0 とする。GPSInfo tag が記載される場合はこのタグを必ず記載する。(注：GPSVersionID タグは Exif Version タグとは異なり Byte で記入する。バージョンが 2.0.0.0 の場合実際には 02000000.H を記載することになる。)

Tag = 0 (0.H)
Type = BYTE
Count = 4
Default = 2.0.0.0
2.0.0.0 = バージョン 2.0
その他 = 予約

北緯 (N) or 南緯 (S) *GPSLatitudeRef*

緯度の北緯もしくは南緯を示す。ASCII 値で'N'は北緯、'S'は南緯を示す。

Tag = 1 (1.H)
Type = ASCII
Count = 2
Default = なし
'N' = 北緯
'S' = 南緯
その他 = 予約

緯度 (数値) *GPSLatitude*

緯度を表す。緯度は、2 つの RATIONAL によって表現し、それぞれ度、分、秒を表す。緯度の表記を度分秒で表す場合 dd/1,mm/1,ss/1 で表現する。度分単位の場合は例として分単位を小数点第 2 位以下まで表記する場合、dd/1,mmmm/100,0/1 で表現する。

Tag = 2 (2.H)
Type = RATIONAL
Count = 3
Default = なし

東経 (E) or 西経 (W) *GPSLongitudeRef*

経度の東経もしくは西経を示す。ASCII 値で'E'は東経、'W'は西経を示す。

Tag = 3 (3.H)
Type = ASCII

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Count = 2

Default = なし

'E' = 東経

'W' = 西経

その他 = 予約

経度（数値） *GPSLongitude*

経度を表す。経度は 2 つの RATIONAL によって表現し、それぞれ度、分、秒を表す。緯度の表記を度分秒で表す場合 ddd/1,mm/1,ss/1 で表現する。度分単位の場合は例として分単位を小数点第 2 位以下まで表記する場合、ddd/1,mmmm/100,0/1 で表現する。

Tag = 4 (4.H)

Type = RATIONAL

Count = 3

Default = なし

高度の単位 *GPSAltitudeRef*

このタグは、高度の基準となる高さを示す。このバージョンでは海抜を基準とし、0 としなければならない。また基準単位はメートルとする。このタグのタイプは BYTE であり、他のリファレンスタグとは異なるため注意が必要である。

Tag = 5 (5.H)

Type = BYTE

Count = 1

Default = 0

0 = 海抜基準

その他 = 予約

高度（数値） *GPSAltitude*

このタグは GPSAlitudeRef を基準とした高度を表す。高度は 1 つの RATIONAL によって表現する。基準単位はメートルとする。

Tag = 6 (6.H)

Type = RATIONAL

Count = 1

Default = なし

GPS 時間（原子時計の時間） *GPSTimeStamp*

UTC（Coordinated Universal Time）時刻を示す。TimeStamp は 3 つの RATIONAL によって表現し、それぞれ時間、分、秒に対応する。

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Tag = 7 (7.H)

Type = RATIONAL

Count = 3

Default = なし

測位につかった衛星信号 *GPSSatellites*

測位に用いた GPS 衛星を示す。これらは ASCII で表現され、衛星の数、衛星の番号、衛星の仰角、衛星の方位角、衛星の SNR などを記述できる。記述のフォーマットについては規定しない。ただし、GPS 受信器が測位できなかった場合、このタグは NULL とする。

Tag = 8 (8.H)

Type = ASCII

Count = Any

Default = なし

GPS 受信機の状態 *GPSStatus*

記録時の GPS 受信機の状態をあらわす。'A'が測位中を表し、'V'が未測位（中断中）を示す。

Tag = 9 (9.H)

Type = ASCII

Count = 2

Default = なし

'A' = 測位中

'V' = 未測位（中断中）

その他 = 予約

GPS の測位方法 *GPSMeasureMode*

GPS の測位モードを示す。'2'が 2 次元測位中であるを示し、'3'が 3 次元測位中であることを示す。

Tag = 10 (A.H)

Type = ASCII

Count = 2

Default = なし

'2' = 2 次元測位中

'3' = 3 次元測位中

その他 = 予約

測位の信頼性 *GPSDOP*

GPS の DOP 値（データの信頼性）を示す。2 次元測位中の場合は、HDOP の値を書き込み、3 次元測位中の場合は、PDOP の値を書き込む。

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Tag = 11 (B.H)

Type = RATIONAL

Count = 1

Default = なし

速度の単位 ***GPSSpeedRef***

GPS 受信器の移動速度の単位を示す。'K'はキロメータ／時を示し、'M'はマイル／時を示し、'N'はノットを示す。

Tag = 12 (C.H)

Type = ASCII

Count = 2

Default = 'K'

'K' = キロメータ

'M' = マイル

'N' = ノット

その他 = 予約

速度（数値） ***GPSSpeed***

GPS 受信器の速度を表す。

Tag = 13 (D.H)

Type = RATIONAL

Count = 1

Default = なし

進行方向の単位 ***GPSTrackRef***

GPS 受信器の進行方向の基準を示す。'T'は真方位、'M'は磁気方位を示す。

Tag = 14 (E.H)

Type = ASCII

Count = 2

Default = 'T'

'T' = 真方位

'M' = 磁気方位

その他 = 予約

進行方向（数値） ***GPSTrack***

GPS 受信器の進行方向を示す。値は 0.00～359.99 までの範囲をとる。

Tag = 15 (F.H)

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Type = RATIONAL

Count = 1

Default = なし

撮影した画像の方向の単位 *GPSImgDirectionRef*

記録した画像の撮影方向の基準を示す。'T'は真方位、'M'は磁気方位を示す。

Tag = 16 (10.H)

Type = ASCII

Count = 2

Default = 'T'

'T' = 真方位

'M' = 磁気方位

その他 = 予約

撮影した画像の方向（数値） *GPSImgDirection*

記録した画像の撮影方向を示す。値は 0.00～359.99 までの範囲をとる。

Tag = 17 (11.H)

Type = RATIONAL

Count = 1

Default = なし

測位に用いた地図データ *GPSMapDatum*

GPS 受信器が使用した測地系を示す。測地系が日本国内の場合は、'TOKYO'もしくは'WGS-84'となる。GPS Info タグを記録する場合には、本タグを記録することを強く推奨する。

Tag = 18 (12.H)

Type = ASCII

Count = Any

Default = なし

目的地の北緯（N）or 南緯（S） *GPSDestLatitudeRef*

目的地の緯度の北緯もしくは南緯を示す。ASCII 値で'N'は北緯、'S'は南緯を示す。

Tag = 19 (13.H)

Type = ASCII

Count = 2

Default = なし

'N' = 北緯

'S' = 南緯

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その他　= 予約

目的地の緯度（数値） *GPSDestLatitude*

目的地の緯度を示す、緯度は 3 つの RATIONAL によって表現され、それぞれ、度分秒を表す。緯度の表記を度分秒で表す場合 dd/1,mm/1,ss/1 で表現する。度分単位の場合は例として分単位を小数点第 2 位以下まで表記する場合、dd/1,mmmm/100,0/1 で表現する。

Tag　= 20 (14.H)
Type　= RATIONAL
Count　= 3
Default　= なし

目的地の東経（E）or 西経（W） *GPSDestLongitudeRef*

目的地の東経もしくは西経を示す。ASCII 値で'E'は東経、'W'は西経を示す。

Tag　= 21 (15.H)
Type　= ASCII
Count　= 2
Default　= なし
'E'　= 東経
'W'　= 西経
その他　= 予約

目的地の経度（数値） *GPSDestLongitude*

目的地の経度を示す。経度は.2 つの RATIONAL によって表現され、それぞれ度分秒を示す。緯度の表記を度分秒で表す場合 dd/1,mm/1,ss/1 で表現する。度分単位の場合は例として分単位を小数点第 2 位以下まで表記する場合、dd/1,mmmm/100,0/1 で表現する。

Tag　= 22 (16.H)
Type　= RATIONAL
Count　= 3
Default　= なし

目的地の方角の単位 *GPSDestBearingRef*

目的地への方向の基準を示す。'T'は真方位、'M'は磁気方位を示す。

Tag　= 23 (17.H)
Type　= ASCII
Count　= 2
Default　= 'T'
'T'　= 真方位

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'M' = 磁気方位

その他 = 予約

目的の方角（数値） *GPSDestBearing*

目的地への方向を示す。値は 0.00～359.99 の範囲をとる。

Tag = 24 （18.H）

Type = RATIONAL

Count = 1

Default = なし

目的地までの距離の単位 *GPSDestDistanceRef*

目的地までの距離の単位を示す。'K'がキロメートル、'M'がマイル、'N'が海里を示す。

Tag = 25 （19.H）

Type = ASCII

Count = 2

Default = 'K'

'K' = キロメートル

'M' = マイル

'N' = 海里

その他 = 予約

目的地までの距離（数値） *GPSDestDistance*

目的地までの距離を示す。

Tag = 26 （1A.H）

Type = RATIONAL

Count = 1

Default = なし

注記：Type が ASCII のタグは、すべて NULL で終端しなければならない。

N 値には終端 NULL の分まで含まれるため、N 数の総計が"データ数+1"となり注意が必要である。例えば、GPSLatitudeRef は、Type ASCII で'N'もしくは'S'以外は値をとりえないが、終端として NULL が付け加わるため、N 値は 2 となる。

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2.6.7. 記載対応レベル

タグの種類と記載の対応レベルを示す。

A. 主画像（0th IFD）の記載対応レベル

主画像（0th IFD）のタグの記載対応レベルを Table 13、Table 14、Table 15 に示す。

Table 13　タグ記載対応レベル（1）　- 0th IFD TIFF Tag -

タグ名称	Field Name	タグ番号		非圧縮			圧縮
		Dec	Hex	点順	面順	YCC	
画像の幅	ImageWidth	256	100	◎	◎	◎	※
画像の高さ	ImageLength	257	101	◎	◎	◎	※
画像のビットの深さ	BitsPerSample	258	102	◎	◎	◎	※
圧縮の種類	Compression	259	103	◎	◎	◎	※
画素構成	PhotometricInterpretation	262	106	◎	◎	◎	※
画像タイトル	ImageDescription	270	10E	○	○	○	○
画像入力機器のメーカー名	Make	271	10F	○	○	○	○
画像入力機器のモデル名	Model	272	110	○	○	○	○
画像データのロケーション	StripOffsets	273	111	◎	◎	◎	×
画像方向	Orientation	274	112	○	○	○	○
コンポーネント数	SamplesPerPixel	277	115	◎	◎	◎	※
ストリップ中のライン数	RowsPerStrip	278	116	◎	◎	◎	×
ストリップのデータ量	StripByteCounts	279	117	◎	◎	◎	×
画像の幅の解像度	XResolution	282	11A	◎	◎	◎	◎
画像の高さの解像度	YResolution	283	11B	◎	◎	◎	◎
画像データの並び	PlanarConfiguration	284	11C	△	◎	△	※
画像の幅と高さの解像度の単位	ResolutionUnit	296	128	◎	◎	◎	◎
再生階調カーブ特性	TransferFunction	301	12D	○	○	○	○
使用ソフトウェア名	Software	305	131	△	△	△	△
ファイル変更日時	DateTime	306	132	○	○	○	○
作者名	Artist	315	13B	△	△	△	△
参照白色点の色度座標値	WhitePoint	318	13E	△	△	△	△
原色の色度座標値	PrimaryChromaticities	319	13F	△	△	△	△
JPEG の SOI へのオフセット	JPEGInterchangeFormat	513	201	×	×	×	×
JPEG データのバイト数	JPEGInterchangeFormatLength	514	202	×	×	×	×
色変換マトリクス係数	YCbCrCoefficients	529	211	×	×	△	△
YCC の画素構成（C の間引き率）	YCbCrSubSampling	530	212	×	×	◎	※
YCC の画素構成（Y と C の位置）	YCbCrPositioning	531	213	×	×	◎	◎
参照黒色点値と参照白色点値	ReferenceBlackWhite	532	214	△	△	△	△
撮影著作権者/編集著作権者	Copyright	33432	8298	△	△	△	△
Exif タグ	Exif IFD Pointer	34665	8769	◎	◎	◎	◎
GPS タグ	GPSInfo IFD Pointer	34853	8825	△	△	△	△

記号の意味
◎：必須（必ず記載しなければならない）
○：準必須（ハードウェア等の制限がない限り記載しなければならない）
△：オプション（機器ごとに必要な場合記録する）
×：記載しない
※：JPEG マーカ中に記録されるため記載しない

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Table 14　タグ記載対応レベル（2）　- 0th IFD Exif Private Tag -

タグ名称	Field Name	タグ番号		非圧縮			圧縮
		Dec	Hex	点順	面順	YCC	
露出時間	ExposureTime	33434	829A	△	△	△	△
Ｆナンバー	FNumber	33437	829D	△	△	△	△
露出プログラム	ExposureProgram	34850	8822	△	△	△	△
スペクトル感度	SpectralSensitivity	34852	8824	△	△	△	△
ISO スピードレート	ISOSpeedRatings	34855	8827	△	△	△	△
光電変換関数	OECF	34856	8828	△	△	△	△
Exif バージョン	Exif Version	36864	9000	◎	◎	◎	◎
原画像データの生成日時	DateTimeOriginal	36867	9003	△	△	△	△
ディジタルデータの作成日時	DateTimeDigitized	36868	9004	△	△	△	△
各コンポーネントの意味	ComponentsConfiguration	37121	9101	×	×	×	◎
画像圧縮モード	CompressedBitsPerPixel	37122	9102	×	×	×	△
シャッタースピード	ShutterSpeedValue	37377	9201	△	△	△	△
絞り値	ApertureValue	37378	9202	△	△	△	△
輝度値	BrightnessValue	37379	9203	△	△	△	△
露光補正値	ExposureBiasValue	37380	9204	△	△	△	△
レンズ最小Ｆ値	MaxApertureValue	37381	9205	△	△	△	△
被写体距離	SubjectDistance	37382	9206	△	△	△	△
測光方式	MeteringMode	37383	9207	△	△	△	△
光源	LightSource	37384	9208	△	△	△	△
フラッシュ	Flash	37385	9209	△	△	△	△
レンズ焦点距離	FocalLength	37386	920A	△	△	△	△
メーカーノート	MakerNote	37500	927C	△	△	△	△
ユーザーコメント	UserComment	37510	9286	△	△	△	△
DateTime のサブセック	SubSecTime	37520	9290	△	△	△	△
DateTimeOriginal のサブセック	SubSecTimeOriginal	37521	9291	△	△	△	△
DateTimeDigitized のサブセック	SubSecTimeDigitized	37522	9292	△	△	△	△
対応フラッシュピックスバージョン	FlashPixVersion	40960	A000	◎	◎	◎	◎
色空間情報	ColorSpace	40961	A001	◎	◎	◎	◎
実効画像幅	PixelXDimension	40962	A002	×	×	×	◎
実効画像高さ	PixelYDimension	40963	A003	×	×	×	◎
関連音声ファイル	RelatedSoundFile	40964	A004	△	△	△	△
フラッシュ強度	FlashEnergy	41483	A20B	△	△	△	△
空間周波数応答	SpatialFrequencyResponse	41484	A20C	△	△	△	△
焦点面の幅の解像度	FocalPlaneXResolution	41486	A20E	△	△	△	△
焦点面の高さの解像度	FocalPlaneYResolution	41487	A20F	△	△	△	△
焦点面解像度単位	FocalPlaneResolutionUnit	41488	A210	△	△	△	△
被写体位置	SubjectLocation	41492	A214	△	△	△	△
露出インデックス	ExposureIndex	41493	A215	△	△	△	△
センサー方式	SensingMethod	41495	A217	△	△	△	△
ファイルソース	FileSource	41728	A300	△	△	△	△
シーンタイプ	SceneType	41729	A301	△	△	△	△
CFA パターン	CFAPattern	41730	A302	△	△	△	△

記号の意味
◎：必須（必ず記載しなければならない）
○：準必須（ハードウェア等の制限がない限り記載しなければならない）
△：オプション（機器ごとに必要な場合記録する）
×：記載しない
※：JPEG マーカ中に記録されるため記載しない

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Table 15　タグ記載対応レベル（3）　- 0th IFD GPS Info Tag -

タグ名称	Field Name	タグ番号		非圧縮			圧縮
		Dec	Hex	点順	面順	YCC	
GPS タグのバージョン	GPSVersionID	0	0	△	△	△	△
北緯(N)or 南緯(S)	GPSLatitudeRef	1	1	△	△	△	△
緯度（数値）	GPSLatitude	2	2	△	△	△	△
東経(E)or 西経(W)	GPSLongitudeRef	3	3	△	△	△	△
経度（数値）	GPSLongitude	4	4	△	△	△	△
高度の単位	GPSAltitudeRef	5	5	△	△	△	△
高度（数値）	GPSAltitude	6	6	△	△	△	△
GPS 時間（原子時計の時間）	GPSTimeStamp	7	7	△	△	△	△
測位につかった衛星信号	GPSSatellites	8	8	△	△	△	△
GPS 受信機の状態	GPSStatus	9	9	△	△	△	△
GPS の測位方法	GPSMeasureMode	10	A	△	△	△	△
測位の信頼性	GPSDOP	11	B	△	△	△	△
速度の単位	GPSSpeedRef	12	C	△	△	△	△
速度（数値）	GPSSpeed	13	D	△	△	△	△
進行方向の単位	GPSTrackRef	14	E	△	△	△	△
進行方向（数値）	GPSTrack	15	F	△	△	△	△
撮影した画像の方向の単位	GPSImgDirectionRef	16	10	△	△	△	△
撮影した画像の方向（数値）	GPSImgDirection	17	11	△	△	△	△
測位に用いた地図データ	GPSMapDatum	18	12	△	△	△	△
目的地の北緯(N)or 南緯(S)	GPSDestLatitudeRef	19	13	△	△	△	△
目的地の緯度（数値）	GPSDestLatitude	20	14	△	△	△	△
目的地の東経(E)or 西経(W)	GPSDestLongitudeRef	21	15	△	△	△	△
目的地の経度（数値）	GPSDestLongitude	22	16	△	△	△	△
目的地の方角の単位	GPSDestBearingRef	23	17	△	△	△	△
目的の方角（数値）	GPSDestBearing	24	18	△	△	△	△
目的地までの距離の単位	GPSDestDistanceRef	25	19	△	△	△	△
目的地までの距離（数値）	GPSDestDistance	26	1A	△	△	△	△

記号の意味
◎：必須（必ず記載しなければならない）
○：準必須（ハードウェア等の制限がない限り記載しなければならない）
△：オプション（機器ごとに必要な場合記録する）
×：記載しない
※：JPEG マーカ中に記録されるため記載しない

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B. サムネイル（1st IFD）の記載対応レベル

サムネイル（1st IFD）のタグの記載対応レベルを Table 16 に示す。

Table 16　タグ記載対応レベル（4）　- 1st IFD TIFF Tag -

タグ名称	Field Name	タグ番号		非圧縮			JPEG
		Dec	Hex	点	面	YCC	
画像の幅	ImageWidth	256	100	◎	◎	◎	※
画像の高さ	ImageLength	257	101	◎	◎	◎	※
画像のビットの深さ	BitsPerSample	258	102	◎	◎	◎	※
圧縮の種類	Compression	259	103	◎	◎	◎	◎
画素構成	PhotometricInterpretation	262	106	◎	◎	◎	※
画像タイトル	ImageDescription	270	10E	△	△	△	△
画像入力機器のメーカー名	Make	271	10F	△	△	△	△
画像入力機器のモデル名	Model	272	110	△	△	△	△
画像データのロケーション	StripOffsets	273	111	◎	◎	◎	×
画像方向	Orientation	274	112	△	△	△	△
コンポーネント数	SamplesPerPixel	277	115	◎	◎	◎	※
ストリップ中のライン数	RowsPerStrip	278	116	◎	◎	◎	×
ストリップのデータ量	StripByteCounts	279	117	◎	◎	◎	×
画像の幅の解像度	XResolution	282	11A	◎	◎	◎	◎
画像の高さの解像度	YResolution	283	11B	◎	◎	◎	◎
画像データの並び	PlanarConfiguration	284	11C	△	◎	△	※
画像の幅と高さの解像度の単位	ResolutionUnit	296	128	◎	◎	◎	◎
再生階調カーブ特性	TransferFunction	301	12D	△	△	△	△
使用ソフトウェア名	Software	305	131	△	△	△	△
ファイル変更日時	DateTime	306	132	△	△	△	△
作者名	Artist	306	13B	△	△	△	△
参照白色点の色度座標値	WhitePoint	318	13E	△	△	△	△
原色の色度座標値	PrimaryChromaticities	319	13F	△	△	△	△
JPEG の SOI へのオフセット	JPEGInterchangeFormat	513	201	×	×	×	◎
JPEG データのバイト数	JPEGInterchangeFormatLength	514	202	×	×	×	◎
色変換マトリクス係数	YCbCrCoefficients	529	211	×	×	△	△
YCC の画素構成（C の間引き率	YCbCrSubSampling	530	212	×	×	◎	※
YCC の画素構成（Y と C の位置	YCbCrPositioning	531	213	×	×	△	△
参照黒色点値と参照白色点値	ReferenceBlackWhite	532	214	△	△	△	△
撮影著作権者/編集著作権者	Copyright	33432	8298	△	△	△	△
Exif プライベートタグ	Exif IFD Pointer	34665	8769	△	△	△	△
GPS Info タグ	GPSInfo IFD Pointer	34853	8825	△	△	△	△

記号の意味
- ◎：必須（必ず記載しなければならない）
- ○：準必須（ハードウェア等の制限がない限り記載しなければならない）
- △：オプション（機器ごとに必要な場合記録する）
- ×：記載しない
- ※：JPEG マーカ中に記録されるため記載しない

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2.7. 使用する JPEG マーカセグメント

圧縮ファイルは、圧縮データ（エントロピー符号化データ）の他に APP1、DQT、DHT、SOF、SOS のマーカセグメントをそれぞれひとつずつ含み、SOI にて始まり EOI で圧縮データが終了する。EOI の後に続くデータ列については規定しない。リスタートマーカ（DRI、RSTm）の挿入はオプションである。また、オプションで APP2 を複数個含む場合がある。Exif 規格では APP1、APP2 以外の APPn マーカ、COM マーカは使用しないが、Exif リーダーは Exif にて未定義のマーカを読み飛ばすことを推奨する。

記録順序は、SOI の直後に APP1 を記録し、APP2 を記録する場合には APP1 に続けて記録する。DQT、DHT、DRI、SOF は APP2 より後ろ、SOS よりも前に記録する。これらの記録順序は問わない。

Exif にて使用するマーカセグメントをTable 17に示す。

Table 17　マーカセグメント

	Marker Name	Marker Code	内容
SOI	Start of Image	FFD8.H	圧縮データの先頭
APP1	Application Segment 1	FFE1.H	Exif の付属情報
APP2	Application Segment 2	FFE2.H	Exif 拡張データ
DQT	Define Quantization Table	FFDB.H	量子化テーブル
DHT	Define Huffman Table	FFC4.H	ハフマンテーブル
DRI	Define Restart Interval	FFDD.H	リスタートインターバル
SOF	Start of Frame	FFC0.H	フレームに関する各種パラメータ
SOS	Start of Scan	FFDA.H	コンポーネントに関する各種パラメータ
EOI	End of Image	FFD9.H	圧縮データの終了

以下、Exif 圧縮ファイルで用いる JPEG Baseline DCT で定義されてたマーカセグメントのデータ構造と、本規格で独自に定義した APP1 および APP2 のデータ構造について説明する。

2.7.1. JPEG マーカセグメントの内容

ここでは、APP1、APP2 以外の JPEG マーカセグメントのデータ構造について説明する。

A. 圧縮データスタート　(SOI : Start of Image)

SOI は圧縮データの先頭を示すマーカコードである（Fig. 15 参照）。

アドレスオフセット (Hex)	コード (Hex)	意味
+00	FF	Marker Prefix
+01	D8	SOI

Fig. 15　SOI 構造図

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B. 量子化テーブル定義　**(DQT : Define Quantization Table)**

DQT は量子化テーブルを定義するマーカコードである。

精度 8 ビット（Pq=0）で最大 3 種類のテーブルを記録することができる。量子化テーブルは、すべてをひとつの DQT マーカセグメント内に記録しなければならない(DQT マーカを複数記録してはならない)。テーブルの値は任意とする（Fig. 16 参照)。DQT、DHT、DRI、SOF の記録順は任意とするが、これらは APP1（APP2 を記録する場合は APP2）以降、SOS 以前の領域に記録する。

アドレスオフセット (Hex)	コード (Hex)	意味
+00	FF	Marker Prefix
+01	DB	DQT
+02	00 C5	フィールドの長さ 2+（1+64）*3=197 （Byte）
+04	00	Y: Pq=0, Nq=0
+05	: : : :	量子化テーブル Y:Q0 : : 量子化テーブル Y:Q63
+45	01	Cb : Pq=0, Nq=1
+46	: : : :	量子化テーブル Cb:Q0 : : 量子化テーブル Cb:Q63
+86	02	Cr : Pq=0, Nq=1
+87	: : : :	量子化テーブル Cr:Q0 : : 量子化テーブル Cr:Q63

Fig. 16 DQT 構造図 （量子化テーブル 3 個）

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C. ハフマンテーブル定義 (DHT : Define Huffman Table)

DHT はハフマンテーブルを定義するマーカコードである。

本規格では 1 つのコンポーネントに対し、DC、AC 1 組のハフマンテーブルを持つこととし、各コンポーネントは DHT で定義されるいずれかのハフマンテーブルに対応していなければならない。ハフマンテーブルは、すべてをひとつの DHT マーカセグメント内に記録しなければならない (DHT マーカを複数記録してはならない)。ハフマンテーブルの値は任意であるが、JPEG 参考値を基本テーブルとして用いることもできる。(Fig. 17 参照)

DQT、DHT、DRI、SOF の記録順は任意とするが、これらは APP1 (APP2 を記録する場合は APP2) 以降、SOS 以前の領域に記録する。

アドレスオフセット (Hex)	コード (Hex)	意味
+00	FF	Marker Prefix
+01	C4	DHT
+02	01 A2	フィールドの長さ 2+ (1+16+12+1+16+162) *2 = 418Byte
+04	00	テーブル番号 Y-DC : 00
+05	⋮	DHT パラメータ
+21	10	テーブル番号 Y-AC : 10
+22	⋮	DHT パラメータ
+D4	01	テーブル番号 C-DC : 01
+D5	⋮	DHT パラメータ
+F1	11	テーブル番号 C-AC : 11
+F2	⋮	DHT パラメータ

Fig. 17 DHT 構造図

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D. リスタートインターバル （DRI : Define Restart Interval）

DRI はリスタートマーカ挿入間隔を定義するマーカである（Fig. 18 参照)。DRI の記録およびリスタートマーカの挿入はオプションである。リスタートマーカを挿入する場合は DRI を記録し、その値は、色差サンプリングが 4:2:2、4:2:0 の場合に関わらず 4MCU（Minimum Coding Unit）単位、すなわち 64 画素単位とする（付録 F参照)。DRI はひとつだけ記録する。

DQT、DHT、DRI、SOF の記録順は任意とするが、これらは APP1（APP2 を記録する場合は APP2) 以降、SOS 以前の領域に記録する。

アドレスオフセット (Hex)	コード (Hex)	意味
+00	FF	Marker Prefix
+00	DD	DRI
+02	00	フィールドの長さ 2+2 = 4 （Byte）
+04	XX YY	00 04

Fig. 18 DRI 構造図

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E. フレームヘッダ (SOF : Start of Frame)

SOF はフレームセグメントの始まりに位置し、そのフレームに関する各種パラメータを示すマーカコードである (Fig. 19 参照)。

DQT、DHT、DRI、SOF の記録順は任意とするが、これらは APP1 (APP2 を記録する場合は APP2) 以降、SOS 以前の領域に記録する。

アドレスオフセット (Hex)	コード (Hex)	意味
+00	FF	Marker Prefix
+00	C0	SOF
+02	00 11	フィールドの長さ 2+1+2+2+1+2*3 = 17 (Byte)
+04	08	データの精度 (bit)
+05	XX YY	垂直ライン数 XXYY (Hex)・lines
+07	WW ZZ	水平画素数 WWZZ (Hex) 画素
+09	03	コンポーネント数
+0A	01	コンポーネント番号 (1:Y)
+0B	21or22	H0 = 2, V0 = 1 (4:2:2) or 2 (4:2:0)
+0C	00	量子化テーブル指定
+0D	02	コンポーネント番号 (2:Cb)
+0E	11	H1 =1, V1 = 1
+0F	01	量子化テーブル指定
+10	03	コンポーネント番号 (3:Cr)
+11	11	H2 =1, V2 = 1
+12	02	量子化テーブル指定

Fig. 19 SOF 構造図

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F. スキャンヘッダ （SOS : Start of Scan）

SOS はスキャンに関する各種パラメータを表すマーカコードである（Fig. 20 参照）。

アドレスオフセット (Hex)	コード (Hex)	意味
+00	FF	Marker Prefix
+00	DA	SOS
+02	00 0C	フィールドの長さ 2+1+3*2+3 = 12 （Byte）
+04	03	スキャン中のコンポーネント数
+05	01	コンポーネントセレクタ Y : 01
+06	00	ハフマンテーブルセレクタ Y : 00
+07	02	コンポーネントセレクタ Cb : 02
+08	11	ハフマンテーブルセレクタ C : 11
+09	03	コンポーネントセレクタ Cr : 03
+0A	11	ハフマンテーブルセレクタ C : 11
+0B	00	ブロック内スキャン開始位置
+0C	3F	ブロック内スキャン終了位置
+0D	00	Successive approximation ビット位置

Fig. 20 SOS 構造図

G. 圧縮データ

圧縮データは、Y, Cb, Cr が所定の比率でブロックインターリーブされ、ハフマン符号化されたバイトデータである。各ブロックの DCT 係数の最後の値が 0 の場合には EOB（エンドオブブロック）が挿入される。また、DRI でリスタートマーカ挿入を定義した場合には、4MCU 間隔でリスタートマーカが挿入される。

H. 圧縮データ終了 （EOI : End of Image）

EOI はエントロピー符号化データの終了を表すマーカコードで、SOI と対をなしている（Fig. 21 参照）。EOI の後に続くデータ列については特に規定しない。

アドレスオフセット (Hex)	コード (Hex)	意味
+00	FF	Marker Prefix
+01	D9	EOI

Fig. 21 EOI 構造図

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2.7.2. 圧縮データの APP1 内部構造

APP1 は、アプリケーション領域であることを表す APP1 マーカと、その大きさを表す length、及び TIFF の構造を模倣した主画像の付属情報から成る。APP1 には 64kByte 以上記録できないので、サムネイル画像を記録する際はその大きさに留意する必要がある。

また、APP1 には JPEG 圧縮されている画像の付属情報を記述する。以下にその特長を述べる。

A. APP1 の記録順序

APP1 はファイルの始まりを示す SOI マーカの直後に記載する（Fig. 6 参照)。

B. APP1 内部の構成

APP1 の内部は、APP1 マーカ、Exif の識別コード、および付属情報本体から構成される（Fig. 22 参照)。

アドレスオフセット (Hex)	コード (Hex)	意味
+00	FF	Marker Prefix
+01	E1	APP1
+02		フィールドの長さ
+04	45	'E'
+05	78	'x'
+06	69	'i'
+07	66	'f'
+08	00	NULL
+09	00	パッド
+0A		付属情報

Fig. 22 APP1 マーカの基本構造

C. Exif 識別コード

Exif 識別コードは、APP1 の内部が Exif であることを表す識別コードで、4Byte のコードの後に 00.H を 2Byte 記載する。これは、JPEG アプリケーション・マーカセグメント（APPn）を利用している他のアプリケーションとの重複を避けるために記録する。

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D.付属情報

付属情報は File Header を含む TIFF の構造をとり、2 つの IFD （0th IFD, 1st IFD） を記録できる。0th IFD には、圧縮されている画像（画像本体）に関する付属情報を記録する。1st IFD には、サムネイル画像を記録することができる。

E. TIFF ヘッダ

APP1 内の TIFF ヘッダは 8 Byte のデータで、バイト順序と最初の IFD を表す Offset of IFD を含む。Offset は、Byte Order の初めの Byte のアドレスを基準とする。例えば、TIFF Header 中の Offset of IFD のアドレスは 4 である（Table 1参照)。

F. JPEG マーカ・セグメントとの関係

付属情報の記録フォーマットは、基本的に非圧縮データの付属情報と同様である。ただし、付属情報の中で、JPEG マーカ・セグメントとして別途記載されている情報については、二重に定義されることを避けるため、 APP1 には記載しない。

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2.7.3. 圧縮データの APP2 内部構造

APP2 は、アプリケーション領域であることを表す APP2 マーカ と、その大きさを表す length 、及び FlashPix（付録 F参照）拡張データから成る。拡張データを記録する必要のない場合には、このマーカセグメントを記録しなくて良い。

APP2 マーカセグメントは、FlashPix 用拡張データ記録のために 2 種類存在する。

一つは、拡張データを構成するストレージとストリームのリストが記録されるコンテンツ・リストセグメントで、ファイル中に唯一、記録される。

コンテンツ・リストセグメントのリストで示されるそれぞれのストリームのデータは、ストリーム・データセグメントとして格納され、ストリーム・データを格納している APP2 マーカセグメントは複数個存在する場合がある。

さらに、もう一つは FlashPix により予約されている APP2 セグメントであり、この中身は FlashPix フォーマットにて規定される。

ストリーム・データとして記録できるデータの中身については、将来、別途規定する。複数の音声データを記録可能となるであろう。

A. APP2 の記録順序

APP2 は APP1 マーカに引き続いてコンテンツ・リストセグメント、ストリーム・データセグメントの順に記録する。ストリーム・データセグメントが複数ある場合には、コンテンツリストに記載された順に記録すること（Fig. 6 参照）。

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B. APP2 内部の構成

APP2 の内部は、APP2 マーカ、識別コード（FPXR)、およびコンテンツ・リストまたはストリーム・データから構成される（Fig. 23 参照)。

アドレスオフセット (Hex)	コード (Hex)	意味
+00	FF	Marker Prefix
+01	E2	APP2
+02		フィールドの長さ
+04	46	'F'
+05	50	'P'
+06	58	'X'
+07	52	'R'
+08	00	NULL
+09	00	Version
+0A		コンテンツ・リスト または ストリーム・データ

Fig. 23 APP2 マーカの基本構造

C. FPXR 識別コード

FPXR 識別コードは、APP2 の内部が FPXR データであることを表す識別コードで、4Byte のコードの後に 00.H を 1Byte 記載する。これは、JPEG アプリケーション・マーカセグメント（APPn）を利用している他のアプリケーションとの重複を避けるために記録する。また、次の 1Byte にバージョン番号（00.H）を記録する。

D. コンテンツ・リストの構成

コンテンツ・リストセグメントは、後に FlashPix 上に展開される際に生成されるストレージとストリームのリストを示す。先頭の 2 バイトはエントリの数である。

コンテンツ・リストのエントリフィールドは以下のとおり。

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エンティティ・サイズ *Entity size*

ストリームのサイズまたは FFFFFFFF.H（ストレージの場合）とする。ビッグエンディアンで記録する。

デフォルト値 *Default value*

ストリーム・データセグメント中で明示的にはセットされていないが各バイトのデフォルトとして使用される固定値。

ストレージ／ストリーム名 *Storage/Stream name*

FlashPix への変換時に加えられるストレージとストリームの名前であり、FlashPix の source image object root ストレージからのフルパスが記載される。ディレクトリの切れ目は '/' で表され、プロパティ値の最初の 1 文字に記述される。Unicode コードページの 16bit 文字列で、ヌルで終端される。リトルエンディアン。

Entity class ID

ストレージの ClassID でありストレージのエントリのときのみこのフィールドが書かれる。リトルエンディアンの 16 バイト。

コンテンツ・リストセグメントのデータ構造を Fig. 24 に示す。

アドレスオフセット (Hex)	バイト数 (Hex)	コード (Hex)	意味
+00	1	FF	Marker Prefix
+01	1	E2	APP2
+02	2		フィールドの長さ
+04	4		"FPXR"
+08	1	00	NULL
+09	1	00	Version
+0A	1	01	コンテンツ・リスト
+0B	2		エントリー数
+0C	4		エンティティサイズ 1
+11	1		デフォルト値 0
+12	m_0		ストレージまたはストリーム名 0
+12+m_0	(n_0)		(Entity Class ID 0)
+12+m_0+n_0	4		エンティティサイズ 1
:	1		デフォルト値 1
:	m_1		ストレージまたはストリーム名 1
:	(n_1)		(Entity Class ID 1)
:	:	:	:
:	4		エンティティサイズ I
:	1		デフォルト値 I
:	m_I		ストレージまたはストリーム名 I
:	(n_I)		(Entity Class ID I)

Fig. 24 コンテンツ・リストセグメントの構成

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E. ストリーム・データセグメントの構成

コンテンツ・リストセグメントに示されるストリームの中身の一部または全部が記録される。JPEG マーカセグメントの容量は 64kByte に制限されているが、これを超える容量のストリームを記録する場合には複数のストリーム・データセグメントに分割される。またこのような複数のストリーム・データセグメントにはストリーム・データを直接書くかわりに一定のデフォールトで埋めることができる。ストリーム・データセグメントのデータは以下のとおり。

コンテンツ・リストへのインデックス ***Index into Contents Lists***

コンテンツ・リストセグメントに記録されるエントリの順 (0 から) を示す。

FlashPix ストリームへのオフセット ***Offset into the full FlashPix stream***

FlashPix のストリームにおいてストリーム・データの第 1 バイトが記録される位置のオフセット。

ストリームデータ ***Stream Data***

FlashPix への変換の際に拡張データとして記録される実際のデータストリーム。このデータの長さはストリーム・データセグメントの length で示される。

ストリーム・データセグメントのデータ構造を Fig. 25 に示す。

アドレスオフセット (Hex)	バイト数 (Hex)	コード (Hex)	意味
+00	1	FF	Marker Prefix
+01	1	E2	APP2
+02	2		フィールドの長さ
+04	4		"FPXR"
+08	1	00	NULL
+09	1	00	Version
+0A	1	02	ストリーム・データ
+0B	2	N	コンテンツリストへのインデックス
+0C	4	(Offset)	FlashPix ストリームへの Offset
+11	可変	(値)	ストリームデータ

Fig. 25 ストリーム・セグメントの構成

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F. 予約セグメント ***(Reserved for future use by the FlashPix format)***

このマーカセグメントは将来の使用のために確保されている。例を Fig. 26 に示す。

アドレスオフセット (Hex)	バイト数 (Hex)	コード (Hex)	意味
+00	1	FF	Marker Prefix
+01	1	E2	APP2
+02	2		フィールドの長さ
+04	4		"FPXR"
+08	1	00	NULL
+09	1	00	Version
+0A	1	03	FlashPix 用に予約
+0B	⋮	⋮	

Fig. 26 FlashPix 用予約データセグメントの構成

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2.8. データの記載

2.8.1. 圧縮画像のサイズに関する規定

圧縮画像フォーマットはJPEGを採用しているが、JPEGは8×8画素のブロック単位で圧縮するため、画像の幅と高さはMCUの倍数(幅は16の倍数画素、高さはYCbCr4:2:2の場合には8の倍数、YCbCr4:2:0の場合には16の倍数画素)であることが望ましい。しかし、すべての画像データのサイズがこれらの制限の範囲に収まるとは限らない。

一方、FlashPixへの変換を目的として圧縮データに4MCU毎にリスタート・マーカを挿入する場合、画像の幅は4MCU(64画素)の倍数でなければならない(高さには制限がない)。

そこで、本規格では実効画像サイズに対して記録サイズを調整するためのデータ挿入(パディング)について以下のように規定する。

A. ライター側の画像サイズ記録手順

Exifライターは、以下に示す規定に沿って決められた画像幅、高さ情報、および必要に応じてパディングされた画像を圧縮して記録する。

幅方向にパディングを施す場合は、必ず右端にパディングデータを付加しなければならない。また、高さ方向にパディングを施す場合は、必ず下端にパディングデータを付加しなければならない。

パディングに用いるデータの値については規定しない。

【画像の幅に関する規定】

画像の幅情報は、実効画像幅タグ(PixelXDimension)、SOFマーカ情報、そしてJPEG圧縮データの3つがある。このうち、実効画像幅タグの記録は必須である。

画像の幅は以下の場合に右端にパディングを行う。パディングする値については規定しない。

- 画像の幅が16の倍数でないときにJPEGブロックの余りを埋める場合
- 画像の幅が64の倍数でないときにリスタート・マーカを挿入するために64の倍数に対する不足を埋める場合

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パディングを行う場合、行わない場合を含めた各画像幅に関する情報の記録方法をFig. 27に示す。SOFの値は、実効画像幅を記録する場合とパディング後の画像幅を記録する場合があるため注意が必要である。

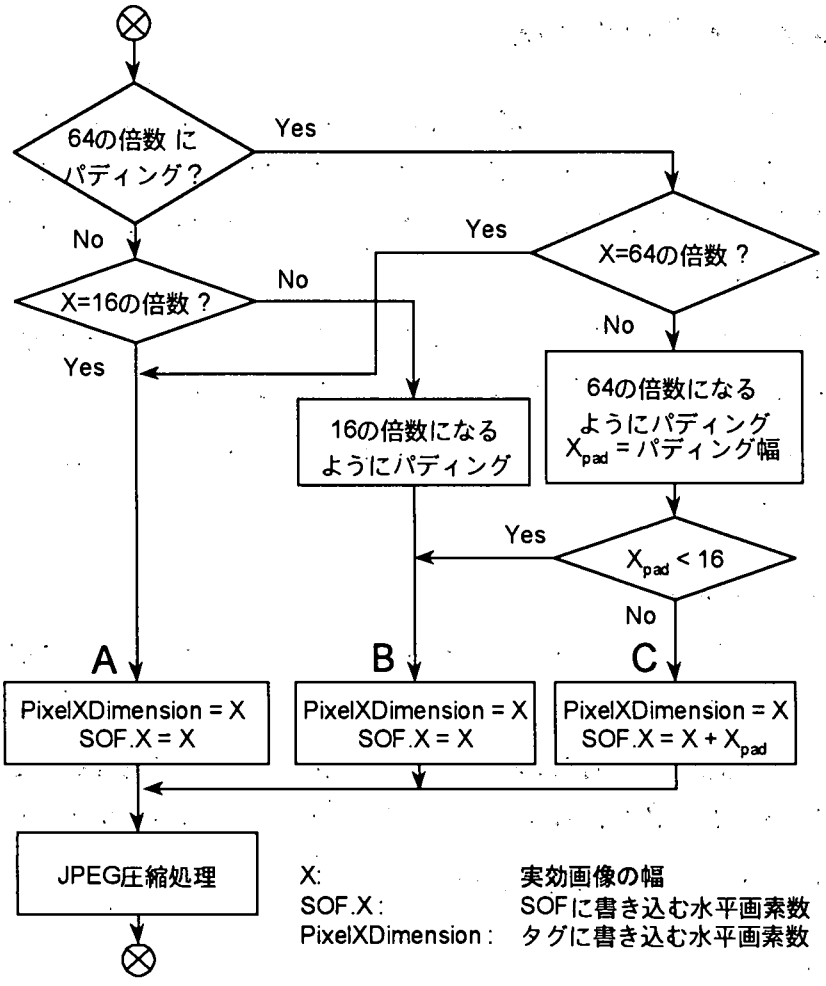


Fig. 27 画像データ幅の記録手順

Fig. 27中のA、B、Cの場合にそれぞれ記録する画像幅方向の情報とパディングデータの幅の例をTable 18に示す。

Table 18 幅方向の情報とパディングデータの記録例

	実効画像幅	実効画像幅タグ	SOF 情報	圧縮データ	パディング幅
A	640	640	640	640	0
B	634	634	634	640	6 (< 1MCU)
C	620	620	640	640	20 (> 1MCU)

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【画像の高さに関する規定】

画像の高さ情報は、実効画像高さタグ（PixelYDimension）、SOF マーカ情報、そして JPEG 圧縮データの３つがある。このうち、実効画像高さタグの記録は必須である。

画像の高さは以下の場合に下端にパディングを行う。パディングする値については規定しない。

- 画像の高さが 16 の倍数でないときに JPEG ブロックの余りを埋める場合

リスタートマーカを挿入する際にはパディングは不要である。パディングを行う場合、行わない場合を含めた各画像高さに関する情報の記録方法をFig. 28に示す。常に SOF には実効画像高さタグと同じ値を記録する。

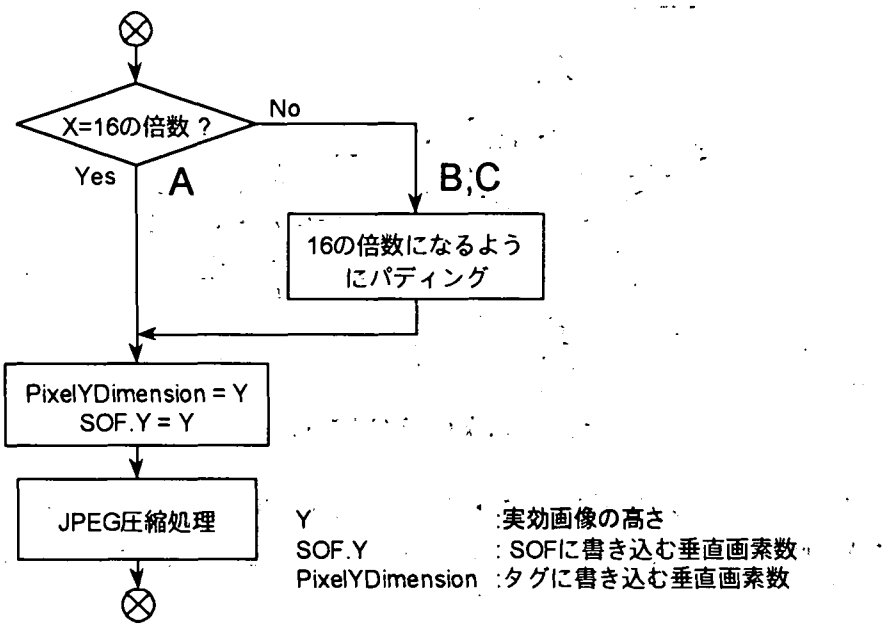


Fig. 28 画像データ高さの記録手順

Fig. 28中の A、B、C の場合にそれぞれ記録する画像高さ方向の情報とパディングデータの高さの例を Table 19に示す。

Table 19 高さ方向の情報とパディングデータの記録例（YCbCr4:2:2 の場合）

	実効画像高さ	実効画像高さタグ	SOF 情報	圧縮データ	パディング高さ
A	480	480	480	480	0
B	474	474	474	480	6 (< 1MCU)
C	460	460	460	464	4 (< 1MCU)

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B. リーダー側の画像サイズ再生手順

Exif リーダー（特に専用ソフトウェア）はFig. 29に示す手順で画像を再生することを推奨する。まず、SOF の情報を元に画像を伸長する。次に、この画像に対して、実効画像幅・高さタグの情報に従って画像の右端、下端をトリミングし、実効画像データを再生する。SOF の情報と実効画像幅・高さタグの情報が等しい場合には、実効画像幅・高さタグによるトリミングは不要である。

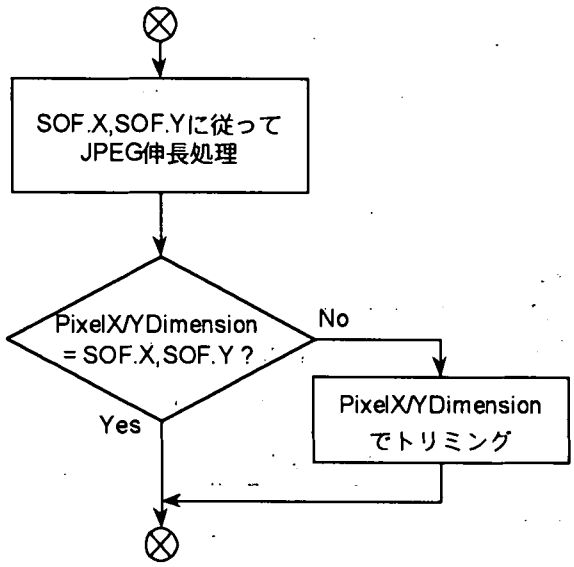


Fig. 29 画像データの再生手順

市販ソフトウェアには、実効画像幅、高さタグを扱う機能が無いことがある。実効画像幅と SOF に記録されている水平画素数が異なる場合は、パディングデータが表示されることがあるため注意が必要である。

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2.8.2. サムネイルに関する規定

A. ライター側

サムネイルを記録するかしないかは、Exif ライターごとの仕様において選択可能とする。したがってサムネイルつきの Exif ファイルとサムネイルのない Exif ファイルが混在することを許す。詳細は2.5.5 参照のこと。

B. リーダー側

サムネイルが記録されたファイルと記録されないファイルの両方について主画像を破綻なく再生できるように設計する。カメラや再生機での再生、カメラから PC への画像転送と表示、あるいは PC ソフト（カメラ用ソフト、単独ソフトウェアなど）においてサムネイルを利用してインデックス表示などの機能を備える場合も、サムネイルなし画像ファイルを再生するケースを想定して、適宜サムネイルを作成するあるいはサムネイルなし表示をおこなうなどの対応をおこなう。

2.8.3. ファイル名に関する規定

A. ライター側

ファイル名及びその文字数は規定しない。但し、ファイル名には ASCII 英数文字を使用する（日本語ファイル名等は使用しない)。又、ファイル名は拡張子を含まずに 8 文字以内とする（ロングファイルネームは使用しない)。拡張子は圧縮データファイルでは".JPG"、非圧縮データファイルでは".TIF"とする。

2.8.4. バイトオーダに関する規定

A. リーダー側

Exif リーダーは、リトルエンディアン形式及びビッグエンディアン形式で記載された Exif ファイルを共に再生できることを推奨する。

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3. Exif 音声ファイル規定

3.1. Exif 音声ファイル規定の概要

本章では、音声ファイルの記録方法を規定し、以下の項目について記載する。

- フォーマットバージョンの定義
- 音声データに関する規定
- 音声データの基本構造
- 使用するチャンク
- ファイル名に関する規定

3.2. フォーマットバージョン

本規格で規定するフォーマットバージョンは 4Byte で記述する（3.6.3章参照）。アドレスの若い方から各バイトを、A1、A2、B1、B2 とし、A1、A2 を規格バージョン上位、B1、B2 を規格バージョン下位とする。今後 Exif のバージョンを更新する場合は、以下の基準で実施する。

- 再生機が従来の情報を正しく認識でき、かつ新たに追加した書き方や情報を読み飛ばすことが期待できる時は規格バージョン下位（B1、B2）を更新する。
- 更新前の規格に従って動作する再生機でファイルを再生すると、誤動作を起こさせる可能性があるような仕様変更を伴った場合は、規格バージョン上位（A1、A2）を更新する。

再生機は、対応する規格バージョン以前のバージョンのファイルを再生できることが望ましい。

3.3. 用語の定義

本規格では、以下のように定義している。

- ""で囲まれた文字は文字列を表し、""Z は NULL（00.H）で終わる文字列を意味している。
- 後尾に".H"が付加されている数値は 16 進数を意味している。
- その他特に記載が無い場合は 10 進数を意味している。

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3.4. 音声データに関する規定

3.4.1. サンプリング周波数

サンプリング周波数は、8.000kHz、11.025kHz、22.050kHz、44.100kHz のいずれかとする。ただし、μLAW PCM は ITU-T G.711 に準拠しているので、8.000kHz のみとする。

3.4.2. ビット数

ビット数は 8bit、16bit のいずれかとする。ただし、μLAW PCM は ITU-T G.711 に準拠しているので、8bit のみとする。IMA-ADPCM は IMA（Interactive Multimedia Association）の規定に従い 4bit のみとする。

3.4.3. チャネル数

チャネル数はモノラル、ステレオ（2ch）のいずれかとする。

3.4.4. 圧縮方式

圧縮方式は以下の 3 方式を規定する。

- 非圧縮音声データ　：PCM
- 非圧縮音声データ　：μ-Law PCM（ITU-T G.711[vii] 準拠）
- 圧縮音声データ　　：IMA-ADPCM[viii]

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3.5. 音声データの基本構造

Exif音声ファイルは、Windows™の標準オーディオファイルである「RIFF WAVE Form Audio File形式[vi]」を基本としており、これにDSCの各種付属情報が記録できるようにしたものである。Exif音声ファイルは、WAVE Form Audio Fileとデータ互換であり、Windows™付属のアクセサリ等で再生できることが特長である。

DSCアプリケーションで必要とされる付属情報のうち、一般の付属情報をINFOリストに、Exif固有の付属情報はExif固有のチャンクに記録する。Exif固有のチャンクは、チャンクの拡張性を利用して必要な情報を追加できるように新設する。Exif固有のチャンクのデータ記載方法はINFOリストに倣っている。

3.5.1. WAVE Form Audio Fileの基本構造

WAVE Form Audio File形式は、RIFF（Resource Interchange File Format）と呼ばれるタグ付きファイル構造を基本としている。

RIFFファイルは、「チャンク」と呼ばれる基本データブロックから成り立っている。

(1) チャンク

チャンクはC言語の構文を用いると［式 1］のような構造体として定義される。チャンクの構造を図示するとFig. 30のよう表される。

```
typedef struct{
        unsigned long   ckID;           // 4文字コード
        unsigned long   ckSize;         // メンバ <ckData> のサイズ
        unsigned char   ckData[ckSize]; // チャンクに含まれるデータ本体
} CK;       - - -  [式 1]
```

アドレスオフセット (Hex)	意味
+00	ckID（4Byte）
+04	ckSize（4Byte）
+08	ckData[ckSize]

Fig. 30 チャンクの構造

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[説明]

- ckID（chunkD：チャンク ID、4 文字コード）は 1 から 4 個の ASCII 英数字の並びで、左詰めに置き、4 個未満の場合は空白文字で残りを埋める。空白文字は文字と文字との間に入れることはできない。この 4 文字コードは、チャンクデータ（後述）の内容を識別するためコードである。チャンクを処理するソフトウェアは、未知のチャンク ID 持つチャンクをスキップすることができる。
- ckSize（chunk Size:チャンクサイズ）は、ckData[ckSize]（chunk Data:チャンクデータ）のサイズ（バイト数）を表す 32 ビット符号無し整数である。この数値には ckID、ckSize 自身、ckData の最後に付いているパッドバイトは含まれない。バイト順序はリトルエンディアン（LSB が先頭、MSB が最後）である。RIFF ファイルの場合、複数バイトから成る数値は全てリトルエンディアンで表記される。連続してチャンクが置かれているときは、次のチャンクの先頭アドレス（ckID）を知るために、ckSize（チャンクサイズ）の値を正しく読み取らなければならない。
- ckData[ckSize]（chunk Data:チャンクデータ）は、そのチャンクに含まれている実際のデータであり、固定サイズのバイナリデータでも、可変サイズのバイナリデータでも構わない。ckData の先頭は、RIFF ファイルの開始位置にワード（16 ビット）単位で境界合わせされている。データのサイズが奇数バイトの場合は、'0'の値を持つパッドバイトが 1 つ ckData の後に付加される。但し、ckSize（chunk Size:チャンクサイズ）には、このパッドバイトの数は含まれない。
- ckData[ckSize]（chunk Data:チャンクデータ）は単なるバイト列ではなく、それ自身構造を持つことが出来る。即ち、ckData 自身がチャンク（サブチャンク）を含むことが出来る。言い換えると、チャンクは階層化することが可能である。サブチャンク含むことが出来るチャンクは、特定のチャンクに限られている。後述の「RIFF チャンク」や「LIST チャンク」は、サブチャンクを含むことの出来るチャンクである。これらのチャンクのサブチャンクは、一般に複数存在することが可能である。他の全てのチャンクは、ckData 内にバイナリデータ要素を 1 つだけ格納する。

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(2) RIFF フォーム

「RIFF フォーム」とは、"RIFF" というチャンク ID（ckID）を持つチャンクを指すと共に、RIFF の構造に従ったファイル形式（RIFF ファイル）をも意味している。

「RIFF チャンク」の ckData（チャンクデータ）は、formType（フォームタイプ）とよばれる先頭の 4 文字コードと、それに続く一連のサブチャンクから成っている。

RIFF チャンクは最上位の階層のチャンクであり、RIFF フォームには必須であると共に、1 つしか存在しない。他の全てチャンクは RIFF チャンクのサブチャンクである。

フォームタイプは一般に、データの内容等を識別するためのコードであり、どのようなサブチャンクが含まれているかも、このコードによって分かる。フォームタイプは登録しなればならない。登録されたフォームタイプは大文字で表記される。

それと同様、チャンク ID（ckID）も登録しなければならない。全てが大文字のチャンク ID は、様々なフォームタイプで使用できる汎用のチャンクを表す。特定のフォームタイプで使用されるチャンク ID は、全て小文字で表記される。

RIFF チャンクを図示するとFig. 31のように表される。

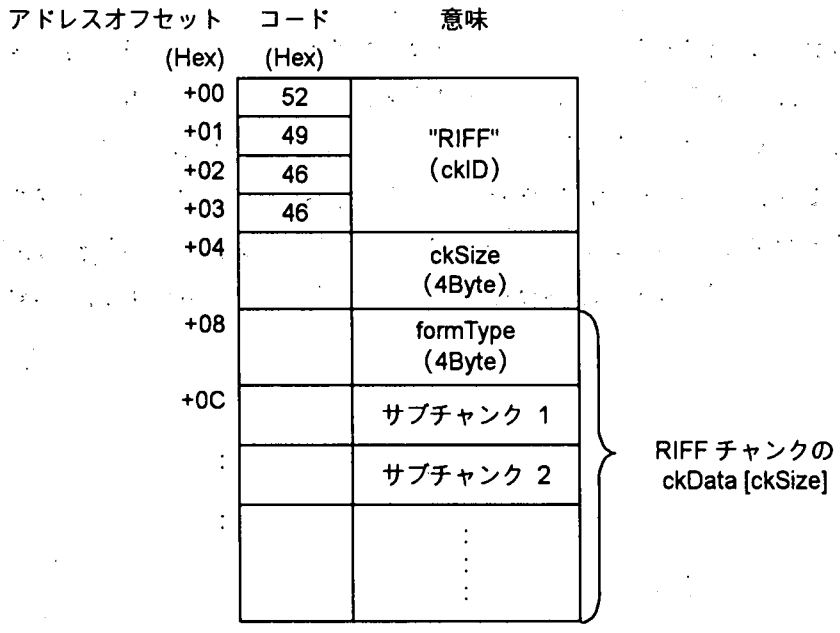


Fig. 31 RIFF チャンクの構造

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［参考］

代表的なフォームタイプをTable 20に挙げる。これらは登録済みのフォームタイプなので、全て大文字で表記される。

Table 20 代表的なフォームタイプ

フォームタイプ	名称
PAL	パレットファイル形式
RDIB	RIFF DIB（Device Independent Bitmap） 形式
RMID	RIFF MIDI 形式
RMMP	RIFF マルチメディアムービーファイル形式
WAVE	WAVE Form Audio File 形式

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(3) WAVE Form Audio File 形式

「WAVE フォーム」は RIFF フォームの 1 つであり、ディジタル化されたサウンドを扱うためのファイルである。フォームタイプは文字通り'WAVE'である。

WAVE Form Audio File の拡張子は ".WAV"である。

WAVE Form Audio File 形式のデータ構造をFig. 32のに示す。

Fig. 32から明らかなように、「RIFF チャンク」のチャンクデータ（ckData [ckSize]）は一般に formType ("WAVE")、fmt-ck（format chunk：フォーマットチャンク）、fact-ck（fact chunk：ファクトチャンク）、data-ck（data chunk：データチャンク）から成っている。fmt-ck と data-ck は必須のチャンクであるが、fact-ck は WAVE フォームのフォーマットタイプ（format type、音声コーディングの形式）に依存して、必須な場合と不要な場合がある。

この他にオプションのサブチャンクを記録し、ここに各種の付属情報を格納することができる。

但しFig. 32ではオプションのチャンクを除いてある。

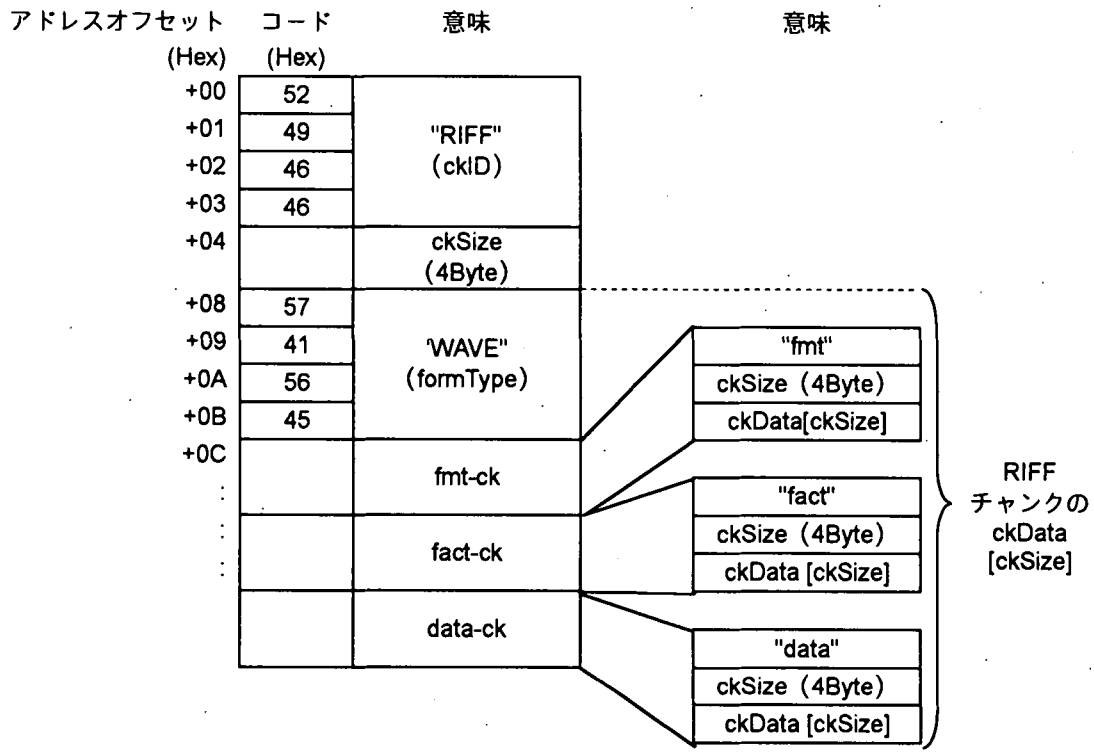


Fig. 32 WAVE Form Audio File 形式のデータ構造

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【fmt-ck】

fmt-ck（format chunk:フォーマットチャンク）は、後述の data-ck（data chunk:データチャンク）に含まれている音声データの形式を指定するフォーマット情報を含んでいる。fmt-ck の ckID（chunk ID:チャンク ID）は、"fmt "である。

"fmt "は 3 文字なので、最後に空白文字（20.H）が入っている。

fmt-ck は必須であり、必ず data-ck の前に記録しなければならない。

fmt-ck はチャンクの構造をしているため、ckSize と ckData[ckSize]をそのメンバとして含んでいるが、ckData の内容はフォーマットタイプ（音声コーディングの形式）に依存する。この ckData は、[式 2]で表される構造体と、[式 3]で表されるバイト列から成っている。

```
struct{
        unsigned int    wFormatTag;         //フォーマットタイプ
        unsigned int    nChannels;          // チャネル数
        unsigned long   nSamplesPerSec;     // サンプリング・レート
        unsignrd long   nAvgBytesPerSec;    // 平均バイト数/秒
        unsigned int    nBlockAlign;        // ブロック境界合せ
        unsigned int    wBitsPerSample;     // ビット数/サンプル
        unsigned int    cbSize;             // 追加バイト数
} WAVEFORMATEX;                                         --- [式 2]
unsigned char   extByte[cbSize];            // 追加バイト列  --- [式 3]
```


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フォーマット情報の各メンバの意味をTable 21に記す。

Table 21　フォーマット情報の各メンバー

メンバ	説明
wFormatTag	WAVE フォームのフォーマットタイプ（音声コーディングの形式）を示す符号無し16 ビット整数。代表的なフォーマットタイプの例を以下に示す。 PCM（パルスコードモジュレーション）形式 : 0001.H μ-Law 形式（ITU-T G.711） : 0007.H IMA-ADPCM（DVI-ADPCM）形式 : 0011.H
nChannels	チャネル数を示す符号無し 16 ビット整数である。モノラルは 1、ステレオは 2 となる。
nSamplesPerSec	サンプリングレート（秒当たりのサンプル数）を示す符号無し 32 ビット整数である。各チャネルはこの速度で再生される。 PCM 形式の場合、このメンバの共通の値は 8.0kHz、11.025kHz、22.05kHz、44.1kHz である。
nAvgBytesPerSec	一秒当たりの平均バイト数を表す符号無し 32 ビット整数であり、data-ck にあるデータはこの値で転送される。 PCM 形式の場合、nAvgBytesPerSec は、以下の式に等しくなる。 nChannels * wBitsPerSample / 8
nBlockAlign	data-ck 内のデータの（バイト単位の）ブロック境界合わせを示す符号無し 16 ビット整数である。PCM 形式の場合、nBlockAlign は以下の式に等しくなる。 nChannels * wBitsPerSample / 8
wBitsPerSample	各チャネル毎のサンプル当たりのビット数を示す符号無し 16 ビット整数である。 PCM 形式の場合、この値は 8 又は 16 である。 圧縮サウンドデータの場合で、この値が定義できないようなときは ‘0’ にする。
cbSize	WAVEFORMATEX 構造体の後に付加された追加のフォーマット情報 extByte[cbSize] のサイズ（バイト数）を示す符号無し 16 ビット整数である。この情報は、非 PCM 形式において追加された属性を格納するために使用する。追加情報が不要の場合は、この値は'0'とする。 PCM 形式の場合、このメンバは不要である（cbSize のフィールド自身を設ける必要がない）。
extByte[cbSize]	WAVEFORMATEX 構造体の後に付加された追加のフォーマット情報を表すバイト列である。 この情報の意味は、フォーマットタイプに依存する。cbSize の値が'0'の場合は、このフィールドは存在しない。 PCM 形式の場合は、cbSize のフィールドと、extByte[cbSize]のフィールドの両方共不要である。

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fmt-ck の構造を図示するとFig. 33のように表される。

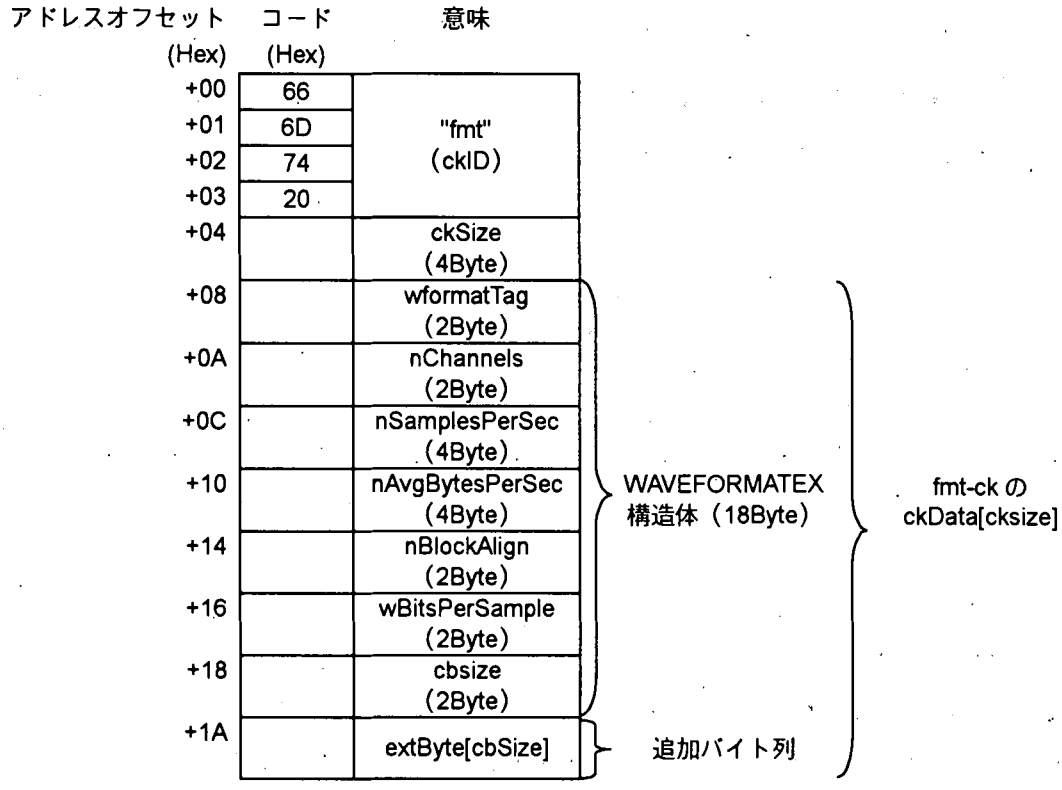


Fig. 33　fmt-ck の構造

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【fact-ck】

fact-ck（fact chunk:ファクトチャンク）は、WAVE ファイルの内容に関して、ファイル依存の情報を格納するために用いられる。fact-ck の ckID（chunk ID:チャンク ID）は、文字通り"fact"である。

fact-ck は、将来の WAVE ファイルで必要とされる情報を格納するために、拡張することを想定しているが、現在は唯一つの情報のみ定義されている。

現在 fact-ck に格納できるのは、[式 4] で定義される情報である。

```
unsigned long   dwSampleLength;                    // サンプル長     --- [式 4]
```

Table 22 fact-ck のメンバー

メンバ	説明
dwSampleLength	音声データのサンプル数（サンプル長）を表す符号無し 32 ビット整数である。 fmt-ck の中の nSamplePerSec の情報と組み合わせると、データ長を秒数で表す事ができる（録音時間）。

現在定義されている情報は dwSampleLength だけなので、fact-ck の ckSize（chunk Size:チャンクサイズ）の値は '00000004.H' として良いが、将来は情報が追加されて ckSize の値が変わる可能性もある（そのときは'00000004.H'よりも大きな値になる）。その場合、プログラムは解釈できないフィールド飛ばして、次のチャンクの処理に進むこと。そのためにも、ckSize の値は正しく読み取る必要がある。

fact-ck の構造を図示するとFig. 34のようになる。ckSize の値は、'00000004.H' に固定してある（Write のときはこの値を使う）。

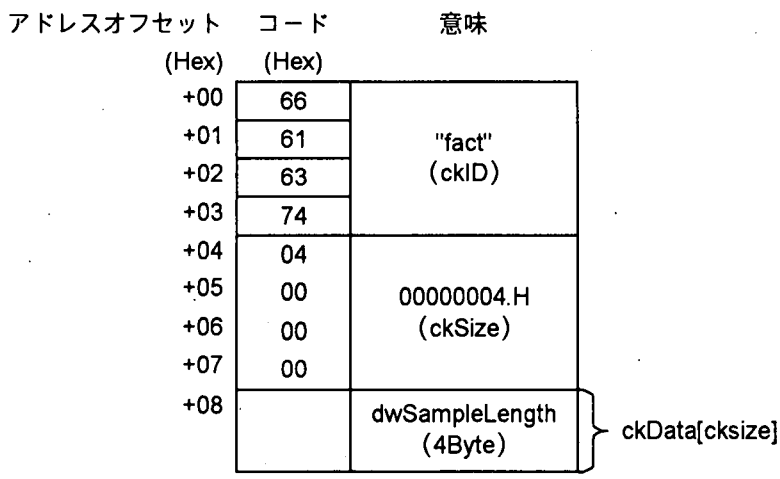


Fig. 34 fact-ck の構造

【data-ck】

data-ck（data chunk:データチャンク）は、音声データを格納するためのチャンクである。ckID（chunk

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ID;チャンク ID）は、文字通り"data"である。

data-ck の ckData（chunk Data:チャンクデータ）は、音声データ本体のみから成る。但し、後にパッドバイトが付加されることがある。

音声データは、そのフォーマットタイプに応じてコード化されている。音声データを再生するときは、fmt-ck の情報を利用する。

data-ck の ckSize（chunk Size:チャンクサイズ）は、コード化された音声データのみのサイズを表す。data-ck の構造を図示するとFig. 35のように表される。

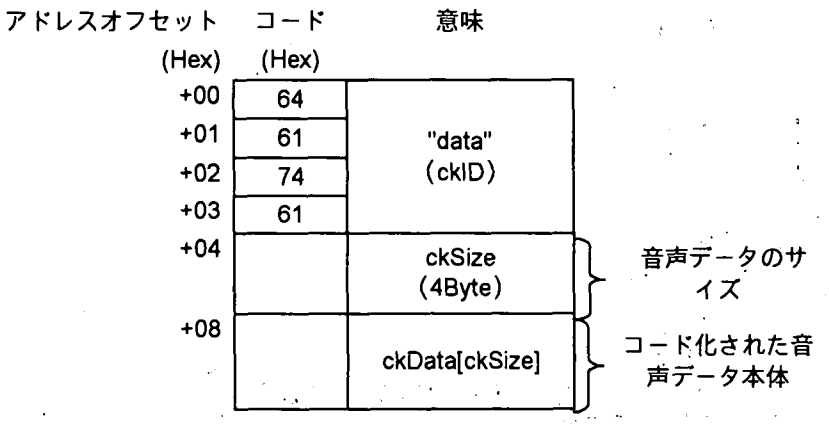


Fig. 35 data-ck の構造

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3.5.2. PCM Audio Data の基本構造

PCM 音声データは、リニアな量子化（A/D 変換）特性を持つ音声データであって、圧縮のための符号化処理はなされていない。再生時の復号処理は不要で、読み出すだけで再生できる点が特長である。

フォーマットタイプが PCM（パルスコードモジュレーション）形式の場合の基本構造をFig. 36に示す。

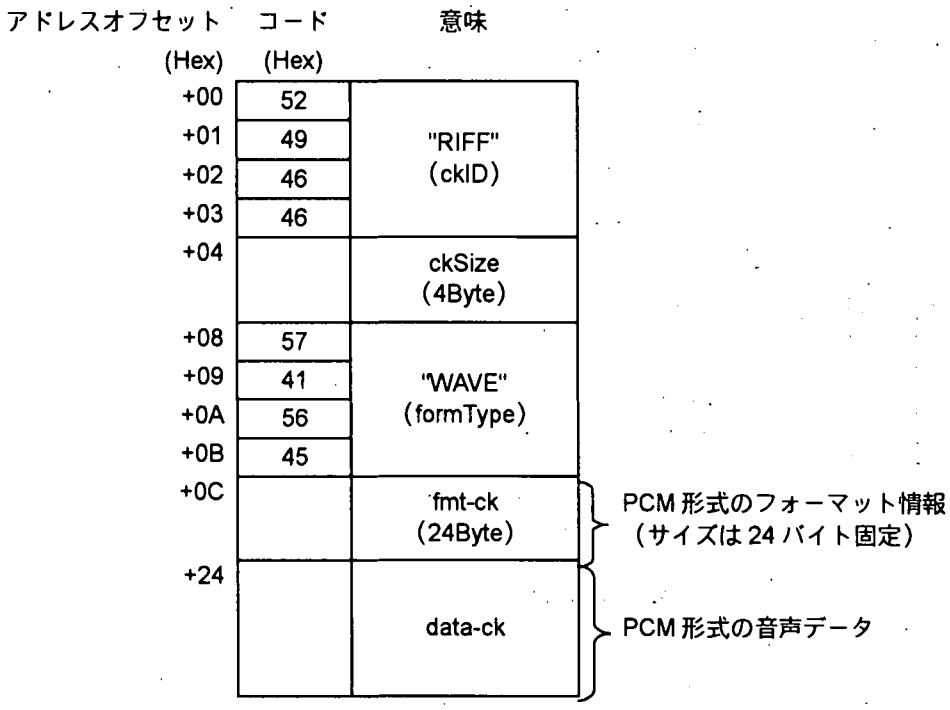


Fig. 36 PCM 形式の基本構造

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PCM 形式の場合、fmt-ck に格納される各情報の具体的な値はTable 23による。

Table 23 PCM 形式の fmt-ck 情報

PCM（パルスコードモジュレーション）形式	
メンバ	数値
ckSize（fmt-ck）	00000010.H（16Byte、cbSize が不要なため）
wFormatTag	0001.H（PCM 形式）
nChannels	各モードの値は以下のとおり。 0001.H（モノラル） or 0002.H（ステレオ）
nSamplesPerSec	各モードの値は以下のとおり。 00001F40.H（8.0kHz） 00002B11.H（11.025kHz） 00005622.H（22.05kHz） 0000AC44.H（44.10kHz）
nAvgBytesPerSec	各モードの値は以下のとおり。 00001F40.H（8.0kHz,8bit モノラル） 00003E80.H（8.0kHz,8bit ステレオ） 00003E80.H（8.0kHz,16bit モノラル） 00007D00.H（8.0kHz,16bit ステレオ） 00002B11.H（11.025kHz,8bit モノラル） 00005622.H（11.025kHz,8bit ステレオ） 00005622.H（11.025kHz,16bit モノラル） 0000AC44.H（11.025kHz,16bit ステレオ） 00005622.H（22.05kHz,8bit モノラル） 0000AC44.H（22.05kHz,8bit ステレオ） 0000AC44.H（22.05kHz,16bit モノラル） 00015888.H（22.05kHz,16bit ステレオ） 0000AC44.H（44.10kHz,8bit モノラル） 00015888.H（44.10kHz,8bit ステレオ） 00015888.H（44.10kHz,16bit モノラル） 0002B110.H（44.10kHz,16bit ステレオ） 定義式：nSamplesPerSec * nBlockAlign
nBlockAlign	各モードの値は以下のとおり。 0001.H（8bit モノラル） 0002.H（8bit ステレオ） 0002.H（16bit モノラル） 0004.H（16bit ステレオ） 定義式：nChannels * wBitsPerSample / 8
wBitsPerSample	各モードの値は以下のとおり。 0008.H（8bit） or 0010.H（16bit）
cbSize	不要
extByte[cbSize]	不要

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PCM 形式の音声データの場合、各サンプルのデータ形式は 8 ビット、又は 16 ビットの整数である。これらのサンプルのデータ形式とその値をTable 24に示す。

Table 24　サンプルデータの形式と値

サンプルサイズ	データ形式	最小値	中間値	最大値
8 ビット PCM	符号無し整数	0(00.H)	128(80.H)	255 (FF.H)
16 ビット PCM	符号付き整数	-32768(8000.H)	0(0000.H)	32767(7FFF.H)

data-ck に含まれる PCM 音声データはFig. 37のようにパッキングする。これらの図において、左側のバイトが下位のアドレス、右側のバイトが上位のアドレスに格納される。



Fig. 37 PCM 音声データのパッキング

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3.5.3. μ-Law Audio Data の基本構造

μ-Law 音声データは、音声のデータの各サンプルが非線形（対数型）の量子化特性を持ったデータから成る。これにより、8 ビットのサイズで 16 ビット相当のデータを表すことができる。再生するときは、リニアな 16 ビットデータに変換してからリニアな D/A 変換器を通すか、又はμ-Law の量子化特性と逆の特性を有する 8 ビットの非線形 D/A 変換器を通してアナログの音声信号を得る方法がある。この非線形な量子化特性の詳細と、8 ビットμ-Law データ／16 ビットリニアデータとの間の変換については、ITU-T G.711[vii]の規格を参照すること。

フォーマットタイプがμ-Law（ITU-T G.711）形式の場合、その基本構造はFig. 38のように表される。

PCM 形式の場合との違いは、fmt-ck のサイズが大きいこと（cbSize のフィールドが存在する）、fact-ck が存在することの 2 点である。

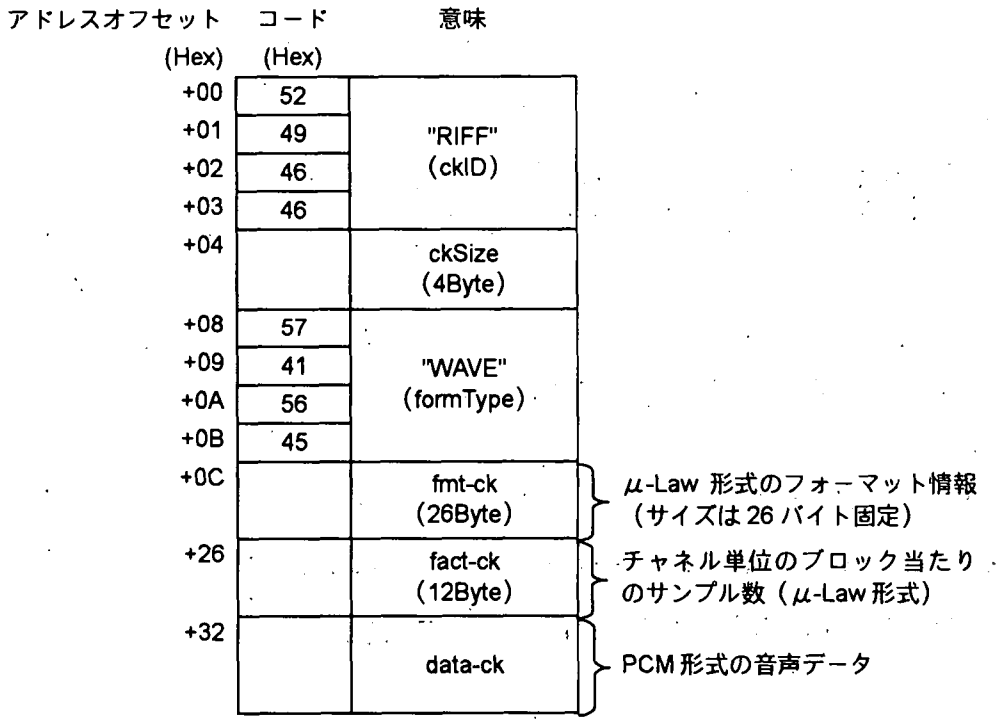


Fig. 38 μ-Law形式の基本構造

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μ-Law 形式の場合、fmt-ck と fact-ck に格納される各情報の具体的な値はTable 25のとおり。

Table 25 μ-Law形式の fmt-ck、fact-ck 情報

μ-Law（ITU-T G.711）形式	
メンバ	数値
ckSize（fmt-ck）	00000012.H （18Byte、WAVEFORMATEX のみ）
wFormatTag	0007.H（μ-Law 形式）
nChannels	各モードの値は以下のとおり。 0001.H（モノラル） or 0002.H（ステレオ）
nSamplesPerSec	00001F40.H（8.0kHz）
nAvgBytesPerSec	各モードの値は以下のとおり。 00001F40.H（8.0kHz, 8bit モノラル） 00003E80.H（8.0kHz, 8bit ステレオ） 定義式：nSamplesPerSec * nBlockAlign
nBlockAlign	各モードの値は以下のとおり。 0001.H（8bit モノラル） 0002.H（8bit ステレオ） 定義式：nChannels * wBitsPerSample / 8
wBitsPerSample	0008.H（8bit）
cbSize	0000.H（extByte[cbSize]は、存在せず）
extByte[cbSize]	不要
dwSampleLength	実際に再生可能なサンプル数を記録することを推奨する。 定義式：(ckSize_of_data-ck) / nBlockAlign

data-ck に含まれるμ-Law 音声データはFig. 39のようにパッキングする。図において、左側のバイトが下位のアドレス、右側のバイトが上位のアドレスに格納される。

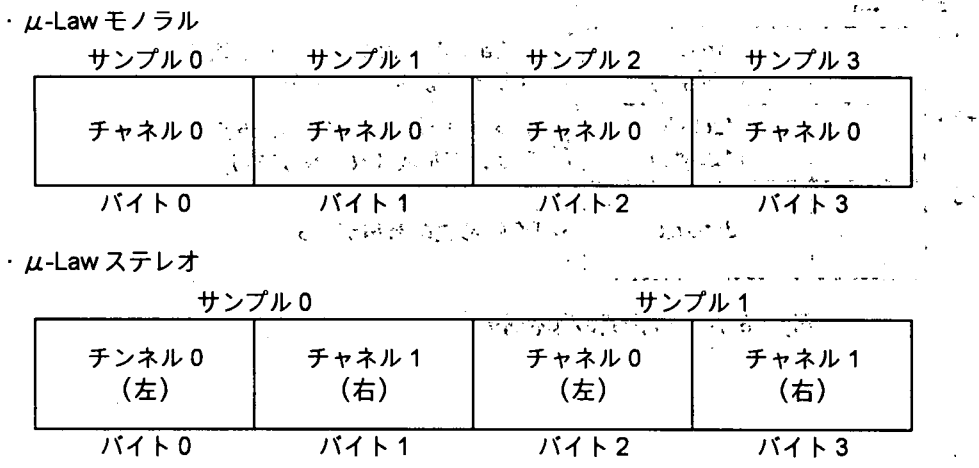


Fig. 39 μ-Law 音声データのパッキング

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3.5.4. IMA-ADPCM Audio Data の基本構造

IMA-ADPCM 音声データは、16 ビットリニア PCM 音声データを圧縮符号化して得られる 4 ビットの音声データである。IMA-ADPCM は、別名 DVI-ADPCM とも呼ばれているように、その圧縮アルゴリズムは元々 Intel's DVI Group （DVI:Digital Video Interactive）で開発されたものであり、IMA（Interactive Multimedia Association）によって標準の音声データ形式の１つに採用されたという経緯がある。

IMA-ADPCM のアルゴリズムの詳細は、IMA Digital Audio Doc-Pac[xvi]等の資料を参照すること。

フォーマットタイプが IMA-ADPCM （DVI-ADPCM）形式の場合、その基本構造をFig. 40に示す。

μ-Law 形式と同様、fact-ck を記録するが、fmt-ck のサイズが大きくなっている点が異なる(cbSize のフィールドの他に、wSamplesPerBlock のフィールドが存在する)。

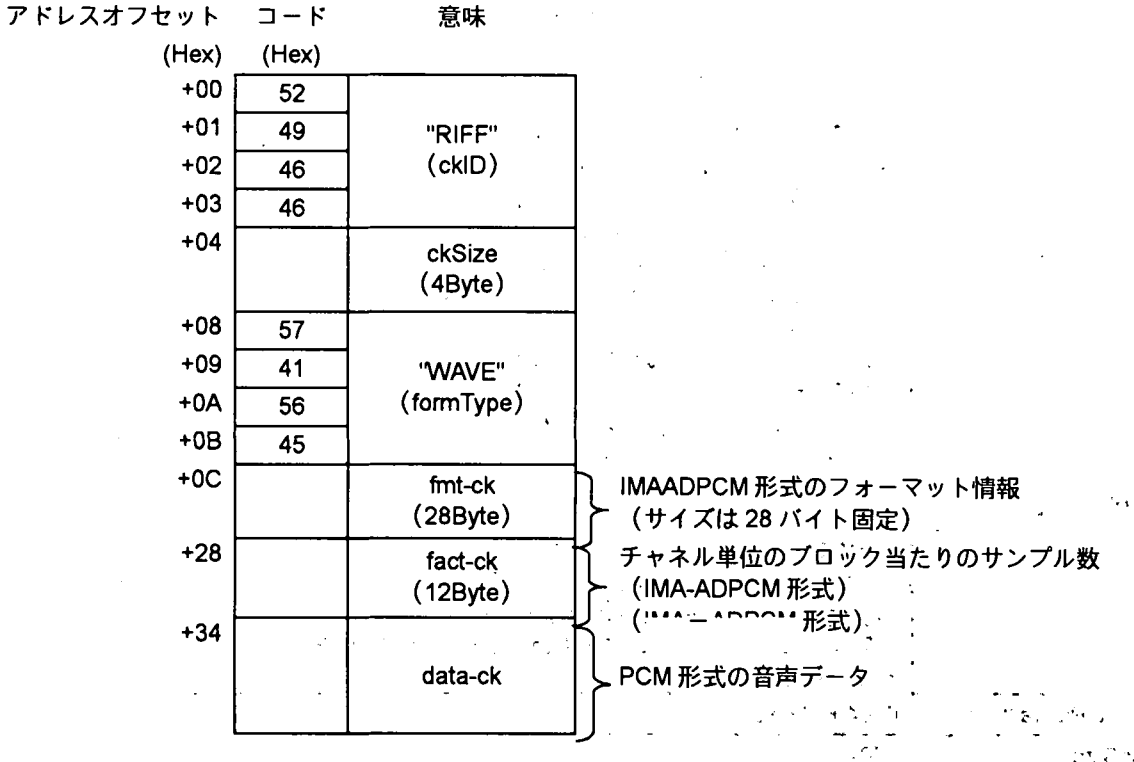


Fig. 40 IMA-ADPCM 形式の基本構造

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IMA-ADPCM 形式の場合、fmt-ck と fact-ck に格納される各情報の具体的な値をTable 26、Table 27に示す。

Table 26 IMA-ADPCM 形式の fmt-ck、fact-ck の情報 (1)

IMA-ADPCM（DVI-ADPCM）形式	
メンバ	数値
ckSize（fmt-ck）	00000014.H（20 バイト）
wFormatTag	0011.H（IMA-ADPCM 形式）
nChannels	0001.H（モノラル） or 0002.H（ステレオ）
nSamplesPerSec	各モードの値は以下のとおり。 00001F40.H（8.0kHz） 00002B11.H（11.025Hz） 00005622.H（22.050Hz） 0000AC44.H（44.10Hz）
nAvgBytesPerSec	各モードの値は以下のとおり。 00000FD7.H（8.0kHz，4bit モノラル） 00001FAE.H（8.0kHz，4bit ステレオ） 000015D4.H（11.025kHz，4bit モノラル） 00002BA9.H（11.025kHz，4bit ステレオ） 00002B5C.H（22.05kHz，4bit モノラル） 000056B9.H（22.05kHz，4bit ステレオ） 0000566D.H（44.10kHz，4bit モノラル） 0000ACDB.H（44.10kHz，4bit ステレオ） 定義式：nSamplesPerSec*nBlockAlign / wSamplesPerBlock
nBlockAlign	各モードの値は以下のとおり。 0100.H（8.0kHz，4bit モノラル） 0200.H（8.0kHz，4bit ステレオ） 0100.H（11.025kHz，4bit モノラル） 0200.H（11.025kHz，4bit ステレオ） 0200.H（22.05kHz，4bit モノラル） 0400.H（22.05kHz，4bit ステレオ） 0400.H（44.10kHz，4bit モノラル） 0800.H（44.10kHz，4bit ステレオ） 定義式は(N＋1) * 4 * nChannels であるが、 256 * nChannels * max (1,nSamplesPerSec / 11.025kHz) を用いることを推奨する
wBitsPerSample	0004.H（4bit）
cbSize	0002.H

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Table 27 IMA-ADPCM 形式の fmt-ck、fact-ck の情報 (2)

IMA-ADPCM（DVI-ADPCM）形式	
extByte[cbSize]	各モードの値は以下のとおり。 01F9.H（8.0kHz，4 bit モノラル） 01F9.H（8.0kHz，4 bit ステレオ） 01F9.H（11.025kHz，4 bit モノラル） 01F9.H（11.025kHz，4 bit ステレオ） 03F9.H（22.05kHz，4 bit モノラル） 03F9.H（22.05kHz，4 bit ステレオ） 07F9.H（44.10kHz，4 bit モノラル） 07F9.H（44.10kHz，4 bit ステレオ） 定義式は、wSamplesPerBlock（チャネル単位のブロック当たりのサンプル数を表す符号無し 16 ビット整数） X =（nBlockAlign -（4 * nChannels））* 8 Y = wBitsPerSamples * nChannels とすれば、 wSamplesPerBlock =（X/Y）+1
dwSampleLength	実際に再生可能なサンプル数を記録することを推奨する。 定義式は以下の通り。 X ＝ ckSize_of_data-ck／nBlockAlign とすれば、 dwSampleLength ＝ (X+1) * wSamplesPerBlock

data-ck に含まれる IMA-ADPCM 音声データは、Fig. 41、Fig. 42、Fig. 43のようにブロック単位でパッキングして記録する。

特長的なことは、各ブロックの先頭にヘッダが存在することである。ヘッダには、そのブロックの最初のサンプル値と、ステップ(量子化テーブル)のインデックスが記録される。各チャネルの音声データは独立しているので、ヘッダワードはチャネルの数だけ存在する。

ヘッダワードは４バイトから成り、[式 5] のように定義される。ヘッダが存在するため、IMA-ADPCM の音声データは任意のブロックから再生することが出来る。即ち、ブロック単位でランダムアクセスが可能である。

Fig. 41～Fig. 43において、左側のバイトが下位のアドレス、右側のバイトが上位のアドレスに格納される。

```
typedef struct {
        signed int   iSamp0;                // ブロックの最初サンプル値
        unsigned char   bStepTableIndex;    // ステップテーブルインデックス
        unsigned char   bReserved;          // 予約バイト
} IMA_ADPCMBLOCKHEADER;                                    --- [式 5]
```


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Fig. 41～Fig. 43中、N、M、Pは以下を表す。

N = (nBlockAlign／(4*nChannels)) - 1 --- [式6]

M = 0, 1, 2, 3, ・・・, N-1 --- [式7]

P = (M*8)+1 --- [式8]

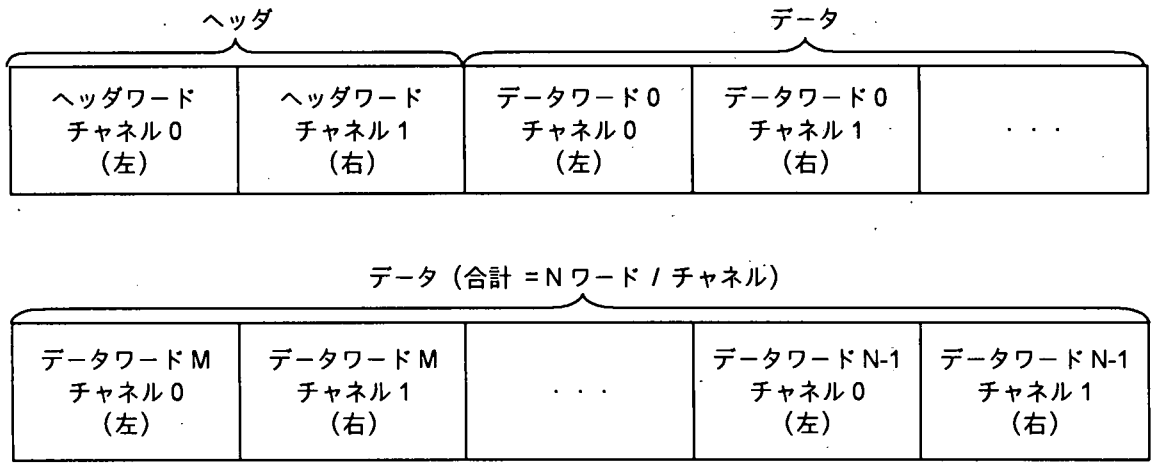


Fig. 41 IMA-ADPCM 音声データのパッキング

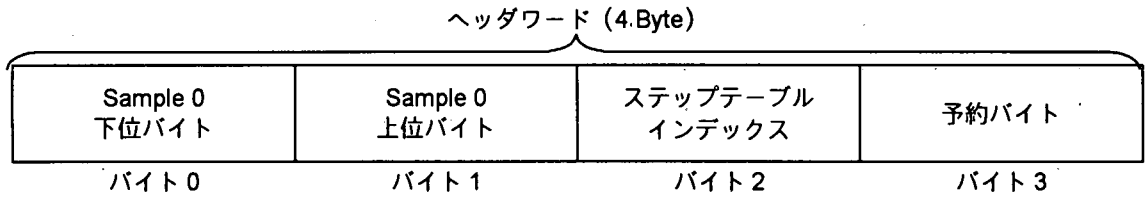


Fig. 42 IMA-ADPCM 音声データのヘッダワード

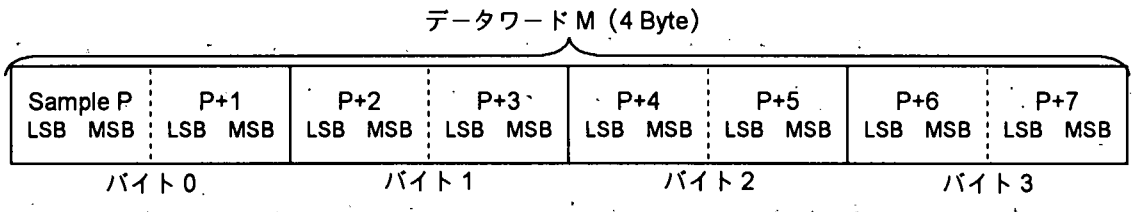


Fig. 43 IMA-ADPCM 音声データのデータワードM

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3.6. 使用するチャンク

Exif 音声ファイルにおいて使用するチャンクについて述べる。

3.6.1. WAVE Form Audio File の基本チャンク

WAVE ファイルの基本構造を示すFig. 32から明らかなように、WAVE Form Audio File の基本チャンクは以下の 4 つである。

- RIFF チャンク
- fmt チャンク
- fact チャンク
- data チャンク

［補足説明］

- fmt チャンク、fact チャンク、data チャンクの 3 つは、RIFF チャンクのサブチャンクである。WAVE ファイルは 1 つの RIFF チャンクから成り、具体的な情報はサブチャンクの方に含まれている。
- フォームタイプが PCM（パルスコードモジュレーション）形式の場合に限って、fact チャンクは不要となるが、非 PCM 形式（μ-Law 形式、IMA-ADPCM 形式など）の場合は必須となっているため、ここでは fact-ck を基本チャンクに含めている。
- 他に、オプションのサブチャンクを入れることも可能である。
- RIFF チャンクのチャンクデータ（ckData）の先頭には、"WAVE"というフォームタイプが含まれている。

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3.6.2. LIST チャンクと INFO リスト

WAVE フォームを始めとする RIFF フォームは、様々な情報を RIFF チャンクのサブチャンクの中に格納する。それらのサブチャンクは、各フォームタイプ毎に決められた専用のものであることが多いが、フォームタイプで規定されるデータとは無関係な付加情報などを格納するために、汎用のチャンクも用意されている。

「LIST チャンク」は、そのような汎用のチャンクである。

ここでは LIST チャンクの使い方について述べる。

(1) LIST チャンク

LIST チャンクは汎用のチャンクであり、様々なフォームタイプのファイルに使用できることが特長である。LIST チャンクは、登録済みの汎用のチャンクであるから、その ckID（チャンク ID）は大文字で表記される。

LIST チャンクはその中に、サブチャンクのリスト（一連のサブチャンク）や、順序シーケンスを含んでいる。

LIST チャンクの ckData（チャンクデータ）は、listType（リストタイプ）と呼ばれる先頭の 4 文字コードと、それに続くサブチャンクのリストから成る。

この構造は RIFF チャンクと似ているが、LIST チャンクは常に RIFF チャンクよりも下位の階層に置かれる点で異なっている。

リストタイプは、リストの内容を識別するために使用される。このため、特定のフォームタイプでしか使われないリストタイプもある。解釈できないリストタイプに遭遇した場合は、その LIST チャンクを無視することができる。

リストタイプは、登録しなければならない。登録済み、且つ様々なフォームタイプで使用できる汎用リストタイプは、大文字で表記される。

特定のフォームタイプでしか使われないリストタイプは、全て小文字で表記される。

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LIST チャンクの構造を図示するとFig. 44のように表される。

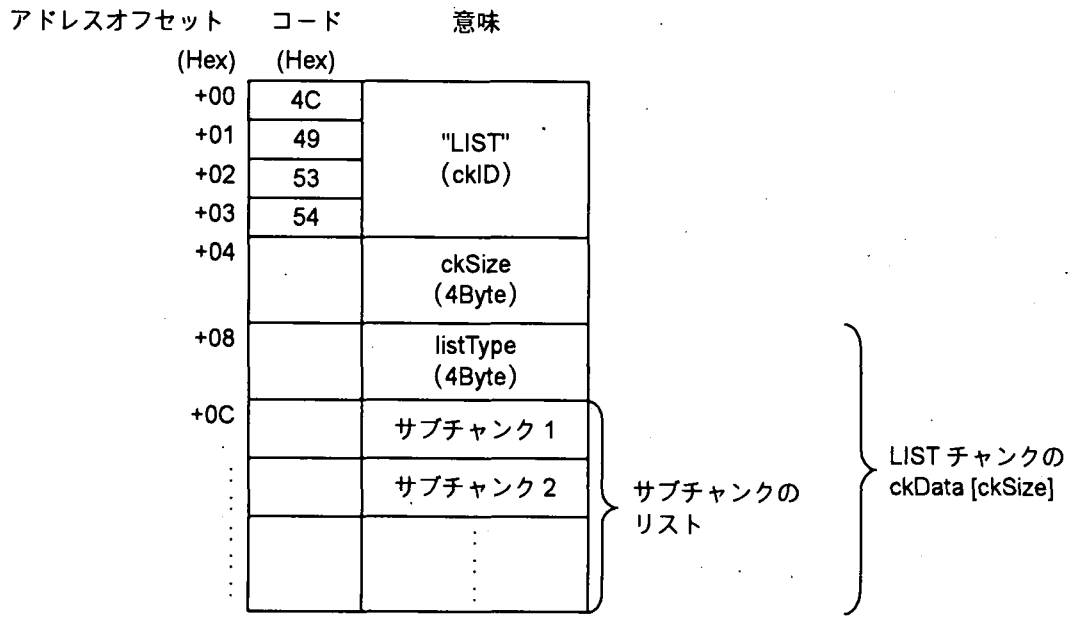


Fig. 44 LIST チャンクの構造

(2) INFO リスト

「INFO リスト」は、"INFO"という登録済みの汎用 listType（リストタイプ）を持つ LIST チャンクである。

タイトル、著作権、コメントなどの補助的な情報は、あらゆるフォームタイプで同じように必要とされるが、INFO リストはこれらの情報を格納するために使用される。

INFO リストに含まれる情報の本体は、サブチャンクのリストの方に格納されているが、これらのサブチャンクには、後述の登録済み汎用チャンクだけを使用する。

INFO リストに含まれる情報は補助的な情報であって、WAVE フォームの音声データのようなメインのデータの解釈には影響を与えないので、スキップしても問題はない。新しいチャンクが定義された等の理由により、 INFO リストに未知のチャンクが含まれていた場合は、そのチャンクを無視すること。

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INFO リスト用として、現在定義されているチャンクをTable 28に示す。これら登録済みのチャンクは、NULL 終端（最後のバイトが '00.H'）された ASCII テキスト文字列の形で情報を格納する。

Table 28 INFO リスト用チャンク一覧

チャンク ID	説明
IARL	アーカイブ位置。ファイルの主題が記録された場所を示す。
IART	作成者。ファイルのオリジナル主題の作成者を示す。
ICMS	依頼者。ファイルの主題の作成を依頼した人物名や団体名。
ICMT	コメント。ファイルやファイルの主題に関する一般的なコメントを示す。
ICOP	著作権。ファイルの著作権情報を表す。
ICRD	作成日。ファイルの主題が作成された日付を指定する。
ICRP	クロップ。イメージクロップ（断ち落し）されているかどうか記述する。
IDIM	寸法。ファイルのオリジナル主題のサイズを指定する。
IDPI	1 インチ当たりのドット数（DPI)。ファイルの製作に使用されるデジタイザのドット密度を表す。
IENG	エンジニア。ファイルに携わったエンジニアの名前を記録する。
IGNR	ジャンル。オリジナル作品のジャンルを記述する。
IKEY	キーワード。ファイルやファイルの主題を参照するキーワードのリスト。
ILGT	明度。ファイル製作のために必要なデジタイザ上での明るさの設定の変化を記述する。
IMED	メディア。"computer image"、"drawing"、"lithograph" 等の情報を記述する。
INAM	名前。ファイルの主題のタイトルを格納する。
IPLT	パレットの設定。イメージ画像をディジタル化するときに要求される色数を指定する。
IPRD	製品。 "Encyclopedia of Pacific Northwest Geography" のように表す。
ISBJ	主題。ファイルの内容を "Aerial view of Seattle" のように表す。
ISFT	ソフトウェア。ファイルの作成に使われたソフトウェアパッケージの名前。
ISHP	鮮明度。ファイル製作のために必要なデジタイザの鮮明度（sharpness）の変化を表す。
ISRC	ソース。ファイルのオリジナル主題を供給した人物名や団体名。
ISRF	ソースフォーム。"slide"、"paper"、"map"等のように、ディジタル化された素材のオリジナルフォームを表す。
ITCH	技術者。主題のファイルをディジタル化した技術者を表す。

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INFO リストの例をFig. 45に示す。

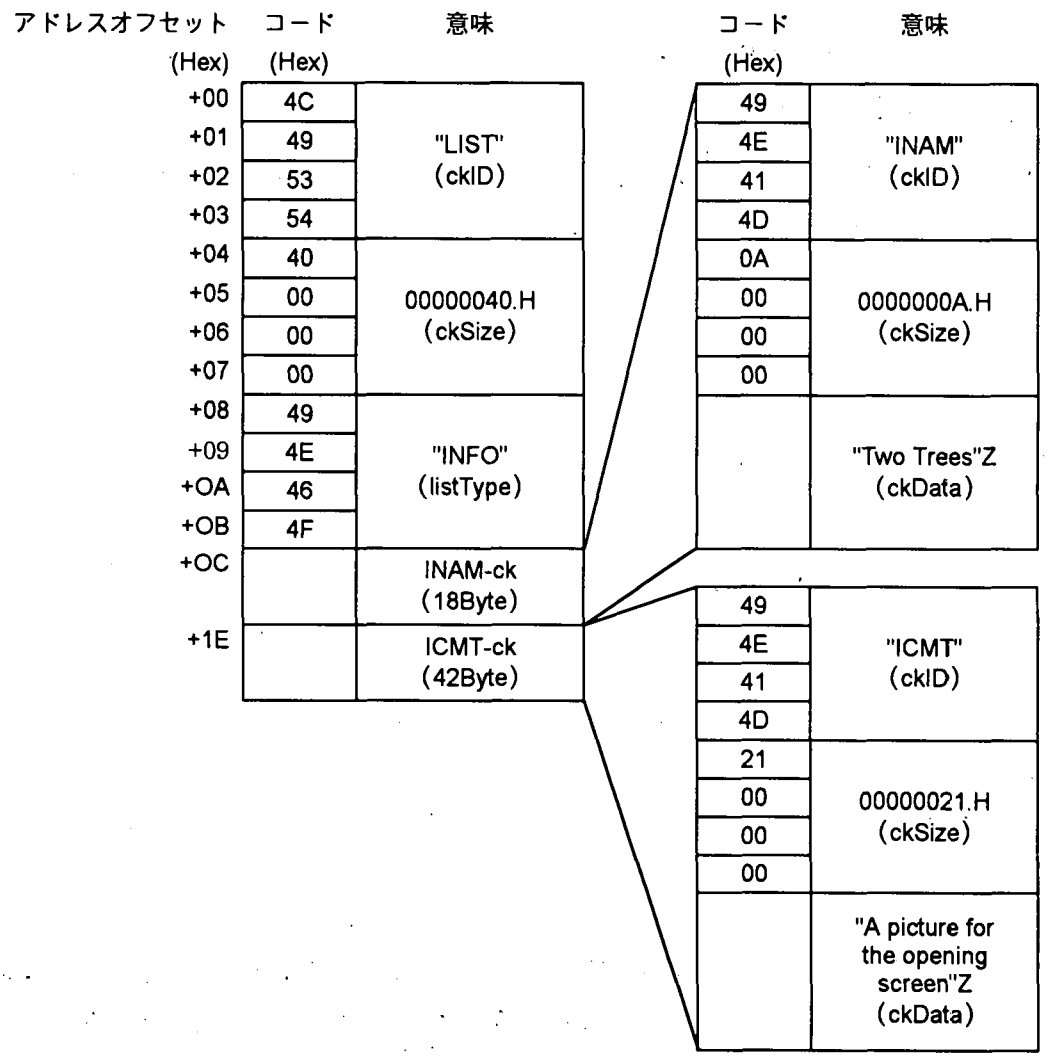


Fig. 45 INFO リストの例

Fig. 45を参考に、INFO リスト使用上の注意事項を述べる。

- 「INAM チャンク」と「ICMT チャンク」に含まれるテキスト文字列情報の最後に 'Z' という文字が置かれているが、これは NULL 終端を意味する。実際に付加されるコードは、'00.H'である。
- 各チャンクのチャンクデータ（ckData）は、偶数バイトから成っていなければならない。格納される情報そのものが奇数バイトから成るときは、データの最後にパッドバイトを 1 つ付加する。
- Fig. 45の例の場合、ICMT チャンクの情報が NULL 終端も含めて 33 バイトであるため、パッドバイト '00.H' を付加しなければならない。INAM チャンクの情報の方は、NULL 終端を含めて 10 バイトであるため、パッドバイトは不要である。
- ICMT チャンクのチャンクサイズ（ckSize）の値は、このパッドバイトを含んでいない。しかし、親チャンクである「LIST チャンク」のチャンクサイズの値は、サブチャンクのパッドバイトを含

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んでいる必要がある。このルールを守らないと、このLISTチャンクの後に置かれているチャンクの先頭アドレスが分からなくなる。

(3) Exif音声ファイルで使用するINFOリスト

Exif音声ファイルで使用するINFOリストは以下の通り。

INFOリストに入れることの出来るチャンクはTable 28に示した通りであるが、Exif音声ファイルで使用するものは、この表の中から選び出した以下に挙げるチャンクのみとする。

[使用するチャンク]

INAM

Exif音声ファイルのタイトルを記録する。タイトルはASCII文字列で記載し、NULL終端する。

この情報の記録はオプションとする。

記載例） "Exif Audio File Example"Z

IGNR

Exif音声ファイルの主題のジャンルを記録する。ジャンル名はASCII文字列で記載し、NULL終端する。この情報の記録はオプションとする。

記載例） "narration"Z

ICRD

Exif音声ファイルの作成年月日を記録する。固定長のASCII文字列で年月日を記述する。「年-月-日」の書式で記録する。即ち、「年」、「月」、「日」のそれぞれの間をハイフン '-' で区切るものとする。「年」は4桁、「月」と「日」はそれぞれ2桁で表す。「月」又は「日」が1桁の値のときは、10の桁を'0'で埋めるものとする。記載順は、「年」、「月」、「日」の順とする。この情報はASCII文字列なので、NULL終端すること。このチャンクは固定長である（チャンクデータが11バイト固定で、パッドバイトが付加される)。この情報の記録はオプションとする。

記載例） "1997-04-08"Z （注：1997年4月8日）

ICMT

Exif音声ファイルや、そのファイルの主題に関する一般的なコメントを記録する。コメントはASCII文字列で記載し、NULL終端する。コメントが複数の文から成るときは、それぞれの文の終わりにピリオドを付ける。改行文字を入れてはならない。この情報の記録はオプションとする。

記載例） "Recorded by Digital Still Camera"Z

IART

Exif音声ファイルの作成者の名前を記録する。名前はASCII文字列で記載し、NULL終端する。この情

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報の記録はオプションとする。

記載例） "Taro Yamada"Z

ICOP

Exif 音声ファイルの著作権情報を記録する。著作権は ASCII 文字列で記載し、NULL 終端する。著作権が複数であれば、セミコロンとその次に空白文字（20.H）を 1 つ置いてそれぞれを区切るものとする。この情報の記録はオプションとする。

記載例） "Copyright Exif Corporation 1997."Z

［注意事項と補足説明］

- カメラは上に挙げたチャンク以外は、記録しないものとする。
- カメラで INFO リストを読む場合、未知のチャンクが発見されたら そのチャンクをスキップすること。INFO リストチャンクは将来追加される可能性もあるが、このようにすることによって再生互換が保たれる。
- 一般の INFO リストの規定に従って、情報を記録すること。
- これらの INFO リストの記録は、全てオプションとする。
- Exif 音声ファイルで使用する INFO リストは、登録済みの汎用のチャンクを利用しているので、この情報は汎用の「RIFF Form Reader」ソフトで読めることが特長である（例えば Windows™ 付属のユーティリティ・ソフトウェアで読める）。

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3.6.3. Exif 音声ファイル固有の付属情報用チャンク

Exif 音声ファイル固有の付属情報の記録は以下の通り。

Exif 固有の付属情報とは、一般の WAVE Form Audio File では定義されていない Exif 音声ファイル専用の付属情報である。この付属情報は補助的な情報であり、メインのデータである音声データの解釈には影響を与えない。従って、Exif 音声ファイルは、標準の WAVE Form Audio File と互換性を持つことができる。

Exif 音声ファイル固有の付属情報は、以下のように記録する。

(1) LIST チャンクを使用する。

上に述べた互換性を実現するため、Exif 音声ファイル固有の付属情報は、登録済みの汎用チャンクである LIST チャンクを利用して記録する。LIST チャンクは全てのフォームタイプで使用できるので、このチャンクを WAVE Form Audio File の中に入れても良い。個々の情報は、この LIST チャンクに含まれるサブチャンクの中に記録する。

(2) 専用のリストタイプ "exif"を定義する。

LIST チャンクに含まれる情報が、Exif 音声ファイル固有の情報であることを明示するため、専用のリストタイプを定義する。このリストタイプとして以下を用いる。

- Exif 専用のリストタイプ："exif"（全て小文字）

Exif 音声ファイル固有の付属情報は、WAVE Form Audio File 形式の中でしか用いられないので、全て小文字で表記される。

以下、リストタイプが "exif"であるような LIST チャンクのことを「exif リスト」と称する。

(3) 個々の付属情報用に専用のチャンクを定義する。

既存のチャンクに該当するものがないため、Exif 音声ファイル固有の付属情報を記録するための専用のチャンクを定義する。固有の付属情報の項目と、その情報を記録するチャンクを以下に示す。

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［情報の項目とチャンク］

ever

本規格のバージョン情報(番号)を記録する。

Exif 画像ファイルと同じように、4 byte で記述する。各バイトを下位のアドレスから順に A1、A2、B1、B2 と表すと、A1、A2 がバージョンの上位、B1、B2 がバージョンの下位を表すものとする。A1、A2、B1、B2 の各バイトは、バージョン番号に対応する ASCII 数字であるが、NULL 終端は不要である。このチャンクは必須とする。

バージョン改訂の基準は、3.2章を参照すること。

記載例） "0200"（注：Version 2.00）

erel

このチャンクが記録されている Exif 音声ファイルと関連のある Exif 画像ファイルを指す情報を記録する。この情報を利用するとカメラやアプリケーションソフトは、画像と音声を関連付けて再生するようなこともできる。

関連情報として、相手先である Exif 画像ファイルのファイル名と拡張子（8 文字+'.'+3 文字の ASCII 文字列とする）を一つだけ記録する。パスは記述しない。画像に関する規定は 2.6.5章「関連ファイル情報」タグを参照のこと。また、ファイル名称の記載方法については、3.7.1章を参照のこと。

Exif 画像ファイルと Exif 音声ファイルの対応関係はTable 29に示すように 3 通りある。Table 29の[2]又は[3]のように、1 つのファイルに複数のファイルが対応しているような場合でも、上に述べた規定に従い相手先のファイル名は 1 つだけ記録するものとする。複数の相手先ファイルが存在する場合、その中で最初に記録されたファイルのファイル名を記録するものとする。

たとえば、Table 29の[2]をでは、Exif 音声ファイル"SND00001.WAV"は、関連する Exif 画像ファイ名として"DSC00001.JPG"のみを示す。逆に 3 つの Exif 画像ファイル"DSC00001.JPG"、"DSC00002.JPG"、"DSC00003.JPG"は、関連する音声フィアルとして Exif 音声ファイル名"SND00001.WAV"を持っている。これら複数の関連情報を組み合わせることによって、多様な再生を行うこともできる。関連情報の利用の仕方については、再生側の運用に任せる。この情報は ASCII 文字列なので、NULL 終端すること。関連する Exif 画像ファイルがある場合は、このチャンクは必須とする。

記載例） "DSC00001.JPG"Z

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Table 29 画像ファイルと音声ファイルの関連情報

	対応関係	Exif 画像ファイル　　Exif 音声ファイル
[1]	1 対 1	DSC00001.JPG ⟷ SND00001.WAV
[2]	多対 1	DSC00001.JPG ⟷ SND00001.WAV DSC00002.JPG → DSC00003.JPG →
[3]	1 対多	DSC00001.JPG ⟷ SND00001.WAV → SND00002.WAV → SND00003.WAV

etim

Exif 音声ファイルの作成時刻を記録する。この時刻は、音声データの録音が開始された時刻を表すものとする。可変長の ASCII 文字列で時刻を記述する。出来るだけ Exif 画像ファイルに合わせるため、「時:分:秒.サブ秒」という書式で記録する。即ち、「時」、「分」、「秒」のそれぞれの間はコロン ':' で区切り、「秒」と「サブ秒」の間はピリオド '.'で区切るものとする。

「時」、「分」、「秒」は 2 桁で表し、1 桁の値のときは 10 の桁を'0'で埋めるものとする。「サブ秒」の桁数は任意とし、「サブ秒」の情報が無い場合はピリオド '.'以下を記録しない。

記載順は、「時」、「分」、「秒」、「サブ秒」の順とする。この情報は ASCII 文字列なので、NULL 終端すること。この情報の記録はオプションとする。

記載例）　"10:05:10.130"Z　　（注：10 時 5 分 10.130 秒）

ecor

Exif 音声ファイルを作成した機器のメーカ名を記録する。メーカ名は ASCII 文字列で記述し、NULL 終端すること。この情報の記録はオプションとする。

記載例）　"Digital Still Camera Corporation"Z

emdl

Exif 音声ファイルを作成した機器のモデル名を記録する。機器のモデル名は ASCII 文字列で記述し、NULL 終端すること。この情報の記録はオプションとする。

例）　"DSCamera1000"Z

emnt

Exif 画像ファイルの場合と同様、Exif 音声ファイルのライターメーカが設計情報や改訂履歴など、メーカ個別の情報を記録する。記録する情報の内容とデータの書式については、各メーカの運用に任せる。他社からは、この情報はチャンクサイズ（ckSize）で規定される大きさのバイト列としか見えない。

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この情報の記録はオプションとする。

eucm

INFO リストに記録できない、或いは適さないようなユーザ゛コメント情報を記録する。基本的には文字情報である。INFO リストに記録できないような、ASCII 以外の各国語文字列も記録することができるため文字コード情報も記録する。このチャンクの記録はオプションとする。

以下、ユーザコメントの記載について述べる。ユーザコメントチャンクの構造をFig. 46に示す。

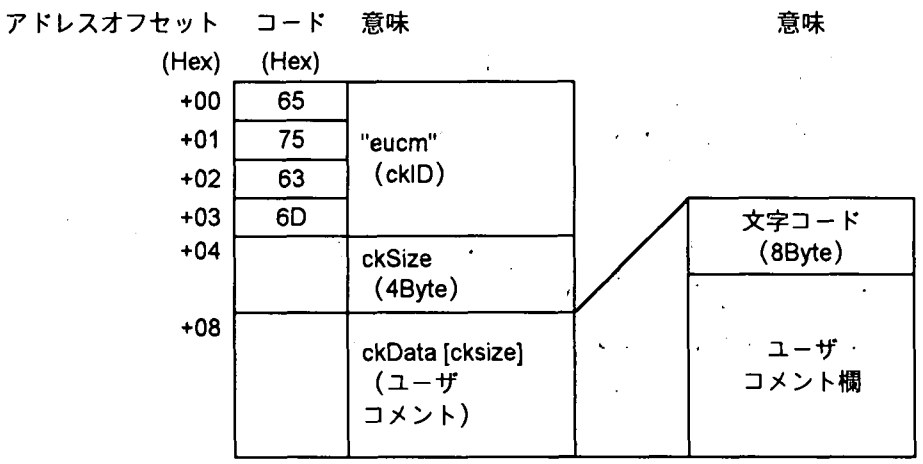


Fig. 46 ユーザコメントチャンクの構造

Fig. 46のとおり、ユーザコメントが格納されるチャンクデータ領域の先頭 8 バイトが文字コード領域となっており、ここに文字コードを記入する。チャンクデータ領域の残りがユーザコメント欄で、ここに実際の情報が置かれる。現在定義されている文字コードをTable 30に示す。文字コードは、重複しないよう登録制とする。又、登録する場合は、その文字形式の仕様を明記した規格書をリファレンス欄に記入する。日本における Shift-JIS のように、明確な仕様書がない文字コードを使用する場合には、Undefined を使用する。

文字コードは、文字コード領域の先頭から記入し、余った領域は NULL ('00.H') でパディングする。ユーザコメント欄に入れる実際の情報の書式を Exif 画像ファイルの「UserComment タグ」の場合と一致させるため、たとえ ASCII 文字列で記載するとしても NULL 終端は行わない。但し、チャンクの規定に従うため、チャンクデータが奇数バイトのときはパッドバイト ('00.H') を 1 つ付加すること。

Table 30 文字コードと文字コード欄記入方法

文字コード	コード記入方法 (8Byte)	リファレンス
ASCII	41.H, 53.H, 43.H, 49.H, 49.H, 00.H, 00.H, 00.H	ITU-T T.50 IA5[ix]
JIS	4A.H, 49.H, 53.H, 00.H, 00.H, 00.H, 00.H, 00.H	JIS X0208-1990[x]
Unicode	55.H, 4E.H, 49.H, 43.H, 4F.H, 44.H, 45.H, 00.H	Unicode Standard [xi]
Undefined	00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H	Undefined

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[注意事項と補足説明]

- exif リストに入れる上記のチャンクは、特定のフォームタイプ（'WAVE'）で使われるため、全て小文字で表記されている。
- ever チャンクのみ必須で、それ以外はオプションである。但し、音声ファイルと関連のある Exif 画像ファイルが存在する場合は、erel チャンクも必須とする。
- カメラで exif リストを読む場合は、emnt チャンクや eucm チャンクの Undefined 形式の文字列のように、認識できない情報に出会うこともある。そのような場合はそのチャンクをスキップすること。
- Exif リーダ、ライターは、一般の LIST チャンクの規定に従わなければならない。
- 汎用の RIFF Form Reader では exif リストは無視される。exif リストの情報を読むには、専用のリーダーが必要である。
- exif リストの構造とその記載例をFig. 47に示す。ever チャンクは必須であり、このチャンクは固定長である（チャンクデータが 4 バイト固定)。erel チャンクのチャンクデータは 13 バイト（奇数）なので、パッドバイトが付加されている。erel チャンクも固定長である。

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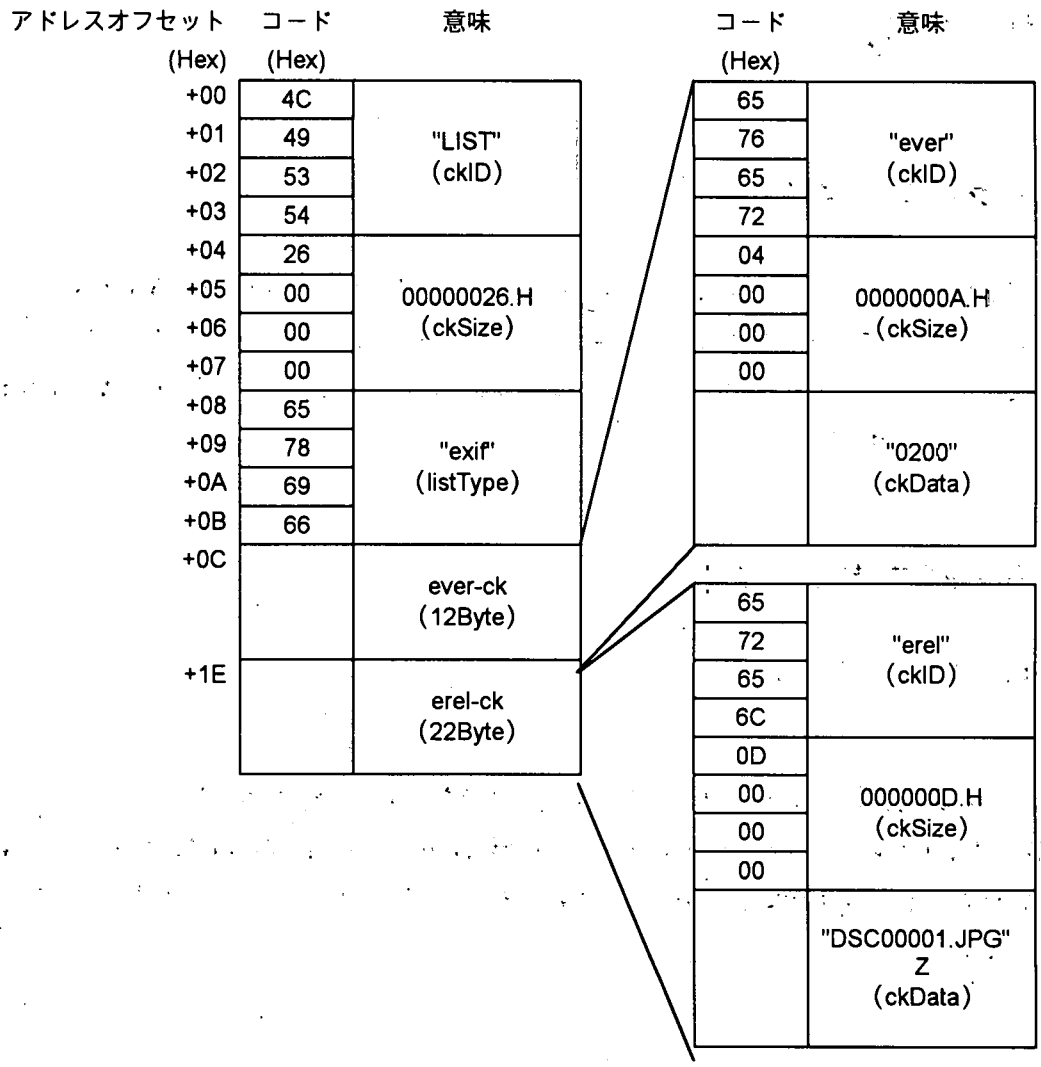


Fig. 47 exif リストの構造と記載例

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3.7. データの記載

3.7.1. ファイル名に関する規定

ファイル名及びその文字数は規定しない。但し、ファイル名にはASCII英数文字を使用する（日本語ファイル名等は使用しない)。又、ファイル名は拡張子を含まずに8文字以内とする（ロングファイルネームは使用しない)。拡張子は、音声データのフォーマットタイプに関わらず".WAV"とする（WAVE Form Audio Fileの拡張子に一致させる)。

3.7.2. 一般的なExif音声ファイル

最も一般的なExif音声ファイルの構成を

Fig. 48に示す。

Fig. 48の中で、影付きの部分はExif音声ファイルで必須の要素を表す。網掛けの部分（fact-ck のみ）は、音声データがPCM（パルスコードモジュレーション）形式の場合は不要、非PCM形式（μ-Law形式,IMA-ADPCM形式など）の場合は必須の要素を表す。網掛け無しの要素はオプションなので、記録してもしなくても良い。

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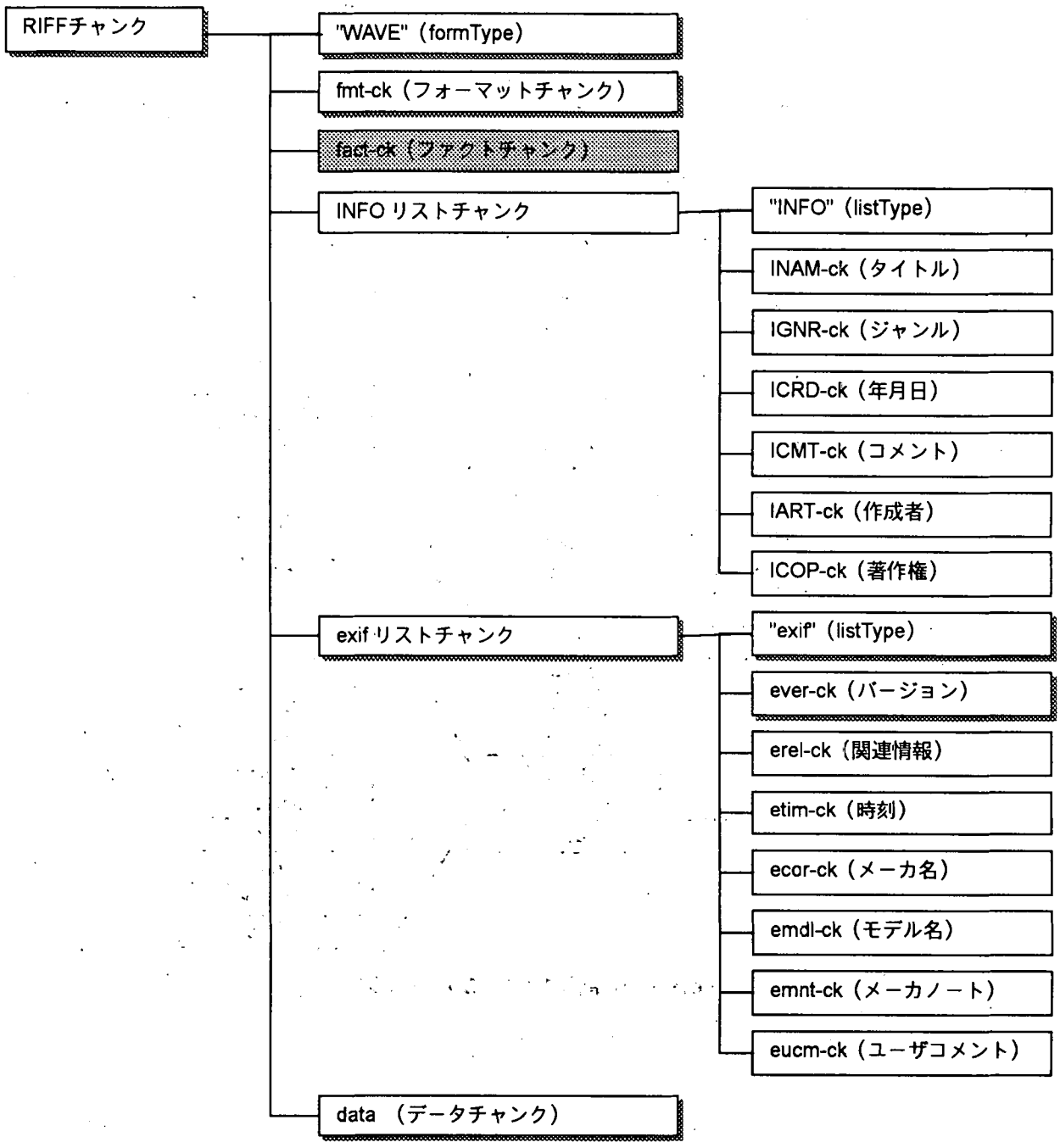


Fig. 48 Exif 音声ファイルの構成

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各要素のデータの記載法については、それぞれの説明の項を参照すること。

Fig. 49は、最も一般的なExif音声ファイルのデータ構造を示している。Exif音声ファイルのデータは、Fig. 49の構造に従って記載する。個々のサブチャンクは、それぞれの規定に従って記載する。オプションのチャンクは省略しても良い。

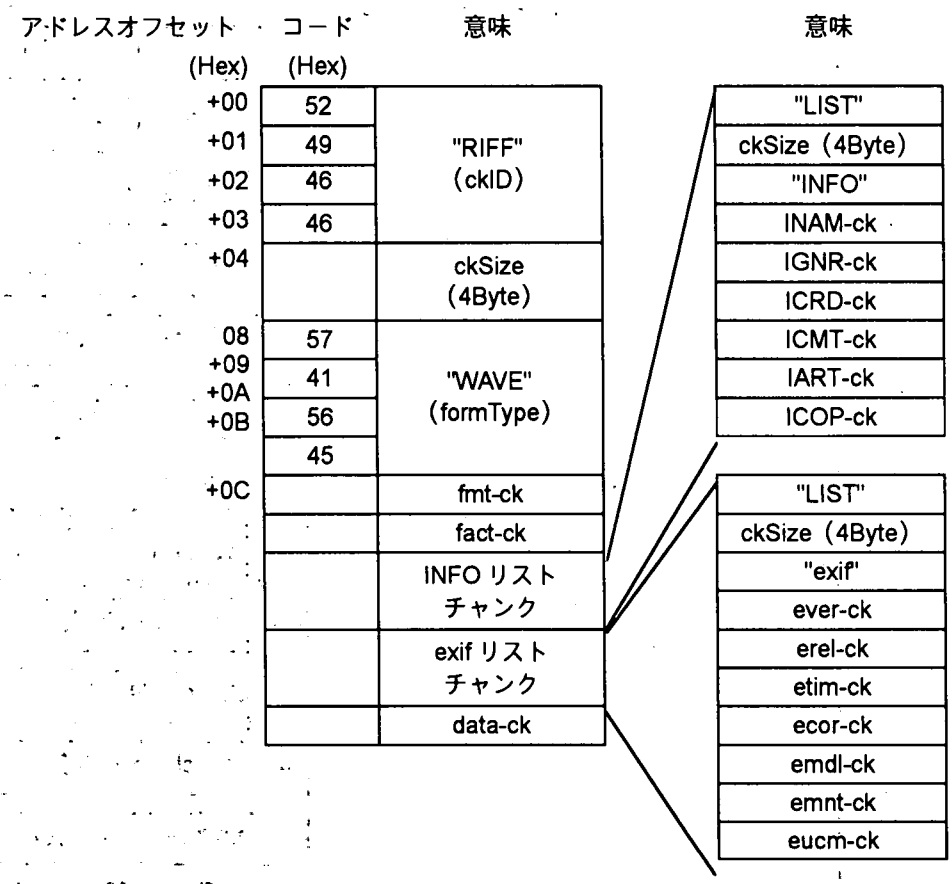


Fig. 49 一般的なExif音声ファイルのデータ構造

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付録 A　画像ファイル記載例

A.1　非圧縮 RGB ファイル

Table 31 非圧縮 RGB ファイル記載例の内容

主画像	
画素数	640(幅) x 480(高さ)
画像タイトル	Exif_TIFF_RGB
画像入力機器のメーカー名	DSCompany
画像入力機器のモデル名	Example
画像方向	正位置
ストリップの数	96
ストリップ中のライン数	5
ストリップ中のバイト数	9600
画像の解像度	72dpi(Width), 72dpi(Length)
画像データの並び	点順次
ファイル変更日時	1997:09:01 12:00:00.000
撮影著作権者／編集著作権者	Copyright, ABCDE,1997
Exif 固有の情報	
バージョン	Ver2.0
原画像データの生成日時	1997:09:01 12:00:00.000
ファイル作成日時	1997:09:01 12:00:00.000
サムネイル	
画素数	80(幅) x 60(高さ)
画像方向	正位置
ストリップの数	1
ストリップ中のライン数	60
ストリップ中のバイト数	14400
画像の解像度	72dpi(Width), 72dpi(Length)

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Table 32 非圧縮 RGB ファイルの記載例

Header	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0000	Byte Order	4D4D ("MM")			
	0002	42	002A			
	0004	0th IFD Offset	00000008			
0th IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	0008	Number of Entries	0014			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageWidth	0100	0004	00000001	00000280
	0016	ImageLength	0101	0004	00000001	000001E0
	0022	BitsPerSample	0102	0003	00000003	000000FE
	002E	Compression	0103	0003	00000001	00010000
	003A	PhotometricInterpretation	0106	0003	00000001	00020000
	0046	ImageDescription	010E	0002	0000000E	00000104
	0052	Make	010F	0002	00000009	00000112
	005E	Model	0110	0002	00000008	0000011C
	006A	StripOffsets	0111	0004	00000060	00000124
	0076	Orientation	0112	0003	00000001	00010000
	0082	SamplesPerPixel	0115	0003	00000001	00030000
	008E	RowsPerStrip	0116	0004	00000001	00000005
	009A	StripByteCounts	0117	0004	00000060	000002A4
	00A6	XResolution	011A	0005	00000001	00000424
	00B2	YResolution	011B	0005	00000001	0000042C
	00BE	PlanarConfiguration	011C	0003	00000001	00010000
	00CA	ResolutionUnit	0128	0003	00000001	00020000
	00D6	DateTime	0132	0002	00000014	00000434
	00E2	Copyright	8298	0002	00000015	00000484
	00EE	Exif IFD Pointer	8769	0004	00000001	0000045E
	Offset (Hex)	**Name**	**Offset (Hex)**			
	00FA	Next IFD Offset	000004EC			
Value longer than 4byte of 0th IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	00FE	BitPerSample Value	000800080008			
	0104	ImageDescription Value	"Exif_TIFF_RGB"00			
	0112	Make Value	"DSCompany"00			
	011C	Model Value	"Example"00			
	0124	StripOffsets Value	offset0,offset1,offset2.....offset95			
	02A4	StripByteCounts Value	count0, count1, count2....count95			
	0424	XResolution Value	0000004800000001			
	042C	YResolution Value	0000004800000001			
	0434	DateTime Value	"1997:09:01 12:00:00"00			
	0448	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	045E	Exif IFD Number	0008			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	0460	ExifVersion	9000	0007	00000004	"0200"
	046C	DateTimeOriginal	9003	0002	00000014	000004C4

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	0478	DateTimeDigitized	9004	0002	00000014	000004D8
	0484	SubSecTime	9290	0002	00000004	"000"00
	0490	SubSecTimeOriginal	9291	0002	00000004	"000"00
	049C	SubSecTimeDigitized	9292	0002	00000004	"000"00
	04A8	FlashPixVersion	A000	0007	00000004	"0100"
	04B4	Colorspace	A001	0003	00000001	0001
	Offset (Hex)	**Name**	**Offset (Hex)**			
	04C0	Next IFD Offset	00000000			
Value longer than 4byte of Exif IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	04C4	SubSecTimeOriginal Value	"1997:09:01 12:00:00"00			
	04D8	SubSecTimeDigitized Value	"1997:09:01 12:00:00"00			
1st IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	04EC	Number Of Entries	000D			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex)**
	04EE	ImageWidth	0100	0004	00000001	00000050
	04FA	ImageLength	0101	0004	00000001	0000003C
	0506	BitsPerSample	0102	0003	00000003	0000058E
	0512	Compression	0103	0003	00000001	00010000
	051E	PhotometricInterpretation	0106	0003	00000001	00020000
	052A	StripOffsets	0111	0004	00000001	000005A4
	0536	SamplesPerPixel	011	0003	00000001	00030000
	0542	RowsPerStrip	0116	0004	00000001	0000003C
	054E	StripByteCounts	0117	0004	00000001	00003840
	055A	XResolution	011A	0005	00000001	00000594
	0566	YResolution	011B	0005	00000001	0000059C
	0572	PlanarConfiguration	011C	0003	00000001	00010000
	057E	ResolutionUnit	0128	0003	00000001	00020000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	058A	Next IFD Offset	00000000			
Value longer than 4byte of 1st IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	058E	BitPerSample Value	000800080008			
	0594	XResolution Value	0000004800000001			
	059C	YResolution Value	0000004800000001			
	05A4	Thumbnail Image Data Strip				
Main Image	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	3DE4	Main Image Data Strip0				
	6364	Main Image Data Strip1				
	:	:				
	:	:				
	0E2864	Main Image Data Strip95				

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A.2 非圧縮 YCbCr ファイル

Table 33 非圧縮 YCbCr ファイル記載例の内容

主画像	
画素数	640(幅) x 480(高さ)
画像タイトル	Exif_TIFF_YCC
画像入力機器のメーカー名	DSCompany
画像入力機器のモデル名	Example
画像方向	正位置
ストリップの数	69
ストリップ中のライン数	7
ストリップ中のバイト数	8960
画像の解像度	72dpi(Width), 72dpi(Length)
画像データの並び	点順次
ファイル変更日時	1997:09:01 12:00:00
画素構成	サブサンプリングは 4:2:2 色差サブサンプリング点は輝度点と一致
撮影著作権者／編集著作権者	Copyright, ABCDE,1997
Exif 固有の情報	
バージョン	Ver2.0
原画像データの生成日時	1997:09:01 12:00:00
ファイル作成日時	1997:09:01 12:00:00
シャッタースピード	59/10（1/60 秒相当）
絞り値	50/10（F 値:5.6 相当）
輝度値	80/10
露光補正値	0/0
レンズ最大 F 値	200/10
被写体距離	20/10
測光方式	マルチスポット
光源	昼光
ストロボ ON/OFF	ON
GPS 情報	
バージョン	Ver2.0
測定位置	北緯 35 度 48 分 8 秒、東経 139 度 34 分 55 秒
高度	海抜 30.48 メートル
GPS 時間	0 時 00 分 00 秒
GPS 受信機の移動状態	真方位 0 度方向に 1km/h で移動
画像の撮影方向	真方位 0 度
測位に用いた地図データ	TOKYO
サムネイル	
画素数	80(幅) x 60(高さ)
画像方向	正位置
ストリップの数	1
ストリップ中のライン数	60
ストリップ中のバイト数	9600
画像の解像度	72dpi(Width), 72dpi(Length)

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Table 34 非圧縮 YCbCr ファイルの記載例

Header	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0000	Byte Order	4D4D ("II")			
	0002	42	2A00			
	0004	0th IFD Offset	08000000			
0th IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	0008	Number of Entries	1700			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageWidth	0001	0400	01000000	80020000
	0016	ImageLength	0101	0400	01000000	E0010000
	0022	BitsPerSample	0201	0300	03000000	22010000
	002E	Compression	0301	0300	01000000	01000000
	003A	PhotometricInterpretation	0601	0300	01000000	06000000
	0046	ImageDescription	0E01	0200	0E000000	28010000
	0052	Make	0F01	0200	09000000	36010000
	005E	Model	1001	0200	08000000	40010000
	006A	StripOffsets	1101	0400	45000000	48010000
	0076	Orientation	1201	0300	01000000	01000000
	0082	SamplesPerPixel	1501	0300	01000000	03000000
	008E	RowsPerStrip	1601	0400	01000000	07000000
	009A	StripByteCounts	1701	0400	45000000	5C020000
	00A6	XResolution	1A01	0500	01000000	70030000
	00B2	YResolution	1B01	0500	01000000	78030000
	00BE	PlanarConfiguration	1C01	0300	01000000	01000000
	00CA	ResolutionUnit	2801	0300	01000000	02000000
	00D6	DateTime	3201	0200	14000000	80030000
	00E2	YCbCrSubSampling	1202	0300	02000000	02000100
	00EE	YCbCrPositioning	1302	0300	01000000	02000000
	00FA	Copyright	9882	0200	15000000	94030000
	0106	Exif IFD Pointer	6987	0400	01000000	AA030000
	0112	GPS IFD Offset	2588	0400	01000000	10050000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	011E	Next IFD Offset	7E060000			
Value longer than 4byte of 0th IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0122	BitPerSample Value	080008000800			
	0128	ImageDescription Value	"Exif_TIFF_YCC"00			
	0136	Make Value	"DSCompany"00			
	0140	Model Value	"Example"00			
	0148	StripOffsets Value	(offset0,offset1,offset2.....offset95)			
	025C	StripByteCounts Value	(count0, count1, count2....count95)			
	0370	XResolution Value	4800000001000000			
	037C	YResolution Value	4800000001000000			
	0380	DateTime Value	"1997:09:01 12:00:00"00			
	0394	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	03AA	Exif IFD Number	1400			

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	Offset (Hex)	Name	Tag ID (Hex)	Type (Hex)	Count (Hex)	ValueOffset (Hex or "ASCII")
	03AC	ExposureTime	9A82	0500	01000000	A0040000
	03B8	FNumber	9D82	0500	01000000	A8040000
	03C4	ExifVersion	0090	0700	04000000	"0200"
	03D0	DateTimeOriginal	0390	0200	14000000	B0040000
	03DC	DateTimeDigitized	0490	0200	14000000	C4040000
	03E8	ShutterSpeedValue	0192	0A00	01000000	D8040000
	03F4	ApertureValue	0292	0500	01000000	E0040000
	0400	BrightnessValue	0392	0A00	01000000	E8040000
	040C	ExposureBiasValue	0492	0A00	01000000	F0040000
	0418	MaxApertureRatioValue	0592	0500	01000000	F8040000
	0424	SubjectDistance	0692	0500	01000000	00050000
	0430	MeteringMode	0792	0300	01000000	01000000
	043C	LightSource	0892	0300	01000000	01000000
	0448	Flash	0992	0300	01000000	00000000
	0454	FocalLength	0A92	0500	01000000	08050000
	0460	SubSecTime	9092	0200	04000000	"000"00
	046C	SubSecTimeOriginal	9192	0200	04000000	"000"00
	0478	SubSecTimeDigitized	9292	0200	04000000	"000"00
	0484	FlashPixVersion	A000	0700	04000000	"0100"
	0490	ColorSpace	A001	0300	01000000	01000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	049C	Next IFD Offset	00000000			
Value longer than 4Byte of Exif IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	04A0	ExposureTime Value	010000003C000000			
	04A8	FNumber Value	0400000001000000			
	04B0	DateTimeOriginal Value	"1997:09:01 12:00:00"00			
	04C4	DateTimeDigitized Value	"1997:09:01 12:00:00"00			
	04D8	ShutterSpeed Value	0600000001000000			
	04E0	ApertureValue Value	0400000001000000			
	04E8	BrightnessValue Value	0000000001000000			
	04F0	ExposureBiasValue Value	0000000001000000			
	04F8	MaxApertureRatio Value	0100000001000000			
	0500	SubjectDistance Value	0F0000000A000000			
	0508	FocalLength Value	3200000001000000			
GPS IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	0510	GPS IFD Number	0013			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	0512	GPSVersionIF	0000	0100	04000000	02000000
	051E	GPSLatitudeRef	0100	0200	02000000	"N"000000
	052A	GPSLatitude	0200	0500	03000000	FA050000
	0536	GPSLongitudeRef	0300	0200	02000000	"E"000000
	0542	GPSLongitude	0400	0500	03000000	12060000
	054E	GPSAltitudeRef	0500	0100	01000000	00000000
	055A	GPSAltitude	0600	0500	01000000	2A060000
	0566	GPSTimeStamp	0700	0500	03000000	32060000
	0572	GPSSatellites	0800	0200	0D000000	4A060000
	057E	GPSStatus	0900	0200	02000000	"A"000000
	058A	GPSMeasureMode	0A00	0200	02000000	"2"000000
	0596	GPSDOP	0B00	0500	01000000	58060000

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	05A2	GPSSpeedRef	0C00	0200	02000000	"K"000000
	05AE	GPSSpeed	0D00	0500	01000000	60060000
	05BA	GPSTrackRef	0E00	0200	02000000	"T"000000
	05C6	GPSTrack	0F00	0500	01000000	68060000
	05D2	GPSImgDirectionRef	1000	0200	02000000	"T"000000
	05DE	GPSImgDirection	1100	0500	01000000	70060000
	05EA	GPSMapDatum	1200	0200	06000000	78060000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	05F6	Next IFD Offset	00000000			
Value longer than 4Byte of GPS IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	05FA	GPSLatitude Value	230000000100000030000000010000000800000001000000			
	0612	GPSLongitude Value	8B0000000100000022000000010000003700000001000000			
	062A	GPSAltitude Value	E80B000064000000			
	0632	GPSTimeStamp Value	00000000010000000000000001000000000000001000000			
	064A	GPSSatellites Value (Last Byte is padded)	"2,7,14,15,16"0000			
	0658	GPSDOP Value	0100000001000000			
	0660	GPSSpeed Value	0000000001000000			
	0668	GPSTrack Value	0000000001000000			
	0670	GPSImgDirection Value	0000000001000000			
	0678	GPSMapDatum Value	"TOKYO"00			
1st IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	067E	Number Of Entries	0F00			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	0680	ImageWidth	0001	0400	01000000	50000000
	068C	ImageLength	0101	0400	01000000	3C000000
	0698	BitsPerSample	0201	0300	03000000	38070000
	06A4	Compression	0301	0300	01000000	01000000
	06B0	PhotometricInterpretation	0601	0300	01000000	06000000
	06BC	StripOffsets	1101	0400	01000000	4E070000
	06C8	SamplesPerPixel	1501	0300	01000000	03000000
	06D4	RowsPerStrip	1601	0400	01000000	3C000000
	06E0	StripByteCounts	1701	0400	01000000	80250000
	06EC	XResolution	1A01	0500	01000000	3E070000
	06F8	YResolution	1B01	0500	01000000	46070000
	0704	PlanarConfiguration	1C01	0300	01000000	01000000
	0710	ResolutionUnit	2801	0300	01000000	02000000
	071C	YCbCrSubSampling	1202	0300	02000000	02000100
	0728	YCbCrPositioning	1302	0300	01000000	02000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	0734	Next IFD Offset	00000000			
Value longer than 4byte of 1st IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0738	BitPerSample Value	080008000800			
	073E	XResolution Value	4800000001000000			
	0746	YResolution Value	4800000001000000			
	074E	(Thumbnail Image Data Strip)				
Main Image Data	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	2CCE	Image Data Strip0				

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	4FCE	Image Data Strip1	:
	:	:	:
	:	:	:
	0978CE	Image Data Strip68	:

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A.3 JPEG 圧縮（4:2:2）ファイル

Table 35 JPEG 圧縮（4:2:2）ファイル記載例の内容

主画像	
記録フォーマット	JPEG
サブサンプリング	YCC 4:2:2
リスタートマーカー	挿入
量子化テーブルの数	3
画素数	640(幅) x 480(高さ)
画像タイトル	Exif_JPEG_422
画像入力機器のメーカー名	DSCompany
画像入力機器のモデル名	Example
画像方向	正位置
画像の解像度	72dpi(Width), 72dpi(Length)
ファイル変更日時	1997:09:01 12:00:00
撮影著作権者／編集著作権者	Copyright, ABCDE,1997
Exif 固有の情報	
バージョン	Ver2.0
原画像データの生成日時	1997:09:01 12:00:00
ファイル作成日時	1997:09:01 12:00:00
コンポーネントの意味	Y,Cb,Cr
画像圧縮モード	2bit/pel
シャッタースピード	59/10（1/60 秒相当）
絞り値	50/10（F 値:5.6 相当）
輝度値	80/10
露光補正値	0/0
レンズ最大 F 値	200/10
被写体距離	20/10
測光方式	マルチスポット
光源	昼光
ストロボ ON/OFF	ON
サムネイル	
記録フォーマット	JPEG
サブサンプリング	YCC 4:2:2
画素数	80(幅) x 60(高さ)
画像の解像度	72dpi(Width), 72dpi(Length)

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Table 36 JPEG 圧縮（4:2:2）ファイルの JPEG ストリーム記載例

Offset (Hex)	Maker Segment	Name	Code (Hex)	Comment
0000	SOI	SOI Marker	FFD8	Start of Image
0002	APP1	APP1 Marker	FFE1	
0004		APP1 Length	291C	
0006		Identifier	"Exif"00	
000B		Pad	00	
000C		APP1 Body		See Next Table
0E39	DQT	DQT Marker	FFDB	Define Quantization Table
0E3B		DQT Length	00C5	
0E3D		Pq, Tq	00	
0E3E		table elements	100B0C0E.....	64Bytes Data
0E7E		Pq,Tq	01	
0E7F		table elements	0F101016....	64Bytes Data
0EBF		Pq,Tq	02	
0EC0		table elements	0F101016....	64Bytes Data
0F00	DHT	DHT Marker	FFC4	
0F02		DHT Length	01A2	
0F04		Th	00	Table 0 for DC
0F05		Li	00010501....	
0F15		Vij	00010203....	
0F21		Th	10	Table 0 for AC
0F22		Li	00020103....	
0F32		Vij	01020300....	
0FD4		Th	01	Table 1 for DC
0FD5		Li	00030101....	
0FE5		Vij	00010203....	
0FF1		Th	11	Table 1 for AC
0FF2		Li	00020102....	
1002		Vij	00010203....	
10A4	DRI	DRI Marker	FFDD	
10A6		DRI Length	0004	
10A8		Ri	0004	
10AA	SOF0	SOF0 Marker	FFC0	
10AC		SOF0 Lentth	0011	
10AE		P	08	
10AF		Y	01E0	
10B1		X	0280	
10B3		Nf	03	
10B4		C1	01	
10B5		H1,V1	21	
10B6		Tq1	00	
10B7		C2	02	
10B8		H2,V2	11	
10B9		Tq2	01	
10BA		C3	03	
10BB		H3,V3	11	
10BC		Tq3	02	
10BD	SOS	SOS Marker	FFDA	
10BF		SOS Length	000C	
10C1		Ns	03	
10C2		Cs1	01	

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10C3		Td1,Ta1	00	
10C4		Cs2	02	
10C5		Td2,Ta2	11	
10C6		Cs3	03	
10C7		Td3,Ta3	11	
10C8		Ss	00	
10C9		Se	3F	
10CA		Ah,Al	00	
10CB	Image Data		F36A....	Compressed Data
111C4	EOI		FFD9	

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Table 37 JPEG 圧縮（4:2:2）ファイルの APP1 記載例

Header	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0000	Byte Order	4D4D ("II")			
	0002	42	2A00			
	0004	0th IFD Offset	08000000			
0th IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	0008	Number of Entries	0B00			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageDescription	0E01	0200	0E000000	92000000
	0016	Make	0F01	0200	09000000	A0000000
	0022	Model	1001	0200	08000000	AA000000
	002E	Orientation	1201	0300	01000000	01000000
	003A	XResolution	1A01	0500	01000000	B2000000
	0046	YResolution	1B01	0500	01000000	BA000000
	0052	ResolutionUnit	2801	0300	01000000	02000000
	005E	DateTime	3201	0200	14000000	C2000000
	006A	YCbCrPositioning	1302	0300	01000000	02000000
	0076	CopyRight	9882	0200	15000000	D6000000
	0082	Exif IFD Pointer	6987	0400	01000000	EC000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	008E	Next IFD Offset	C402			
Value longer than 4byte of 0th IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0092	ImageDescription Value	"Exif_JPEG_422"00			
	00A0	Make Value	"DSCompany"00			
	00AA	Model Value	"Example"00			
	00B2	XResolution Value	4800000001000000			
	00BA	YResolution Value	4800000001000000			
	00C2	DateTime Value	"1997:09:01 12:00:00"00			
	00D6	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	00EC	Exif IFD Number	1900			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	00EE	ExposureTime	9A82	0500	01000000	1E020000
	00FA	FNumber	9D82	0500	01000000	26020000
	0106	ExifVersion	0090	0700	04000000	"0200"
	0112	DateTimeOriginal	0390	0200	14000000	2E020000
	011E	DateTimeDigitized	0490	0200	14000000	42020000
	012A	ComponentsConfiguration	0191	0700	04000000	01020000
	0136	CompressedBitsPerPixel	0292	0500	01000000	56020000
	0142	ShutterSpeedValue	0192	0A00	01000000	5E020000
	014E	ApertureValue	0292	0500	01000000	66020000
	015A	BrightnessValue	0392	0A00	01000000	6E020000
	0166	ExposureBiasValue	0492	0A00	01000000	76020000
	0172	MaxApertureRatioValue	0592	0500	01000000	7E020000
	017E	SubjectDistance	0692	0500	01000000	86020000
	018A	MeteringMode	0792	0300	01000000	01000000

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	0196	LightSource	0892	0300	01000000	01000000
	01A2	Flash	0992	0300	01000000	00000000
	01AE	FocalLength	0A92	0500	01000000	8E020000
	01BA	UserComments	8692	0700	2E000000	96020000
	01C6	SubSecTime	9092	0200	04000000	"000"00
	01D2	SubSecTimeOriginal	9192	0200	04000000	"000"00
	01DE	SubSecTimeDigitized	9292	0200	04000000	"000"00
	01EA	FlashPixVersion	A000	0700	04000000	"0100"
	01F6	Colorspace	A001	0300	01000000	01000000
	0202	Pixel X Dimension	A002	0400	01000000	80020000
	020E	Pixel Y Dimension	A003	0400	01000000	E0010000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	021A	Next IFD Offset	00000000			
Value longer than 4Byte of Exif IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	021E	ExposureTime Value	010000003C000000			
	0226	FNumber Value	0400000001000000			
	022E	DateTimeOriginal Value	"1997:09:01 12:00:00"00			
	0242	DateTimeDigitized Value	"1997:09:01 12:00:00"00			
	0256	CompressedBitsPerPixel Value	0200000001000000			
	025E	ShutterSpeedValue Value	0600000001000000			
	0266	ApertureValue Value	0400000001000000			
	026E	BrightnessValue Value	0000000001000000			
	0276	ExposureBiasValue Value	0000000001000000			
	027E	MaxApertureRatioValue Value	0100000001000000			
	0286	SubjectDistance Value	0F0000000A000000			
	028E	FocalLength Value	3200000001000000			
	0296	UserComment Value (46Bytes)	4A49530000000000....			
1st IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	02C4	Number Of Entries	0700			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	02C6	Compression	0301	0300	01000000	01000000
	02D2	XResolution	1A01	0500	01000000	1E030000
	02DE	YResolution	1B01	0500	01000000	26030000
	02EA	ResolutionUnit	2801	0300	01000000	02000000
	02F6	JPEGInterchangeFormat	0102	0400	01000000	2D0E0000
	0302	JPEGInterchangeFormatLength	0202	0400	01000000	FF0A0000
	030E	YCbCrPositioning	1302	0300	01000000	02000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	031A	Next IFD Offset	00000000			
Value longer than 4byte of 1st IFD	**Offset (Hex)**	**Data (Hex or "ASCII")**	**Name**			
	031E	4800000001000000	XResolution Value			
	0326	4800000001000000	YResolution Value			
Thumbnail Image Data	**Offset (Hex)**	**Name**	**Data**			
	032E	Thumbnail Data	(JPEG Stream)			

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A.4 JPEG 圧縮（4:2:0）ファイル

Table 38 JPEG 圧縮（4:2:0）ファイル記載例の内容

主画像	
記録フォーマット	JPEG
サブサンプリング	YCC 4:2:0
リスタートマーカー	挿入
量子化テーブルの数	2
画素数	620(幅) x 475(高さ)
有効画像データ	620x475
SOF の記録画素数	640x475
DCT データ	640x480
画像タイトル	Exif_JPEG_420
画像入力機器のメーカー名	DSCompany
画像入力機器のモデル名	Example
画像方向	正位置
画像の解像度	72dpi(Width), 72dpi(Length)
ファイル変更日時	1997:09:01 12:00:00
撮影著作権者／編集著作権者	Copyright, ABCDE,1997
Exif 固有の情報	
バージョン	Ver2.0
原画像データの生成日時	1997:09:01 12:00:00
ファイル作成日時	1997:09:01 12:00:00
コンポーネントの意味	Y,Cb,Cr
画像圧縮モード	2bit/pel
シャッタースピード	59/10（1/60 秒相当）
絞り値	50/10（F 値:5.6 相当）
輝度値	80/10
露光補正値	0/0
レンズ最大 F 値	200/10
被写体距離	20/10
測光方式	マルチスポット
光源	昼光
ストロボ ON/OFF	ON
サムネイル	
記録フォーマット	TIFF
サブサンプリング	YCC 4:2:0
画素数	80x60
画像の解像度	72dpi(Width), 72dpi(Length)

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Table 39 JPEG 圧縮（4:2:0）ファイルの JPEG ストリーム記載例

Offset (Hex)	Maker Segment	Name	Code (Hex)	Comment
0000	SOI	SOI Marker	FFD8	Start of Image
0002	APP1	APP1 Marker	FFE1	
0004		APP1 Length	1FBC	
0006		Identifier	"Exif"00	
000B		Pad	00	
000C		APP1 Body		See Next Table
1FC0	DQT	DQT Marker	FFDB	Define Quantization Table
1FC2		DQT Length	0084	
1FC4		Pq, Tq	00	
1FC5		table elements	08060607....	64Bytes Data
2005		Pq,Tq	01	
2006		table elements	0909090C....	64Bytes Data
2046	DHT	DHT Marker	FFC4	
2048		DHT Length	01A2	
204A		Th	00	Table 0 for DC
204B		Li	00010501....	
205B		Vij	00010203....	
2067		Th	10	Table 0 for AC
2068		Li	00020103....	
2078		Vij	01020300....	
211A		Th	01	Table 1 for DC
211B		Li	00030101....	
212B		Vij	00010203....	
2137		Th	11	Table 1 for AC
2138		Li	00020102....	
2148		Vij	00010203....	
21EA	DRI	DR Marker	FFDD	
21EC		DRI Length	0004	
21EE		Ri	0004	
21F0	SOF0	SOF0 Marker	FFC0	
21F2		SOF0 Lentth	0011	
21F4		P	08	
21F5		Y	01DB	
21F7		X	0280	
21F9		Nf	03	
21FA		C1	01	
21FB		H1,V1	22	
21FC		Tq1	00	
21FD		C2	02	
21FE		H2,V2	11	
21FF		Tq2	01	
2200		C3	03	
2201		H3,V3	11	
2202		Tq3	01	
2203	SOS	SOS Marker	FFDA	
2205		SOS Length	000C	
2207		Ns	03	
2208		Cs1	01	
2209		Td1,Ta1	00	
220A		Cs2	02	

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220B		Td2,Ta2	11	
220C		Cs3	03	
220D		Td3,Ta3	11	
220E		Ss	00	
220F		Se	3F	
2210		Ah,Al	00	
2211	Image Data		F9FE....	Compressed Data
13BA4	EOI		FFD9	

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Table 40 JPEG 圧縮（4:2:0）ファイルの APP1 記載例

Header	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0000	Byte Order	4D4D ("II")			
	0002	42	2A00			
	0004	0th IFD Offset	08000000			
0th IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	0008	Number of Entries	0B00			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageDescription	0E01	0200	0E000000	92000000
	0016	Make	0F01	0200	09000000	A0000000
	0022	Model	1001	0200	08000000	AA000000
	002E	Orientation	1201	0300	01000000	01000000
	003A	XResolution	1A01	0500	01000000	B2000000
	0046	YResolution	1B01	0500	01000000	BA000000
	0052	ResolutionUnit	2801	0300	01000000	02000000
	005E	DateTime	3201	0200	14000000	C2000000
	006A	YCbCrPositioning	1302	0300	01000000	02000000
	0076	Copyright	9882	0200	15000000	D6000000
	0082	Exif IFD Pointer	6987	0400	01000000	EC000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	008E	Next IFD Offset	C402			
Value longer than 4byte of 0th IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0092	ImageDescription Value	"Exif_JPEG_420"00			
	00A0	Make Value	"DSCompany"00			
	00AA	Model Value	"Example"00			
	00B2	XResolution Value	4800000001000000			
	00BA	YResolution Value	4800000001000000			
	00C2	DateTime Value	"1997:09:01 12:00:00"00			
	00D6	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	00EC	Exif IFD Number	1900			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	00EE	ExposureTime	9A82	0500	01000000	1E020000
	00FA	FNumber	9D82	0500	01000000	26020000
	0106	ExifVersion	0090	0700	04000000	"0200"
	0112	DateTimeOriginal	0390	0200	14000000	2E020000
	011E	DateTimeDigitized	0490	0200	14000000	42020000
	012A	ComponentsConfiguration	0191	0700	04000000	01020300
	0136	CompressedBitsPerPixel	0292	0500	01000000	56020000
	0142	ShutterSpeedValue	0192	0A00	01000000	5E020000
	014E	ApertureValue	0292	0500	01000000	66020000
	015A	BrightnessValue	0392	0A00	01000000	6E020000
	0166	ExposureBiasValue	0492	0A00	01000000	76020000
	0172	MaxApertureRatioValue	0592	0500	01000000	7E020000
	017E	SubjectDistance	0692	0500	01000000	86020000
	018A	MeteringMode	0792	0300	01000000	01000000

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	0196	LightSource	0892	0300	01000000	01000000
	01A2	Flash	0992	0300	01000000	00000000
	01AE	FocalLength	0A92	0500	01000000	8E020000
	01BA	UserComments	8692	0700	2E000000	96020000
	01C6	SubSecTime	9092	0200	04000000	30303000
	01D2	SubSecTimeOriginal	9192	0200	04000000	"000"00
	01DE	SubSecTimeDigitized	9292	0200	04000000	"000"00
	01EA	FlashPixVersion	A000	0700	04000000	"0100"
	01F6	ColorSpace	A001	0300	01000000	01000000
	0202	Pixel X Dimension	A002	0400	01000000	6C020000
	020E	Pixel Y Dimension	A003	0400	01000000	DB010000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	021A	Next IFD Offset	00000000			
Value longer than 4Byte of Exif IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	021E	ExposureTime Value	010000003C000000			
	0226	FNumber Value	0400000001000000			
	022E	DateTimeOriginal Value	"1997:09:01 12:00:00"00			
	0242	DateTimeDigitized Value	"1997:09:01 12:00:00"00			
	0256	CompressedBitsPerPixel Value	0200000001000000			
	025E	ShutterSpeedValue Value	0600000001000000			
	0266	ApertureValue Value	0400000001000000			
	026E	BrightnessValue Value	0000000001000000			
	0276	ExposureBiasValue Value	0000000001000000			
	027E	MaxApertureRatioValue Value	0100000001000000			
	0286	SubjectDistance Value	0F0000000A000000			
	028E	FocalLength Value	3200000001000000			
	0296	UserComment Value (46Bytes)	4A49530000000000....			
1st IFD	**Offset (Hex)**	**Name**	**Entry Number (Hex)**			
	02C4	Number Of Entries	0F00			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	02C6	ImageWidth	0001	0400	01000000	50000000
	02D2	ImageLength	0101	0400	01000000	3C000000
	02DE	BitsPerSample	0201	0300	03000000	7E030000
	02EA	Compression	0301	0300	01000000	01000000
	02F6	PhotometricInterpretation	0601	0300	01000000	06000000
	0302	StripOffsets	1101	0400	01000000	94030000
	030E	SamplesPerPixel	1501	0300	01000000	03000000
	031A	RowsPerStrip	1601	0400	01000000	3C000000
	0326	StripByteCounts	1701	0400	01000000	201C0000
	0332	XResolution	1A01	0500	01000000	84030000
	033E	YResolution	1B01	0500	01000000	8C030000
	034A	PlanarConfiguration	1C01	0300	01000000	01000000
	0356	ResolutionUnit	2801	0300	01000000	02000000
	0362	YCbCrSubSampling	1202	0300	02000000	02000200
	036E	YCbCrPositioning	1302	0300	01000000	02000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	037A	Next IFD Offset	00000000			
Value longer than 4byte of 1st IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			

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	037E	BitsPerSample Value	,080008000800
	0384	XResolution Value	4800000001000000
	038C	YResolution Value	4800000001000000
Thumbnail Image Data	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**
	0394	Thumbnail Image Data Strip	:

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付録 B　音声ファイル記載例

B.1　PCM Audio Data

Table 41 PCM 音声ファイル記載例の内容

音声データ	
フォーマットタイプ	PCM 形式
チャネル数	モノラル
サンプリング周波数	22.05kHz
ビット数	8 ビット/サンプル
全サンプル数	27768 サンプル
付属情報	
音声のタイトル	ExifPCMExampleZ
音声のジャンル	無し
録音年月日	1997-07-13（1997 年 7 月 13 日）
録音者	Taro Yamada
録音著作権	Copyright Exif Corporation on 1997.
Exif 固有の情報	
Exif バージョン	0200（Version 2.0）
Exif 画像ファイルとの関連	DSC00001.JPGZ
録音開始時刻	10:15:30.130Z（10 時 15 分 30.130 秒）
録音機器のメーカ名	DSC CorporationZ
録音機器のモデル名	DSC1000Z
メーカノート	無し
ユーザコメント	無し

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Table 42 PCM 音声ファイルの記載例

	Offset (Hex)	Name	Comment	Data (Hex or "Ascii")
RIFF-ck	0000	ckID	RIFF	52494646
	0004	ckSize		766D0000
	0008	formType	WAVE	57415645
fmt-ck	000C	ckID	fmt_	666D7420
	0010	ckSize		10000000
	0014	wFormatTag	PCM 形式	0100
	0016	nchannels	モノラル	0100
	0018	nSamplesPerSec	22.05kHz	22560000
	001C	nAvgBytesPerSec	22050 バイト/sec	22560000
	0020	nBlockAlign	1 バイト/ブロック	0100
	0022	wBitsPerSample	8 ビット/サンプル	0800
INFO-LIST	0024	ckID	LIST	4C495354
	0028	ckSize		6E000000
	002C	listType	INFO	494E464F
INAM-ck	0030	ckID	INAM	494E414D
	0034	ckSize		0F000000
	0038	ckData	（音声タイトル）	"ExifPCMExample"0000
ICRD-ck	0048	ckID	ICRD	49435244
	004C	ckSize		0B000000
	0050	ckData	（1997 年 7 月 13 日）	"1997-07-13"0000
IART-ck	005C	ckID	IART	49415254
	0060	ckSize		0C000000
	0064	ckData	（作成者名）	"Taro Yamada"00
ICOP-ck	0070	ckID	ICOP	49434F50
	0074	ckSize		21000000
	0078	ckData	（著作権）	"Copyright Exif Corporation on 1997."0000
exif-LIST	009A	ckID	LIST	4C495354
	009E	ckSize		64000000
	00A2	listType	exif	65786966
ever-ck	00A6	ckID	ever	65766572
	00AA	ckSize		4000000
	00AE	ckData	Ver.2.0	200
erel-ck	00B2	ckID	erel	6572656C
	00B6	ckSize		0D000000
	00BA	ckData	（Exif 画像ファイルとの関連）	"DSC00001.JPG"0000
etim-ck	00C8	ckID	etim	6574696D
	00CC	ckSize		0D000000
	00D0	ckData	（10 時 15 分 30.130 秒）	"10:15:30.130"0000
ecor-ck	00DE	ckID	ecor	65636F72
	00E2	ckSize		10000000
	00E6	ckSize	（機器のメーカ名）	"DSC Corporation"00
emdl-ck	00F6	ckID	emdl	656D646C
	00FA	ckSize		8000000
	00FE	ckData	（機器のモデル名）	"DSC1000"00
data-ck	0106	ckID	data	64617461
	010A	ckSize		706C0000
	010E	ckData	PCM Audio Data	00000000000・・・・・・・・・・・・・・・・・

（全サンプル数＝27768）

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B.2 μ-Law Audio Data

Table 43 μ-Law 音声ファイル記載例の内容

音声データ	
フォーマットタイプ	μLAW PCM
チャネル数	モノラル
サンプリング周波数	8.000kHz
ビット数	8bit
全サンプル数	
付属情報	
音声のタイトル	uLAW PCM ExampleZ
音声のジャンル	GreetingZ
録音年月日	1997-07-17(1997 年 7 月 17 日)
録音者	Interactive Multimedia AssociationZ
録音著作権	Copyright ABCZ
Exif 固有の情報	
Exif バージョン	0200（Version 2.0）
Exif 画像ファイルとの関連	DSC00001.JPGZ
録音開始時刻	10:20:30.130Z(10 時 20 分 30.130 秒)
録音機器のメーカ名	ABCD CorporationZ
録音機器のモデル名	CameraXYZZ
メーカノート	0000000000000000
ユーザコメント	UserComent (ASCII)

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Table 44 μ-Law 音声ファイルの記載例

	Offset (Hex)	Name	Comment	Data (Hex or "Ascii")
RIFF-ck	0000	ckID	RIFF	52494646
	0004	ckSize		AAB60100
	0008	formType	WAVE	57415645
fmt-ck	000C	ckID	fmt_	666D7420
	0010	ckSize		12000000
	0014	wFormatTag	μ LAW 形式	0700
	0016	nchannels	モノラル	0100
	0018	nSamplesPerSec	8.00kHz	401F0000
	001C	nAvgBytesPerSec	8.00kByte/sec	401F0000
	0020	nBlockAlign	1 バイト/ブロック	0100
	0022	wBitsPerSample	8 ビット/サンプル	0800
	0024	cbSize	0	0000
fact-ck	0026	ckID	fact	66616374
	002A	ckSize		04000000
	002E	dwSampleLength		28B50100
INFO-LIST	0032	ckID	LIST	4C495354
	0036	ckSize		AC000000
	003A	listType	INFO	494E464F
INAM-ck	003E	ckID	INAM	494E414D
	0042	ckSize		12000000
	0046	ckData	（音声タイトル）	"uLAW PCM Example"00
IGNR-ck	0058	ckID	IGNR	49474E52
	005C	ckSize		09000000
	0060	ckData	（録音のジャンル）	"Greeting"Z
ICRD-ck	006A	ckID	ICRD	49435244
	006E	ckSize		0B000000
	0072	ckData	（1997 年 7 月 17 日）	"1997-07-17"00
ICMT-ck	007E	ckID	ICMT	49434D54
	0082	ckSize		18000000
	0086	ckData	(This File uLAW Sample)	"This File uLAW Sample"000000
IART-ck	009E	ckID	IART	49415254
	00A2	ckSize		23000000
	00A6	ckData	（作成者名）	"Interactive Multimedia Association"00
ICOP-ck	00CA	ckID	ICOP	49434F50
	00CE	ckSize		10000000
	00D2	ckData	（著作権）	"ABCD Corporation"00
exif-LIST	00E2	ckID	LIST	4C495354
	00E6	ckSize		94000000
	00EA	listType	exif	65786966
ever-ck	00EE	ckID	ever	4C495354
	00F2	ckSize		94000000
	00F6	ckData	Ver.2.0	65786966
erel-ck	00FA	ckID	erel	4C495354
	00FE	ckSize		94000000
	0102	ckData	（Exif 画像ファイルとの関連）	"DSC00001.JPG"00
etim-ck	0110	ckID	etim	4C495354
	0114	ckSize		94000000
	0118	ckData	（10 時 20 分 30.130 秒）	"10:20:30.130"00
ecor-ck	0126	ckID	ecor	4C495354
	012A	ckSize		94000000

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		012E	ckSize	（機器のメーカ名）	"ABCD Corporation"00
	emdl-ck	0140	ckID	emdl	656D646C
		0144	ckSize		0A000000
		0148	ckData	（機器のモデル名）	"CameraXY"0000
	emnt-ck	0152	ckID	emnt	656D6E74
		0156	ckSize		08000000
		015A	ckData	（メーカノート）	0000000000000000
	eucm-ck	0162	ckID	eucm	6575636D
		0166	ckSize		14000000
		016A	ckData	（ユーザコメント）	415343494900000055736572204 36F6D
data-ck		017E	ckID	data	64617461
		0182	ckSize		28B50100
		0186	ckData	μ-Law Audio Data	F2FE00007FFF0000E3……

（全サンプル数＝111912）

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B.3 IMA-ADPCM Audio Data

Table 45 IMA-ADPCM 音声ファイル記載例の内容

音声データ	
フォーマットタイプ	IMA-ADPCM 形式
チャネル数	ステレオ
サンプリング周波数	8.000kHz
1 ブロックあたりのバイト数	8110 バイト/秒
サンプル当たりのビット数	4 ビット/サンプル
データの全バイト数	35840 バイト
付属情報	
音声のタイトル	IMA-ADPCM ExampleZ
音声のジャンル	無し
録音年月日	1997-08-11Z（1997 年 8 月 11 日）
コメント	無し
録音者	Hanako YamadaZ
録音著作権	Copyright XYZ on 1997.Z
Exif 固有の情報	
Exif バージョン	0200（Version 2.0）
Exif 画像ファイルとの関連	DSC00001.JPGZ
録音開始時刻	15:14:13.135Z（15 時 14 分 13.135 秒）
録音機器のメーカ名	DSC International CorporationZ
録音機器のモデル名	DSC Camera-2Z
メーカノート	無し
ユーザコメント	無し

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Table 46 IMA-ADPCM 音声ファイルの記載例

	Offset (Hex)	Name	Comment	Data (Hex or "Ascii")
RIFF-ck	0000	ckID	RIFF	52494646
	0004	ckSize		248D0000
	0008	formType	WAVE	57415645
fmt-ck	000C	ckID	"fmt_"	666D7420
	0010	ckSize		14000000
	0014	wFormatTag	IMA-ADPCM形式	1100
	0016	nchannels	ステレオ	0200
	0018	nSamplesPerSec	8.0kHz	401F0000
	001C	nAvgBytesPerSec	8110バイト/sec	AE1F0000
	0020	nBlockAlign	512バイト/ブロック	0002
	0022	wBitsPerSample	4ビット/サンプル	0400
	0024	cbSize	追加バイト数＝2	0200
	0026	wSamplesPerBlock	505バイト/ブロック	F901
fact-ck	0028	ckID	fact	66616374
	002C	ckSize		04000000
	0030	dwSampleLengh	35350サンプル	168A0000
INFO-LIST	0034	ckID	LIST	4C495354
	0038	ckSize		68000000
	003C	listType	INFO	494E464F
INAM-ck	0040	ckID	INAM	494E414D
	0044	ckSize		12000000
	0048	ckData	（音声タイトル）	"IMA-ADPCM Example"00
IGNR-ck	0058	ckID	IGNR	49474E52
	005C	ckSize		09000000
	0060	ckData	（録音のジャンル）	"Greeting"Z
ICRD-ck	005A	ckID	ICRD	49435244
	005E	ckSize		0B000000
	0062	ckData	（1997年8月11日）	"1997-08-11"0000
IART-ck	006E	ckID	IART	49415254
	0072	ckSize		0E000000
	0076	ckData	（作成者名）	"Hanako Yamada"00
ICOP-ck	0084	ckID	ICOP	49434F50
	0088	ckSize		17000000
	008C	ckData	（著作権）	"Copyright XYZ on 1997."0000
exif-LIST	00E2	ckID	LIST	4C495354
	00E6	ckSize		94000000
	00EA	listType	exif	65786966
ever-ck	00A4	ckID	LIST	4C495354
	00A8	ckSize		78000000
	00AC	listType	exif	65786966
erel-ck	00BC	ckID	erel	6572656C
	00C0	ckSize		0D000000
	00C4	ckData	（Exif画像ファイルとの関連）	"DSC00001.JPG"0000
etim-ck	00D2	ckID	etim	6574696D
	00D6	ckSize		0D000000
	00DA	ckData	（15時14分13.135秒）	"15:14:13.135"0000
ecor-ck	00E8	ckID	ecor	65636F72
	00EC	ckSize		1E000000
	00F0	ckSize	（機器のメーカ名）	"DSC International Corporation"00
emdl-ck	010E	ckID	emdl	656D646C

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	0112	ckSize		0D000000
	0116	ckData	（機器のモデル名）	"DSC Camera-2"0000
data-ck				
	0124	ckID	data	64617461
	0128	ckSize		008C0000
	012C	ckData		.....

（全バイト数＝35840）



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付録 C APEX について

本規格ではカメラ情報として、APEX （Additive System of Photographic Exposure ） という単位を用いている。APEX は露光量 （Ev 値） を表すのに都合がよい単位である。APEX と他の単位との関係は基本的には以下のようになっている。

- 絞り値（ApertureValue:Av） = 2 $\log_2$ （ F ナンバー）
- シャッタースピード （ShutterSpeedValue:Tv） = - $\log_2$ （ 露出時間 ）
- 輝度値 （BrightnessValue:Bv） = $\log_2$ （ B / NK ） 但し、B:cd/cm^2 , N,K : constant

フイルム感度（本規格では使用されていない）は以下のように表せる

フイルム感度（Sv） = $\log_2$ （ ASA / 3.125 ）

これらの値を用いて露光量（Ev）を計算すると以下のようになる。

Ev = Av + Tv = Bv + Sv

以下の表はカメラ情報として実際に使用されている値の一例である。

Table 47 APEX 値の例

ApertureValue (APEX)	F-Number
0	1
1	1.4
2	2
3	2.8
4	4
5	5.6
6	8
7	11
8	16
9	22
10	32

ShutterSpeed Value (APEX)	ExposureTime (second)
-5	30
-4	15
-3	8
-2	4
-1	2
0	1
1	1/2
2	1/4
3	1/8
4	1/15
5	1/30
6	1/60
7	1/125
8	1/250
9	1/500
10	1/1000
11	1/2000

BrightnessValue (APEX)	foot lambert
-2	1/4
-1	1/2
0	1
1	2
2	4
3	8
4	15
5	30

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付録 D　推奨運用例

本章にて記載される推奨運用例は、PC カードや Smart Media 等の汎用リムーバブルメディアを記録媒体として持つ DSC やその関連機器間の互換性を高めるための運用例であり Exif の運用を制限するものではない。

DSC に代表される組み込み機器にて、その記録媒体をハンドリングするための処理能力に限りがある場合などには以下の運用例を推奨する。

D.1　ディレクトリに関する運用推奨例

ライター側

ルートディレクトリの下にサブディレクトリ"IMxxxxxx"を作成し、この中に Exif ファイルを記録する。なお、"xxxxxx"は最大 6 文字の英数字であり特殊文字は禁止とする。また、"IM"は大文字とする。以後、このディレクトリを Exif ディレクトリと呼ぶ。

D.2　ファイル名に関する運用推奨例

リーダー側

Exif リーダーは上記 D.1 で示される Exif ディレクトリに存在するファイルのうち拡張子 "JPG" を有するファイルは Exif 圧縮ファイル、拡張子 "TIF" を有するファイルは Exif 非圧縮ファイル、拡張子 "WAV" を有するファイルは音声ファイルとして、ファイル内部の必須タグまたはチャンクデータを確認の上、適宜再生する。これ以外の拡張子を有するファイルの扱いについては規定しない。

D.3　ファイル操作に関する運用推奨例

Exif の圧縮ファイル、非圧縮ファイル、音声ファイルは同一 Exif ディレクトリ内に混在して記録することができる。Exif ディレクトリは"IMxxxxxx"の規定（上記 D.1 の規定）を守る範囲でルートディレクトリの下に複数作成してよい。具体的な運用ケースを以下に示す。

運用ケース

記録媒体にすでに自己記録 Exif ディレクトリ（例:IMFIDX10）とは異なる他機種記録 Exif ディレクトリ（例:IMXYZ）が記録されている場合、自己記録 Exif ディレクトリ（IMFIDX10）を別途ルート下に

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作成し、その中にExifファイルを記録することができる。

この場合、従来記録されているExifディレクトリ（IMXYZ）はそのまま保存される（Fig. 50参照）

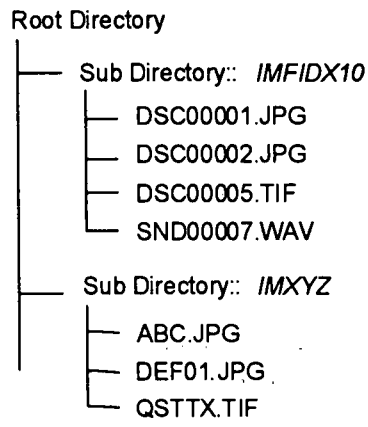


Fig. 50　ディレクトリ構造およびファイル記録例

リーダー側

ルートディレクトリの下に存在するExifディレクトリ "IMxxxxxx"（上位2文字が"IM"であるサブディレクトリ）中に記録され、かつファイル名に関する規定（2.8.3章、3.7.1章参照）を満たすファイル名をもつファイルを認識し、必須タグまたはチャンクの内容が機器の仕様に合っていればこれを再生する。

ルートディレクトリの下に複数のExifディレクトリ "IMxxxxxx" が記録されている場合はそれらに記録されるファイルを認識可能とする。

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付録 E　色空間ガイドライン

このガイドラインでは、参考として sRGB[xvii]、ITU-R BT.709[xviii]、ITU-R BT.601[xix]について解説する。詳しくは参考文献を参照されたい。

E.1　sRGB について

sRGB は標準モニタの特性と鑑賞条件をより厳密に規定した色空間の規格である（詳細は IEC/TC 100 の PT 61966 で審議中)。この規格は市場のモニタ特性を中央値で代表するよう定められている。

一方 ITU-R BT.709 はカメラでシーンを撮影し標準モニタで表示するための変換方式を規定しており、カメラの標準規格となっている。ただし ITU-R BT.709 ではこの標準モニタの特性について明確には定義されていない。したがって sRGB は ITU-R BT.709 と整合性をとりつつ、これを補う規格と解釈することができる。

実際のカメラでは、sRGB で規定される標準モニタ特性と鑑賞条件を前提条件としながら ITU-R BT.709 に準拠した特性で撮像することで、標準的な色空間の画像を生成することができる。

E.2　調子（明るさとコントラスト）再現

被写体の反射率を ITU-R BT.709 に基づいて非線形変換し、8 ビットに量子化して記録する。

ITU-R BT.709 の変換特性は以下のとおり。

(1) R,G,B≧0.018 のとき

$R' = 1.099R^{0.45}-0.099$

$G' = 1.099G^{0.45}-0.099$

$B' = 1.099B^{0.45}-0.099$

(2) R,G,B<0.018 のとき

$R' = 4.5R$

$G' = 4.5G$

$B' = 4.5B$

この変換の後にディジタル記録のため 255 倍して 8 ビット量子化を行なう。

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E.3 輝度・色差変換式

R,G,B と輝度 Y,色差 Cb, Cr の変換は ITU-R BT.601 に準拠した以下の式にておこなう。

$$Y = 0.299R + 0.587G + 0.114B$$

$$Cb = (-0.299R - 0.587G + 0.886B) \times 0.564 + offset$$

$$Cr = (0.701R - 0.587G - 0.114B) \times 0.713 + offset$$

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付録 F　FlashPix への変換について

本規格では、画質劣化無く、また付属情報もすべて保存される形で FlashPix フォーマットに変換できるようデータ記録方式に考慮がされている。FlashPix への変換機能があらかじめ準備されているという意味で FlashPix-Ready（FPXR）ファイルと呼ぶ。

FlashPix-Ready 機能は大きく分けて以下の 3 つからなる。

- Exif タグ情報はすべて FlashPix の Image Info Property Set 対応
- APP2 の拡張データは FlashPix 拡張データに変換可能
- JPEG 画像はリスタート・マーカを利用して画質劣化無く FlashPix のタイル構造に変換可能

Fig. 51に変換の模式図を示す。

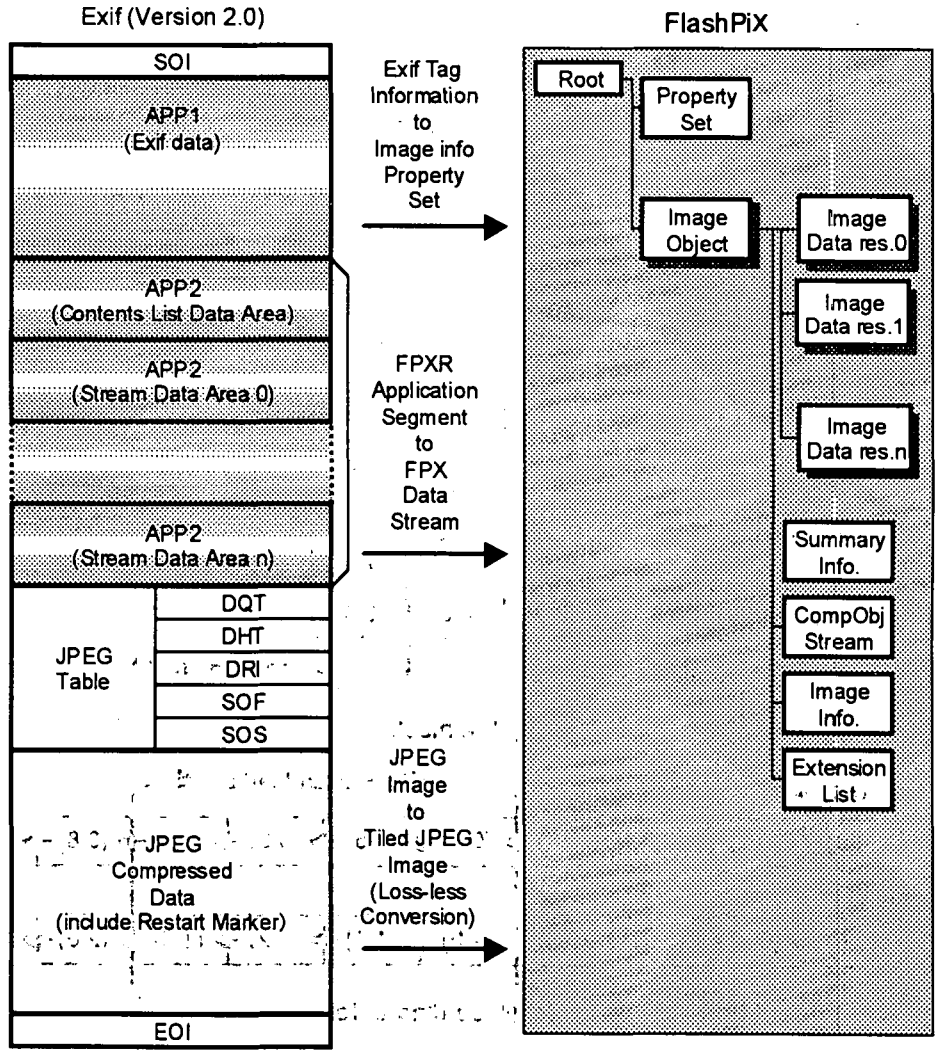


Fig. 51　Exif から FlashPix への変換

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F.1 画像データの変換

FlashPix の圧縮画像データは、JPEG で圧縮した 64×64 画素のタイルで構成されている。リスタート・マーカの無い JPEG 画像を FlashPix 画像に変換するためには、JPEG を伸長・再圧縮しなければならず、画像劣化を引き起こす可能性があるが、リスタート・マーカを 64 画素毎に挿入しておけば、JPEG 圧縮データを並べ替えるだけで FlashPix の最高解像度画像を作ることができる。

Fig. 52にリスタート・マーカを用いた圧縮データの並べ替えの模式図を示す。

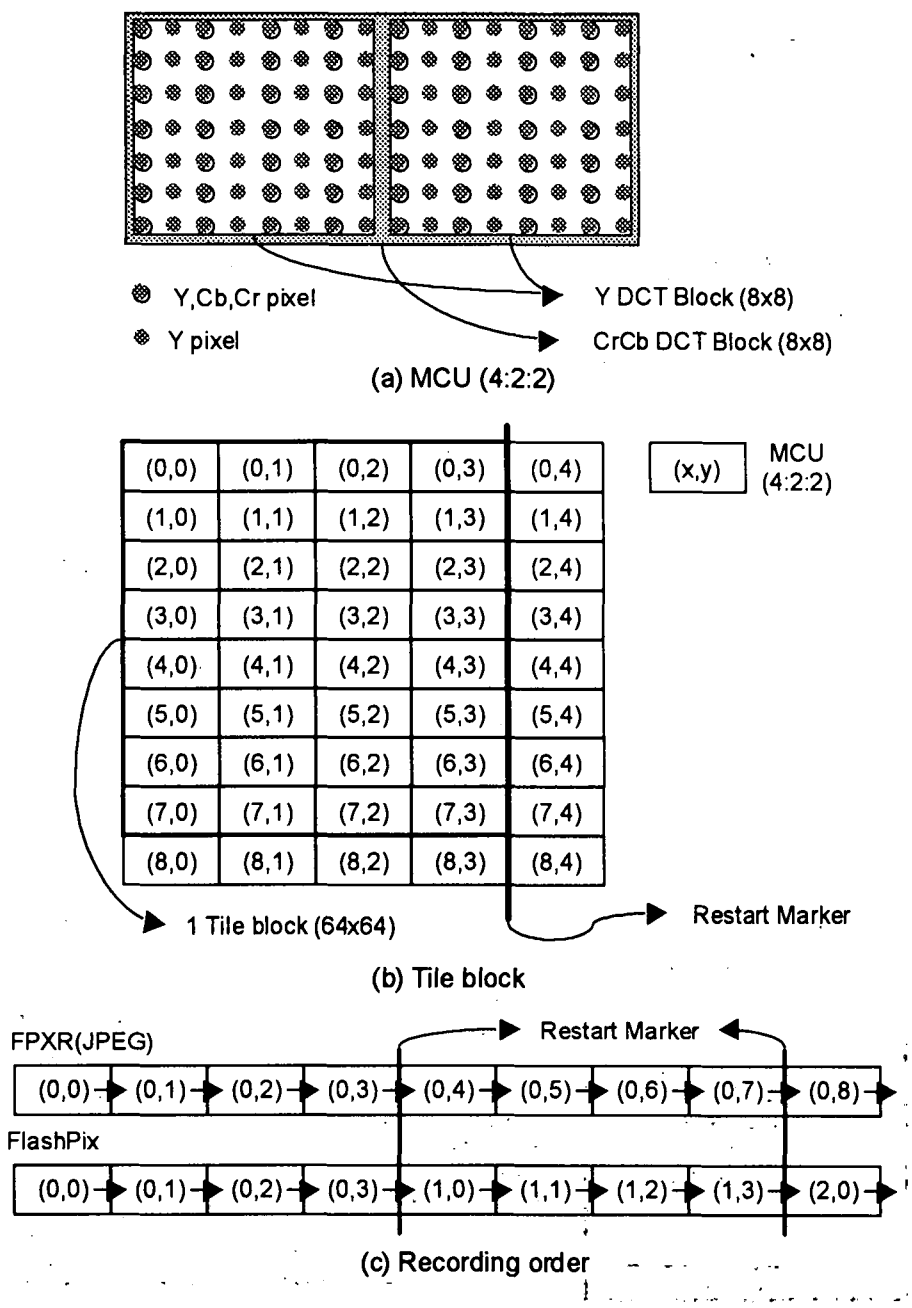


Fig. 52 リスタート・マーカを用いた FlashPix への変換

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リスタート・マーカの記録はオプションであり、その有無によらず FlashPix に変換可能であるが、リスタート・マーカ無しの場合は画像劣化および変換のための処理時間が長くなることがあるので注意が必要である。

一方、リスタート・マーカを 64 画素毎に挿入するためには、画像データの幅は 64 の倍数でなければならない。そこで、実効画素幅はタグ情報（PixelXDimension）に記録し、JPEG 圧縮データは実効画像の右端にパディングして 64 の倍数にした物を記録されている（2.8.1章参照)。

FlashPix 規格も同様に、64 の倍数に満たない部分にはパディングを施す規定となっており、FlashPix へ変換する場合には、右端のパディングデータも実効画像データと同等に扱って良い。

また、画像の高さ方向の 64 の倍数に満たない部分はパディングされていないため、FlashPix に変換する際に下端をパディングしなければならない。

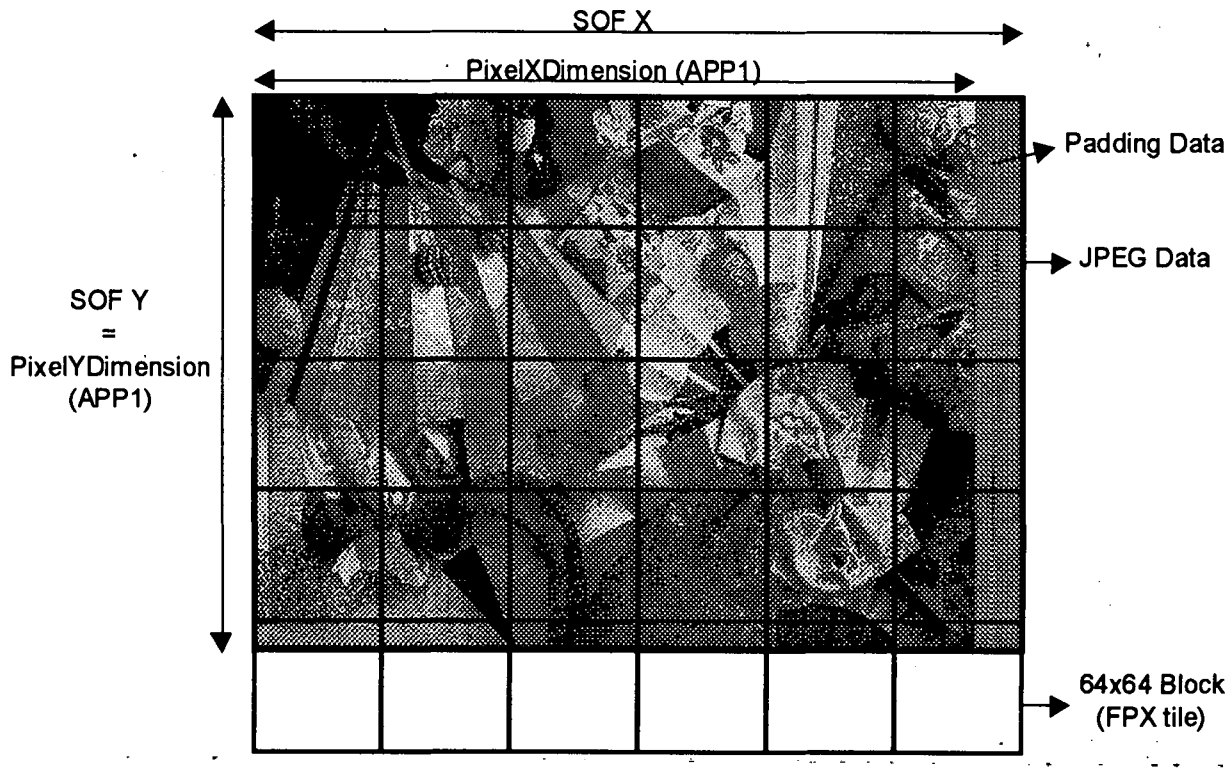


Fig. 53 画像サイズ制限

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F.2 タグデータの変換

Exif の付属情報は、FlashPix 変換時に、その付属情報を記録する仕組みである Property set に 1 対に変換することができる。以下に各タグ情報の FlashPix PropertySet への変換規則を示す。(GPS Info タグの変換については TBD)

Table 48 Exif タグ・ FlashPix Property set 変換表(1) (TIFF タグ)

Exif			FPX		
Field Name	Tag Code		Property Set	Group	Name
	Dec	Hex			
ImageWidth	256	100	-	-	-
ImageLength	257	101	-	-	-
BitsPerSample	258	102	-	-	-
Compression	259	103	-	-	-
PhotometricInterpretation	262	106	-	-	-
ImageDescription	270	10E	Image Info	Content Description	Caption text
Make	271	10F	Image Info	Camera Information	Camera manufacturer name
Model	272	110	Image Info	Camera Information	Camera model name
StripOffsets	273	111	-	-	-
Orientation	274	112	Transform	-	Spatial Orientation
SamplesPerPixel	277	115	-	-	-
RowsPerStrip	278	116	-	-	-
StripByteCounts	279	117	-	-	-
XResolution	282	11A	Image Contents	Primary description	Default display width
YResolution	283	11B	Image Contents	Primary description	Default display height
PlanarConfiguration	284	11C	-	-	-
ResolutionUnit	296	128	Image Contents	Primary description	Display height/width units
TransferFunction	301	12D	-	-	-
Software	305	131	Image Info	File source	Softaware Name
DateTime	306	132	Ignore	Ignore	Ignore
Artist	306	13B	Image Info	Intellectual Property	Authorship
WhitePoint	318	13E	-	-	-
PrimaryChromaticities	319	13F	-	-	-
YCbCrCoefficients	529	211	-	-	-
YCbCrSubSampling	530	212	-	-	-
YCbCrPositioning	531	213	Ignore	Ignore	Ignore
ReferenceBlackWhite	532	214	-	-	-
Copyright	33432	8298	Image Info	Intellectual Property	Copyright message
Exif IFD Pointer	34665	8769	-	-	-
GPS Info IFD Pointer	34853	8825	-	-	-

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Table 49 Exif タグ・ FlashPix Property set 変換表(2) （Exif プライベートタグ）

Exif			FPX		
Field Name	Tag Code		Property Set	Group	Name
	Dec	Hex			
ExposureTime	33434	829A	Image Info	Per Picture Camera Setting	Exposure time
FNumber	33437	829D	Image Info	Per Picture Camera Setting	F-number
ExposureProgram	34850	8822	Image Info	Per Picture Camera Setting	Exposure program
SpectralSensitivity	34852	8824	Image Info	Digital Camera Characterization	Spectral sensitivity
ISOSpeedRatings	34855	8827	Image Info	Digital Camera Characterization	ISO speed ratings
OECF	34857	8829	Image Info	Digital Camera Characterization	OECF
ExifVersion	36864	9000	-	-	-
DateTimeOriginal	36867	9003	Image Info	Content Description	Date of the original image
			Image Info	Per Picture Camera Setting	Capture date
DateTimeDigitized	36868	9004	Summary Info	-	Create date/time
ComponentsConfiguration	37121	9101	Ignore	Ignore	Ignore
CompressedBitsPerPixel	37122	9102	Ignore	Ignore	Ignore
ShutterSpeedValue	37377	9201	Image Info	Per Picture Camera Setting	Exposure time
ApertureValue	37378	9202	Image Info	Per Picture Camera Setting	F-number
BrightnessValue	37379	9203	Image Info	Per Picture Camera Setting	Brightness value
ExposureBiasValue	37380	9204	Image Info	Per Picture Camera Setting	Exoisure bias value
MaxApertureValue	37381	9205	Image Info	Per Picture Camera Setting	Maximum aperture value
SubjectDistance	37382	9206	Image Info	Per Picture Camera Setting	Subject distance
MeteringMode	37383	9207	Image Info	Per Picture Camera Setting	Metering mode
LightSource	37384	9208	Image Info	Per Picture Camera Setting	Scene illuminant
Flash	37385	9209	Image Info	Per Picture Camera Setting	Flash
			Image Info	Per Picture Camera Setting	Flash return
FocalLength	37386	920A	Image Info	Per Picture Camera Setting	Focal length
MakerNote	37500	927C	-	-	-
UserComment	37510	9286	Image Info	Content description	Content description notes
SubSecTime	37520	9290	Ignore	Ignore	Ignore
SubSecTimeOriginal	37521	9291	Image Info	Content Description	Date of the original image
			Image Info	Per Picture Camera Setting	Capture date
SubSecTimeDigitized	37522	9292	Summary Info	-	Create date/time
FlashPixVersion	40960	A000	-	-	-
ColorSpace	40961	A001	Image Contents	resolution description	Subimage color
PixelXDimension	40962	A002	Image Contents	Primary description	Highest resolution width
PixelYDimension	40963	A003	Image Contents	Primary description	Highest resolution length
RelatedSoundFile	40964	A004	-	-	-
FlashEnergy	41483	A20B	Image Info	Per Picture Camera Setting	Flash Energy
SpatialFrequencyResponse	41484	A20C	Image Info	Digital Camera Characterization	Spatial frequency response
FocalplaneXResolution	41486	A20E	Image Info	Digital Camera Characterization	Focal plane X resolution
FocalplaneYResolution	41487	A20F	Image Info	Digital Camera Characterization	Focal plane Y resolution
FocalplaneResolutionUnit	41488	A210	Image Info	Digital Camera Characterization	Focal plane resolution unit
SubjectLocation	41492	A214	Image Info	Per Picture Camera Setting	Subject location
ExposureIndex	41493	A215	Image Info	Per Picture Camera Setting	Exposure index
SensingMethod	41495	A217	Image Info	Digital Camera Characterization	Sensing method
FileSource	41728	A300	Image Info	File Source	File source
SceneType	41729	A301	Image Info	File Source	Scene type
CFAPattern	41730	A302	Image Info	Digital Camera Characterization	CFA pattern

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Table 50 Exif タグ・ FlashPix Property set 変換表 (3) （GPS Info タグ）

Exif			FPX		
Field Name	Tag Code		Property Set	Group	Name
	Dec	Hex			
GPSVersionID	0	0	GPS Info extension	-	GPSVersionID
GPSLatitudeRef	1	1	GPS Info extension	-	GPSLatitudeRef
GPSLatitude	2	2	GPS Info extension	-	GPSLatitude
GPSLongitudeRef	3	3	GPS Info extension	-	GPSLongitudeRef
GPSLongitude	4	4	GPS Info extension	-	GPSLongitude
GPSAltitudeRef	5	5	GPS Info extension	-	GPSAltitudeRef
GPSAltitude	6	6	GPS Info extension	-	GPSAltitude
GPSTimeStamp	7	7	GPS Info extension	-	GPSTimeStamp
GPSSatellites	8	8	GPS Info extension	-	GPSSatellites
GPSStatus	9	9	GPS Info extension	-	GPSStatus
GPSMeasureMode	10	A	GPS Info extension	-	GPSMeasureMode
GPSDOP	11	B	GPS Info extension	-	GPSDOP
GPSSpeedRef	12	C	GPS Info extension	-	GPSSpeedRef
GPSSpeed	13	D	GPS Info extension	-	GPSSpeed
GPSTrackRef	14	E	GPS Info extension	-	GPSTrackRef
GPSTrack	15	F	GPS Info extension	-	GPSTrack
GPSImgDirectionRef	16	10	GPS Info extension	-	GPSImgDirectionRef
GPSImgDirection	17	11	GPS Info extension	-	GPSImgDirection
GPSMapDatum	18	12	GPS Info extension	-	GPSMapDatum
GPSDestLatitudeRef	19	13	GPS Info extension	-	GPSDestLatitudeRef
GPSDestLatitude	20	14	GPS Info extension	-	GPSDestLatitude
GPSDestLongitudeRef	21	15	GPS Info extension	-	GPSDestLongitudeRef
GPSDestLongitude	22	16	GPS Info extension	-	GPSDestLongitude
GPSDestBearingRef	23	17	GPS Info extension	-	GPSDestBearingRef
GPSDestBearing	24	18	GPS Info extension	-	GPSDestBearing
GPSDestDistanceRef	25	19	GPS Info extension	-	GPSDestDistanceRef
GPSDestDistance	26	1A	GPS Info extension	-	GPSDestDistance

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F.3 FlashPix 拡張データ（APP2）の変換

APP2 セグメントに記録された拡張データは、容易に FlashPix データに変換できる。

最初に、APP2 に 1 エントリー・1 ストリームのデータが記録されている場合の変換例をFig. 54に示す。

まず、FlashPix ファイルの Structured Storage 構造の中のストリーム名称 "/¥005MyPropertySet"（¥005 は 005.H を示す）にデータサイズ 8000.H、デフォルト値 00.H の領域を確保し、ここに APP2-2 に記録されているストリームデータをオフセット 00000000.H すなわち確保した領域の先頭からコピーすれば良い。

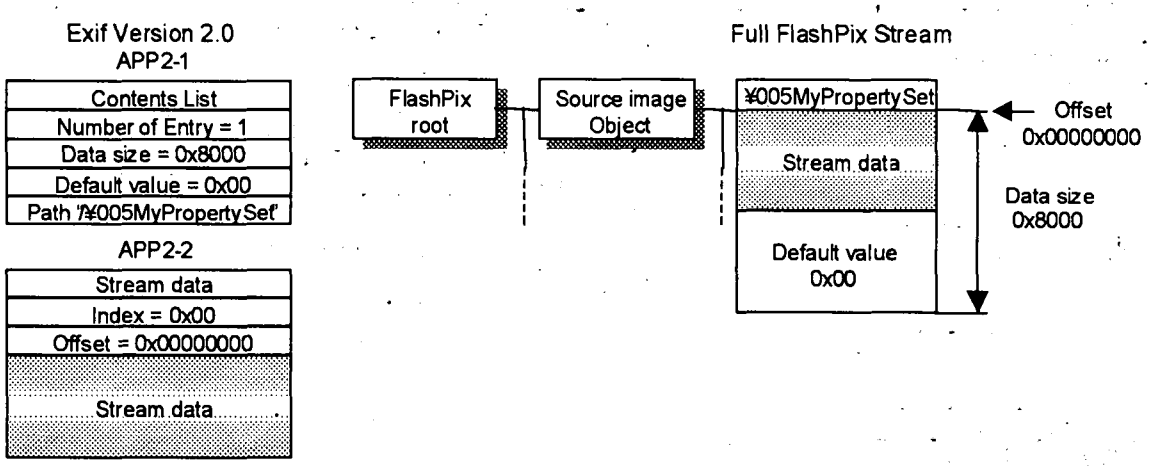


Fig. 54 FlashPix 拡張データ変換例 (1)

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次に、APP2 に 1 エントリー・2 ストリームのデータが記録されている場合の変換例をFig. 55に示す。

同様に FlashPix ファイルの Structured Storage 構造の中のストリーム名称 "/¥005MyPropertySet"にデータサイズ 10000.H、デフォルト値 00.H の領域を確保し、APP2-2 に記録されているストリームデータをオフセット 00000000.H すなわち確保した領域の先頭からコピーし、APP2-3 に記録されているストリームデータをオフセット 00008000.H からコピーすれば良い。

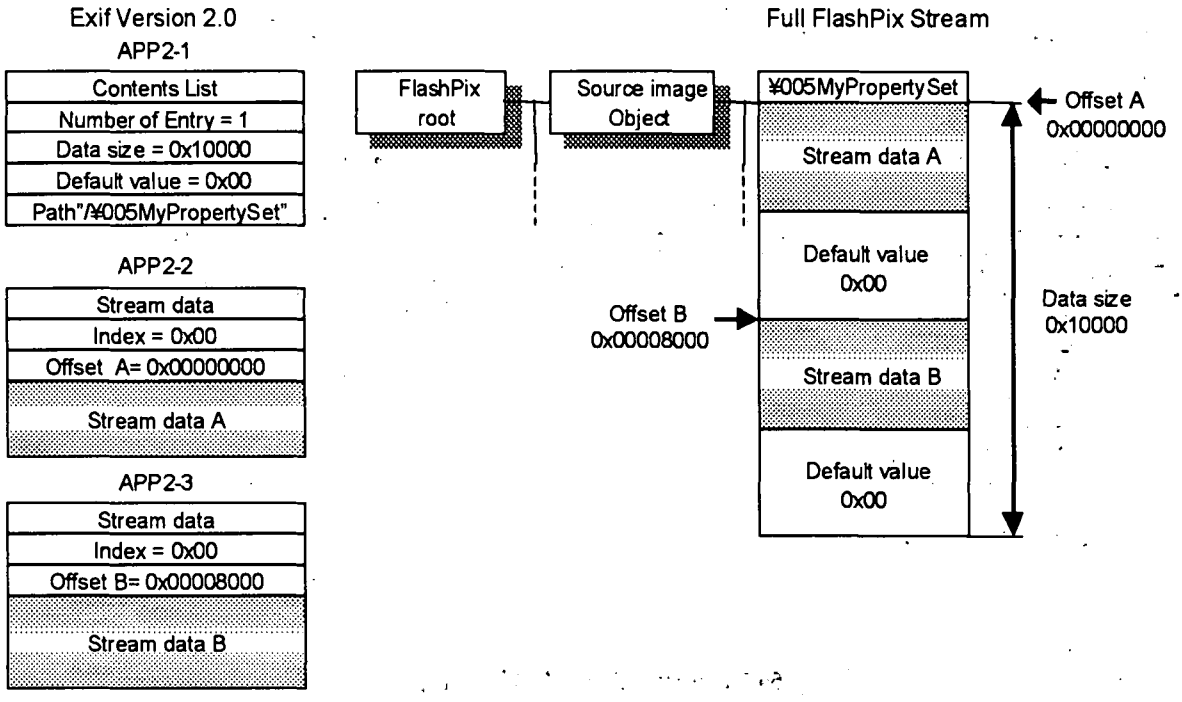


Fig. 55 FlashPix 拡張データ変換例 (2)

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最後に、APP2 に 2 エントリー・ 1 ストリームのデータが記録されている場合の変換例をFig. 56に示す。

FlashPix ファイルの Structured Storage 構造の中のストレージ名称 "/¥005MyStrage"の下層のストリーム名称 "MyPropertySet"にデータサイズ 8000.H、デフォルト値 00.H の領域を確保し、ここに APP2-2 に記録されているストリームデータをオフセット 00000000.H すなわち確保した領域の先頭からコピーすれば良い。

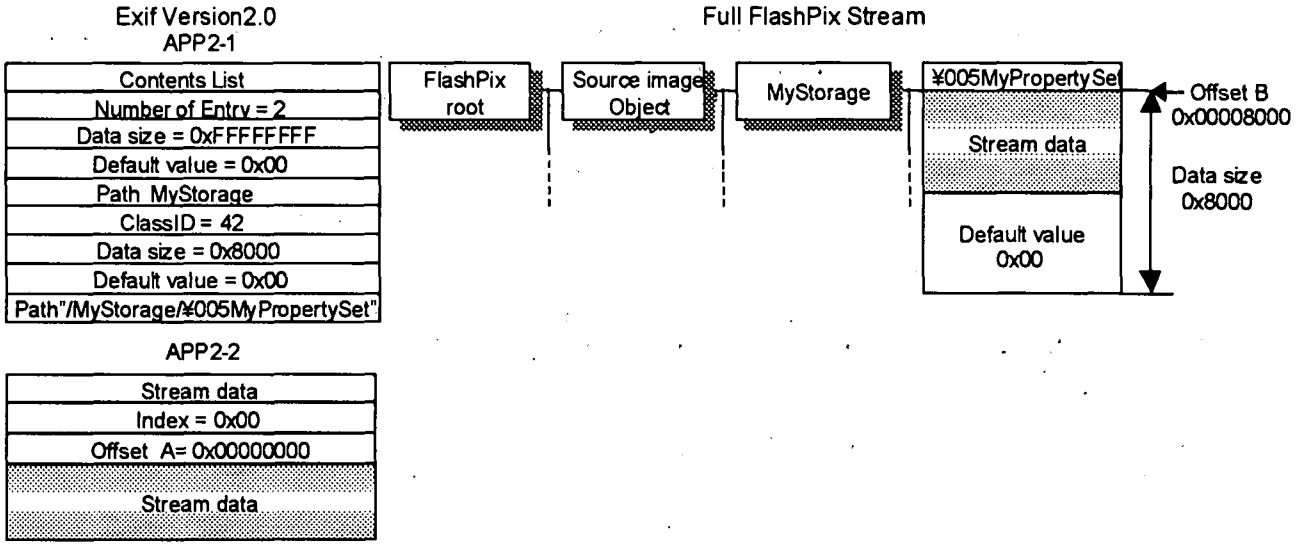


Fig. 56 FlashPix 拡張データ変換例 (3)

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〃	福岡宏樹	（株）リコー
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〃	筒井 聡	（株）リコー
〃	鈴木尋士	社団法人 日本電子工業振興協会

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－禁無断転載－

ディジタルスチルカメラ用画像ファイルフォーマット規格
Version2..0
Digital Still CameraImege File Format Standard for digital still camera(exif)Ver.2.0

発 行 日 平成9年１１月
編集・発行 社団法人 日本電子工業振興協会
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Exhibit C

JAPAN ELECTRONIC INDUSTRY

DEVELOPMENT ASSOCIATION STANDARD

Digital Still Camera Image File Format Standard

(Exchangeable image file formatfor Digital Still Camera:Exif)

Version 2.1

(Difference from Ver.2.0)

JEIDA-49-1998

Revised June 1998

JAPAN ELECTRONIC INDUSTRY

DEVELOPMENT ASSOCIATION

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First Printing, June 1998

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Revision History

Exif Version 2.1 has following modification and addition to Exif Version 2.0.

[Additions]

- Addition of Interoperability IFD
- Addition of [Appendix D.4 Recommended Exif Interoperability Rules ExifR98]

[Changes]

- Content of ExifVersion Tag is changed into 2.1

This document contains the differences between the Exif Version 2.0 Specification and Exif Version 2.1 Specification. All the page numbers, figure numbers, table numbers and so on are continuous from Exif Version 2.0 specification.

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JEIDA 規格

ディジタルスチルカメラ用画像ファイル
フォーマット規格（Exif）
Version 2.1
（Version 2.0差分）

JEIDA－49－1998

平成10年６月 改正

社団法人 **日本電子工業振興協会**

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序　文

近年の半導体や光記録媒体、磁気記録媒体等、記録容量の増加傾向は、ディジタル技術の進歩および情報処理技術の技術革新により、静止画像を電気信号として取り込み、電気的に処理、蓄積および編集したりすることが、可能となってきている。

近年、ディジタルスチルカメラは急速に普及が進んでおり、記録される画像データファイルの規格を統一することへの要求がさらに高まってきている。

このため、Version1.1 の精度を向上させるとともに異なるメーカ間の画像ファイルの互換性をさらに向上させるため、平成9年１１月に Version2.0 を刊行したが、その後、ディジタルスチルカメラ等の機器間における互換性の確保の必要性が生じてきており、より厳密な互換性の確保等のため、本規格を作成したものである。

本規格の作成に当たって、ご支援ご協力を賜った関係各庁、関係会員、ならびに直接労を賜った委員長をはじめ委員各位に厚く感謝の意を表するとともに、本規格が多方面に広く利用され、わが国の電子工業の発展に寄与できることを念願する次第である。

平成１０年6月

社団法人　日本電子工業振興協会
会 長　西 室 泰 三

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2. Exif Image File Specification

Only the modification and addition to Exif Version 2.0 Specification will be described here.

2.6. Tags

2.6.3. Exif-specific IFD

Interoperability Tags are newly defined in Exif Version 2.1.

C. Interoperability IFD

Interoperability IFD is composed of tags, which store the information to ensure the interoperability, and pointed by the following tag located in Exif IFD.

Pointer to Interoperability IFD

Tag	= 40965 (A005.H)
Type	= LONG
Count	= 1
Default	= None

The internal structure of Interoperability IFD is same as TIFF defined IFD structure but does not contain the image data characteristically compared with normal TIFF IFD.

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2.6.5. Exif IFD Attribute Information

Table 4 in Exif Version 2.0 Specification will be replaced as following table having an addition of the pointer to Interoperability IFD.

Table 4 Exif IFD Attribute Information (1)

Tag Name	Field Name	Tag ID Dec	Tag ID Hex	Type	Count
A. Tags Relating to Version					
Exif version	ExifVersion	36864	9000	UNDEFINED	4
Supported FlashPix version	FlashPixVersion	40960	A000	UNDEFINED	4
B. Tag Relating to Image Data Characteristics					
Color space information	ColorSpace	40961	A001	SHORT	1
C. Tags Relating to Image Configuration					
Meaning of each component	ComponentsConfiguration	37121	9101	UNDEFINED	4
Image compression mode	CompressedBitsPerPixel	37122	9102	RATIONAL	1
Valid image width	PixelXDimension	40962	A002	SHORT or LONG	1
Valid image height	PixelYDimension	40963	A003	SHORT or LONG	1
D. Tags Relating to User Information					
Manufacturer notes	MakerNote	37500	927C	UNDEFINED	Any
User comments	UserComment	37510	9286	UNDEFINED	Any
E. Tag Relating to Related File Information					
Related audio file	RelatedSoundFile	40964	A004	ASCII	13
F. Tags Relating to Date and Time					
Date and time of original data generation	DateTimeOriginal	36867	9003	ASCII	20
Date and time of digital data generation	DateTimeDigitized	36868	9004	ASCII	20
DateTime subseconds	SubSecTime	37520	9290	ASCII	Any
DateTimeOriginal subseconds	SubSecTimeOriginal	37521	9291	ASCII	Any
DateTimeDigitized subseconds	SubSecTimeDigitized	37522	9292	ASCII	Any
G. Tags Relating to Picture-Taking Conditions					
See Table 5					
H. Tags Relating to Date and Time					
Pointer of interoperability IFD	interoperable IFD Pointer	40965	A005	LONG	1

A. Tags Relating to Version

The version of this standard supported. Nonexistence of this field is taken to mean nonconformance to the standard (see section 2.2). Conformance to this standard is indicated by recording "0020" as 4-byte ASCII. Since the type is UNDEFINED, there is no NULL for termination.

Exif Version

Tag = 36864 (9000.H)

Type = UNDEFINED

Count = 4

Default = "0210"

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2.6.7. interoperability IFD Attribute Information

The attached information(field name, code) stored in Interoperability IFD is listed in Table 12-2 and the meaning will be explained also.

Table 12-2 interoperability IFD Attribute Information

Tag Name	Field Name	Tag ID		Type	Count
		Dec	Hex		
A. Attached Information Related to Interoperability					
	Interoperability Identification	interoperability Index	0	0	ASCII	Any

A. Tags Relating to Interoperability

The rules for Exif image files define the description of the following tag. Other tags stored in Interoperability IFD may be defined dependently to each interoperability rule.

Interoperability Index

Indicates the identification of the interoperability rule.

Use "R98" for stating ExifR98 Rules when using interoperability rules recommended in Appendix D. Four bytes used including the termination code(NULL). See the separate volume of Recommended Exif Interoperability Rules (ExifR98) for other tags used for ExifR98.

Tag = 1 (1.H)

Type = ASCII

Count = Any

Default = none

"R98" = Recommended Exif Interoprability Rules (ExifR98)

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2.6.8. Tag Support Levels

Table 14 in Exif Version 2.0 Specification will be replaced as following table having addition of the pointer to Interoperability IFD. Table 15-2 defining the support level of Interoperability IFD will be added also.

Table 14 Tag Support Levels (2) - 0th IFD Exif Private Tags –

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
Exposure time	ExposureTime	33434	829A	O	O	O	O
F number	FNumber	33437	829D	O	O	O	O
Exposure program	ExposureProgram	34850	8822	O	O	O	O
Spectral sensitivity	SpectralSensitivity	34852	8824	O	O	O	O
ISO speed ratings	ISOSpeedRatings	34855	8827	O	O	O	O
Optoelectric coefficient	OECF	34856	8828	O	O	O	O
Exif Version	ExifVersion	36864	9000	M	M	M	M
Date and time original image was generated	DateTimeOriginal	36867	9003	O	O	O	O
Date and time image was made digital data	DateTimeDigitized	36868	9004	O	O	O	O
Meaning of each component	ComponentsConfiguration	37121	9101	N	N	N	M
Image compression mode	CompressedBitsPerPixel	37122	9102	N	N	N	O
Shutter speed	ShutterSpeedValue	37377	9201	O	O	O	O
Aperture	ApertureValue	37378	9202	O	O	O	O
Brightness	BrightnessValue	37379	9203	O	O	O	O
Exposure bias	ExposureBiasValue	37380	9204	O	O	O	O
Maximum lens aperture	MaxApertureValue	37381	9205	O	O	O	O
Subject distance	SubjectDistance	37382	9206	O	O	O	O
Metering mode	MeteringMode	37383	9207	O	O	O	O
Light source	LightSource	37384	9208	O	O	O	O
Flash	Flash	37385	9209	O	O	O	O
Lens focal length	FocalLength	37386	920A	O	O	O	O
Manufacturer notes	MakerNote	37500	927C	O	O	O	O
User comments	UserComment	37510	9286	O	O	O	O
DateTime subseconds	SubSecTime	37520	9290	O	O	O	O
DateTimeOriginal subseconds	SubSecTimeOriginal	37521	9291	O	O	O	O
DateTimeDigitized subseconds	SubSecTimeDigitized	37522	9292	O	O	O	O
Supported FlashPix version	FlashPixVersion	40960	A000	M	M	M	M
Color space information	ColorSpace	40961	A001	M	M	M	M
Valid image width	PixelXDimension	40962	A002	N	N	N	M
Valid image height	PixelYDimension	40963	A003	N	N	N	M
Related audio file	RelatedSoundFile	40964	A004	O	O	O	O
InterOperability tag	InterOperability IFD Pointer	40965	A005	N	N	N	O
Flash energy	FlashEnergy	41483	A20B	O	O	O	O
Spatial frequency response	SpatialFrequencyResponse	41484	A20C	O	O	O	O
Focal plane X resolution	FocalPlaneXResolution	41486	A20E	O	O	O	O
Focal plane Y resolution	FocalPlaneYResolution	41487	A20F	O	O	O	O
Focal plane resolution unit	FocalPlaneResolutionUnit	41488	A210	O	O	O	O
Subject location	SubjectLocation	41492	A214	O	O	O	O
Exposure index	ExposureIndex	41493	A215	O	O	O	O
Sensing method	SensingMethod	41495	A217	O	O	O	O
File source	FileSource	41728	A300	O	O	O	O
Scene type	SceneType	41729	A301	O	O	O	O
CFA pattern	CFAPattern	41730	A302	O	O	O	O

Notation
M : Mandatory (must be recorded)
R : Conditionally mandatory (must be recorded if hardware permits)
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

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Table 15-2 Tag Support Levels - 0th IFD InterOperability Tag -

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
Interoperability Identification	Interoperability Index	0	0	N	N	N	O

Notation
M : Mandatory (must be recorded)
R : Conditionally mandatory (must be recorded if hardware permits)
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

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Appendix D Recommended Implementation Examples

D.4 Introducing "Recommended Exif Interoperability Rules" (ExifR98)

ExifR98 is established as detailed rules recommended by this specification to ensure the more strict playback Interoperability among the devices using this specification than D.1 - D.3 of this Appendix. In ExifR98, naming rules of directories and files to store images are defined and the thumbnail format and covering range of playback is defined according to the function of devices.

Separate Volume : Recommended Exif Interoperability Rules **ExifR98**

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Exif Ver.2.0 misprint correction table

Page/Line	Version 2.0 Misprint	Correction
P18 L8	3 = SHOT	3 = SHORT
P21 L23	Default = 8	Default = 8 8 8
P27 L7	Tag = 513(201.H)	Tag = 514(202.H)
P49 Fig.11	RATIONAL 0th row n-1th row	SRATIONAL 0th column n-1th column
P50 Fig.12	0th row n-1th row	0th column n-1th column
P52 Fig.13	(all of) WORD	(all of) BYTE
P128 Table 34 Flash ValueOffset		
	00000000	01000000
P159 Table 49 PixelYDimension FPX name		
	Highest resolution length	Highest resolution height

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JEIDA 規格

ディジタルスチルカメラ用画像ファイル
フォーマット規格（Exif）
Version 2.1
（Version 2.0差分）

日本語版

JEIDA－49－1998

平成10年6月 改正

社団法人 日本電子工業振興協会

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規格改訂について

Exif Version 2.1 は、Exif Version 2.0 に対し以下の追加・変更をしたものである。

［追加点］

- interoperability IFD の追加
- 「付録 D.4 推奨互換性細則 ExifR98 について」の追加

［変更点］

- ExifVersion Tag の記載内容を 2.1 へ変更

本規格書は Exif Version 2.0 規格書と Version 2.1 の差分を収録したものである。ページ番号、図表番号などはすべて Version 2.0 規格書と通し番号としている。

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2.6.5. Exif IFD の付属情報 33
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2. Exif 画像ファイル規定

Exif Version 2.0 規格に対して追加・変更のある箇所のみ記載する。

2.6. 使用するタグ

2.6.3. Exif 固有の IFD

Exif Version 2.1 では新たに互換性 IFD を規定する。

C. 互換性 IFD

互換性 IFD は、互換性を保証するために必要な情報を記載するためのタグの集まりであり、Exif IFD 中の以下のタグからポイントされる。

互換性 IFD へのポインタ ***Interoperability IFD Pointer***

Tag	= 40965（A005.H）
Type	= LONG
Count	= 1
Default	=なし

互換性 IFD の内部は、TIFF で定められる IFD 構造と同様である。ただし、通常の TIFF のように画像データを持たないのが特長である。

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2.6.5. Exif IFD の付属情報

Exif Version 2.0 規格書中 Table 4 は互換性 IFD へのポインタを加えて以下に置き換えられる。

Table 4 Exif IFD の付属情報 (1)

分類	タグ名称	Field Name	タグ番号 Dec	タグ番号 Hex	タイプ	カウント
A. バージョンに関するタグ						
	Exif バージョン	ExifVersion	36864	9000	UNDEFINED	4
	対応フラッシュピックスバージョン	FlashPixVersion	40960	A000	UNDEFINED	4
B. 画像データの特性に関するタグ						
	色空間情報	ColorSpace	40961	A001	SHORT	1
C. 構造に関するタグ						
	各コンポーネントの意味	ComponentsConfiguration	37121	9101	UNDEFINED	4
	画像圧縮モード	CompressedBitsPerPixel	37122	9102	RATIONAL	1
	実効画像幅	PixelXDimension	40962	A002	SHORT or LONG	1
	実効画像高さ	PixelYDimension	40963	A003	SHORT or LONG	1
D. ユーザー情報に関するタグ						
	メーカーノート	MakerNote	37500	927C	UNDEFINED	Any
	ユーザーコメント	UserComment	37510	9286	UNDEFINED	Any
E. 関連ファイル情報に関するタグ						
	関連音声ファイル	RelatedSoundFile	40964	A004	ASCII	13
F. 日時に関するタグ						
	原画像データの生成日時	DateTimeOriginal	36867	9003	ASCII	20
	ディジタルデータの作成日時	DateTimeDigitized	36868	9004	ASCII	20
	DateTime のサブセック	SubSecTime	37520	9290	ASCII	Any
	DateTimeOriginal のサブセック	SubSecTimeOriginal	37521	9291	ASCII	Any
	DateTimeDigitized のサブセック	SubSecTimeDigitized	37522	9292	ASCII	Any
G. 撮影条件に関するタグ						
	Table 5 参照					
H. IFD へのポインタ						
	互換性 IFD へのポインタ	Interoperability IFD Pointer	40965	A005	LONG	1

A. バージョンに関するタグ

Exif バージョン *Exif Version*

本規格での対応バージョンを示す。このフィールドが存在しなければ、本規格に準拠していないと判断される（2.2 章参照）。本規格に準拠する場合には、4Byte の ASCII "0210"を記録する。Type が UNDEFINED のため最後に NULL は記録しない。

Tag = 36864 (9000.H)

Type = UNDEFINED

Count = 4

Default = "0210"

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2.6.7. 互換性に関する付属情報

互換性 IFD に記録される付属情報（フィールド名、コード）一覧を Table12-2 に示す。また、これらの内容を以下に説明する。

Table 12-2 互換性に関する付属情報一覧

分類	タグ名称 Field Name	タグ番号 Dec	タグ番号 Hex	タイプ	カウント
A. 互換性に関するタグ					
	互換性識別子 InteroperabilityIndex	0	0	ASCII	Any

A. 互換性に関するタグ

Exif 画像ファイル規定では、以下のタグの記載を規定する。互換性 IFD に記録するその他のタグについては、互換ルールごとに定めてよい。

互換性識別子 *Interoperability Index*

互換性の規則の種類を示す。

付録 D で推奨される ExifR98 ルールであることを宣言する場合は"R98"と記載する。終端コードを含めて 4Byte である。ExifR98 で使用するその他のタグについては、「別冊 Exif 互換性細則（ExifR98)」を参照のこと。

Tag = 1 (1.H)
Type = ASCII
Count = Any
Default = なし
"R98" = Exif 互換性細則 (ExifR98)

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2.6.8. 記載対応レベル

Exif Version 2.0 規格書 Table 14 に互換性 IFD へのポインタを追加し以下の通りとする。また、新たに互換性 IFD の記載対応レベル Table 15-2 を追加する。

Table 14　タグ記載対応レベル（2）　- 0th IFD Exif Private Tag -

タグ名称	Field Name	タグ番号		非圧縮			圧縮
		Dec	Hex	点順	面順	YCC	
露出時間	ExposureTime	33434	829A	△	△	△	△
F ナンバー	FNumber	33437	829D	△	△	△	△
露出プログラム	ExposureProgram	34850	8822	△	△	△	△
スペクトル感度	SpectralSensitivity	34852	8824	△	△	△	△
ISO スピードレート	ISOSpeedRatings	34855	8827	△	△	△	△
光電変換関数	OECF	34856	8828	△	△	△	△
Exif バージョン	ExifVersion	36864	9000	◎	◎	◎	◎
原画像データの生成日時	DateTimeOriginal	36867	9003	△	△	△	△
ディジタルデータの作成日時	DateTimeDigitized	36868	9004	△	△	△	△
各コンポーネントの意味	ComponentsConfiguration	37121	9101	×	×	×	◎
画像圧縮モード	CompressedBitsPerPixel	37122	9102	×	×	×	△
シャッタースピード	ShutterSpeedValue	37377	9201	△	△	△	△
絞り値	ApertureValue	37378	9202	△	△	△	△
輝度値	BrightnessValue	37379	9203	△	△	△	△
露光補正値	ExposureBiasValue	37380	9204	△	△	△	△
レンズ最小 F 値	MaxApertureValue	37381	9205	△	△	△	△
被写体距離	SubjectDistance	37382	9206	△	△	△	△
測光方式	MeteringMode	37383	9207	△	△	△	△
光源	LightSource	37384	9208	△	△	△	△
フラッシュ	Flash	37385	9209	△	△	△	△
レンズ焦点距離	FocalLength	37386	920A	△	△	△	△
メーカーノート	MakerNote	37500	927C	△	△	△	△
ユーザーコメント	UserComment	37510	9286	△	△	△	△
DateTime のサブセック	SubSecTime	37520	9290	△	△	△	△
DateTimeOriginal のサブセック	SubSecTimeOriginal	37521	9291	△	△	△	△
DateTimeDigitized のサブセック	SubSecTimeDigitized	37522	9292	△	△	△	△
対応フラッシュピックスバージョン	FlashPixVersion	40960	A000	◎	◎	◎	◎
色空間情報	ColorSpace	40961	A001	◎	◎	◎	◎
実効画像幅	PixelXDimension	40962	A002	×	×	×	◎
実効画像高さ	PixelYDimension	40963	A003	×	×	×	◎
関連音声ファイル	RelatedSoundFile	40964	A004	△	△	△	△
互換性 IFD へのポインタ	Interoperability IFD Pointer	40965	A005	×	×	×	△
フラッシュ強度	FlashEnergy	41483	A20B	△	△	△	△
空間周波数応答	SpatialFrequencyResponse	41484	A20C	△	△	△	△
焦点面の幅の解像度	FocalPlaneXResolution	41486	A20E	△	△	△	△
焦点面の高さの解像度	FocalPlaneYResolution	41487	A20F	△	△	△	△
焦点面解像度単位	FocalPlaneResolutionUnit	41488	A210	△	△	△	△
被写体位置	SubjectLocation	41492	A214	△	△	△	△
露出インデックス	ExposureIndex	41493	A215	△	△	△	△
センサー方式	SensingMethod	41495	A217	△	△	△	△
ファイルソース	FileSource	41728	A300	△	△	△	△
シーンタイプ	SceneType	41729	A301	△	△	△	△
CFA パターン	CFAPattern	41730	A302	△	△	△	△

記号の意味
◎：必須（必ず記載しなければならない）
○：準必須（ハードウェア等の制限がない限り記載しなければならない）
△：オプション（機器ごとに必要な場合記録する）
×：記載しない
※：JPEG マーカ中に記録されるため記載しない

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Table 15-2　タグ記載対応レベル　- 0th IFD InterOperability Tag -

タグ名称　Field Name	タグ番号		非圧縮			圧縮
	Dec	Hex	点順	面順	YCC	
互換性識別子　Interoperability Index	0	0	×	×	×	△

記号の意味
◎：必須（必ず記載しなければならない）
○：準必須（ハードウェア等の制限がない限り記載しなければならない）
△：オプション（機器ごとに必要な場合記録する）
×：記載しない
※：JPEG マーカ中に記録されるため記載しない

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付録 D 推奨運用例

D.4 推奨互換性細則 ExifR98 について

本付録 D.1～D.3 に記載される運用例に対して、さらに厳密に機器間の再生互換をとるため、本規格が推奨する細則として ExifR98 が別途定められている。ExifR98 では画像ファイルを保存するディレクトリやファイル名が規定されているほか、サムネイルのフォーマット、再生する範囲が機器の機能ごとに定められている。

「別冊　Exif 互換性細則 ExifR98」

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Exif Ver.2.0 誤記訂正表

ページ/行	Version 2.0 誤記	訂正
P18 L7	一つのピット	一つのビット
P18 L8	3 = SHOT	3 = SHORT
P21 L23	Default = 8	Default = 8 8 8
P27 L6	Tag = 513(201.H)	Tag = 514(202.H)
P47 L28	3 = 露出優先	3 = 絞り優先
P48 Fig.11	RATIONAL 0行目の n-1行目の	SRATIONAL 0列目の n-1列目の
P50 Fig.12	0行目の n-1行目の	0列目の n-1列目の
P51 L24,25	2版、3版	2板、3板
P52 Fig.13	WORD (全て)	BYTE （全て）
P101 Fig.40	(IMA-ADPCM形式)	一つを削除
P126 Table 34 Flash ValueOffset		
	00000000	01000000
P159 Table 49 PixelYDimension FPX name		
	Highest resolution length	Highest resolution height

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－禁無断転載－

ディジタルスチルカメラ用画像ファイルフォーマット規格
Version2.1 (Version2.0差分)

Digital Still Cameralmege File Format Standard for digital still camera(exif)Ver.2.1(Difference from Ver.2.0)

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Exhibit D

Digital Still Camera Image File Format Standard

(Exchangeable image file format for Digital Still Cameras: Exif)

Version 2.1

June 12, 1998

Japan Electronic Industry Development Association

(JEIDA)

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Revision History

This "Digital Still Camera Image File Format Standard" is issued as a standard for the image file format (Exif: Exchangeable image file format) used in digital still cameras and related systems. It was first published in October 1996 as Version 1.0[i]. Then in May 1997, Version 1.1[ii] was issued, adding specifications for optional attribute information as well as stipulations relating to format implementation, in addition to the mandatory specifications of Version 1.0.

The desire for a uniform file format standard for the image data stored by digital still cameras has increased as these cameras have grown in popularity. At the same time, with the broadening application of this technology, a similar desire has arisen for uniformity of the attribute information that can be recorded in a file.

The Version 2.0[iii] makes improvements to the Exif format for greater ease of use, while allowing for backward compatibility with products of manufacturers currently implementing Exif Version 1.x or considering its future implementation. The present Version 2.1 contains Recommended Exif Interoperability Rules.

The following additions and changes are made from Version 1.1 to Version 2.1.

[Additions]

- Audio file format specification
- JPEG compressed thumbnail specification
- Chrominance sampling method Y:Cb:Cr = 4:2:0.
- Tags for FlashPix transformation
- Additional tags for picture-taking conditions
- APP2 marker segment specification for FlashPix extensions
- Definition of color space information
- Addition of Interoperability IFD (Version 2.1)
- Addition of [Appendix D.1 Recommended Exif Interoperability Rules ExifR98] (Version2.1)

[Changes]

- Combined into one chapter the separate chapters on the Exif file specification and implementation specification (Exif-1).
- Removed the limitation on number of pixels (multiples of 8 and 16) to allow for expanded implementation.
- Content of ExifVersion Tag is changed into 2.1

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1. General

1.1. Objectives

This document specifies a standard file format for the image data recorded by digital still cameras (DSC) and related systems, which use a PC Card or other removable memory medium. The aim is to ensure data compatibility and exchangeability, providing a framework in which these products can be used readily by ordinary consumers. In this way it is hoped the standard will contribute to the infrastructure of the information age, as it evolves with the rapid proliferation of personal computers and other information technologies.

1.2. Scope and Abbreviation

This standard applies to the image files recorded on PC Cards and other removable memory by DSC and related systems. The standard is abbreviated as Exif (Exchangeable image file format).

Note: This standard makes no warranty with respect to the use of "Exif" as a trademark.

1.3. Format Structure

This standard consists of the Exif image file specification and the Exif audio file specification (see Fig. 1). The recording medium specification shall conform to the standard for the particular medium used and is not specified here. Recommendations on implementation are given in Appendix D for directory and file naming.

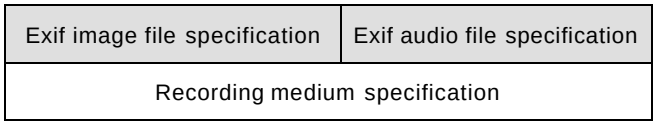


Fig. 1 Format structure

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1.4. Exif Image File Specification

The Exif image file specification stipulates the method of recording image data in files, and specifies the following items:

- Structure of image data files,
- Tags used by this standard,
- Definition and management of format versions.

Features of the Exif image file specification include the following.

The file-recording format is based on existing formats. Compressed files are recorded as JPEG (ISO/IEC 10918-1[iv]) with application marker segments (APP1 and APP2) inserted. Uncompressed files are recorded in TIFF Rev. 6.0[v] format. The use of existing formats means files recorded using a DSC or related system can be read directly by commercial applications, and makes possible the use of functions for viewing and manipulating the images.

Related attribute information for both compressed and uncompressed files is stored in the tag information format defined in TIFF Rev. 6.0. Information specific to the camera system and not defined in TIFF is stored in private tags registered for Exif. The Exif image file specification also specifies the method for recording thumbnails. The reason for using the TIFF Rev. 6.0 tag format in the compressed file APP1 segment is to facilitate exchange of attribute data between Exif compressed and uncompressed files.

Compressed files can record extended data exceeding 64 Kbytes by dividing it into multiple APP2 segments. The APP2 segment is used when recording FlashPix[vi] extensions.

A feature of Exif image files is their compatibility with standard formats in wide use today, enabling them to be used on personal computers and other information systems. The intention is to promote widespread use of digital still cameras.

Details of the Exif image file specification are given in Chapter 2 of this document.

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1.5. Exif Audio File Specification

The Exif audio file specification stipulates the method of writing audio data in files, and specifies the following items:

- Structure of audio data files,
- Chunks,
- Definition and management of format versions.

Features of the Exif audio file specification include the following.

Files are recorded using the existing RIFF WAVE Form Audio File format.[vii] As data formats, PCM and μ-Law PCM (conforming to ITU-T G.711[viii]) are used for uncompressed audio data, and IMA-ADPCM[ix] for compressed audio data. As with the image files specification, the aim is to enable direct reading, playback and manipulation of the files using the functions in commercial applications.

Related attribute information is stored as an *INFO list* in the case of general attributes, and as Exif-specific chunks in the case of attributes specific to Exif. The Exif-specific chunks are newly provided to enable necessary information to be added by making use of chunk extensibility. The recording of data in an Exif-specific chunk is done in the same way as for an *INFO list*.

Exif audio files, like image files, feature compatibility with standard formats already in wide use, in order to promote the widespread use of digital still cameras.

Details of the Exif audio file specification are given in Chapter 3 of this document.

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1.6. Relation between Image and Audio File Specification

This standard includes specifications not only for an image file format but also for an audio file format enabling the recording of audio as a supplementary function.

Also specified in this standard is the relational information indicating the relation between image files and audio files.

Mapping between image files and audio files can be done in various ways; but the Exif standard specifies only the simplest mapping, with others left up to the implementation.

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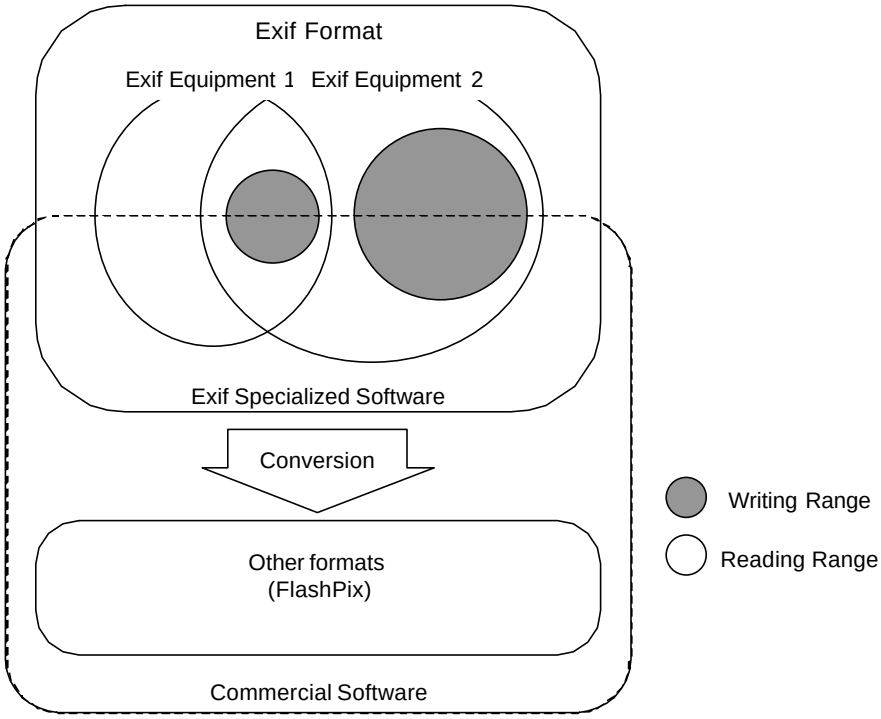
1.7. Presupposed Systems and Compatibility

The image systems presupposed by this standard consist of three elements as follows:

- Equipment: Imaging devices such as cameras, printers and filing equipment,
- Commercial software: Off-the-shelf image processing software running on personal computers,
- Specialized software: Dedicated (system-specific) image processing software running on personal computers.

Image file compatibility on these systems is achieved as follows. The DSC or other system writes data to files in the format specified in this standard. A basic condition of equipment with a playback function is that it be able to read the files it recorded itself. In a personal computer environment, the basic requirement is that dedicated software be able to read all the images, audio and attribute information recorded in conformance with this standard (see Fig. 2).

Fig. 2 Compatibility Concepts



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2. Exif Image File Specification

2.1. Outline of the Exif Image File Specification

This chapter gives details of the image file specification, covering the following items:

- Format version definition,
- Specifications relating to image data,
- Basic structure of image data,
- Tags,
- JPEG marker segments,
- Specifications on data recording.

2.2. Format Version

The version of the format specified here is recorded as 4 bytes (see section 2.6.5). The address bytes are recorded as A1, A2, B1, and B2, starting with the lowest number. A1 and A2 store the upper part of the standard version, with the lower part stored in B1 and B2. When changes are made to the version number of this standard, the following rules apply.

- When the changes are such that data readers can properly recognize conventional information and skip the data that was recorded using newly added functions, the lower part of the version (B1, B2) is changed.
- When there is a possibility that a data reader implementing the old standard may operate incorrectly due to the new specifications, the upper part of the version (A1, A2) is changed.

Players should be able to play back files of versions earlier than the supported standard.

2.3. Definition of Glossary

Terms and notation are used as follows in this standard:

- "Tag" is used as a synonym of "field",
- ".H" appended to a numerical value means it is hexadecimal notation,
- Unless otherwise indicated, other numerical values are given in decimal notation,

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- The initial IFD in a file is the "0th IFD," with the next IFD being called the 1st IFD,
- The original image is called the "primary image," and small images used to index the primary images are called "thumbnail" images,
- Data referred to in the JPEG standard as "Interoperability coded data" is here called "compressed data".

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2.4. Specifications Relating to Image Data

2.4.1. Number of Pixels

There is no limit on number of pixels of the primary image when it is recorded as either uncompressed or JPEG compressed data. Note that when recording as JPEG compressed data images for which the number of lines (*ImageLength*) or number of samples/line (*ImageWidth*) is not a multiple of 8 or 16, the method of recording is as stipulated in section 2.8.1. The above specification applies similarly to thumbnails.

2.4.2. Pixel Aspect

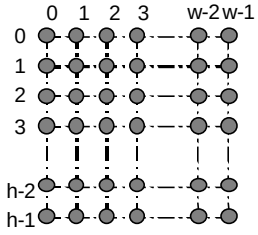
Image data is recorded as square pixels with a pixel aspect ratio of 1:1. This specification is applied similarly to thumbnails.

2.4.3. Pixel Composition and Sampling

The combination of pixel composition and pixel sampling for image data must be RGB 4:4:4 and either Y:Cb:Cr = 4:2:2 or Y:Cb:Cr = 4:2:0. The pixel composition of image data must also be 8 bits each. This specification is applied similarly to thumbnails.

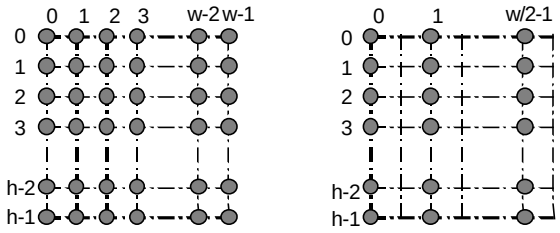
As sampling points on the elements making up pixels, the Y and Cb,Cr sampling points may be either co-sited or centered. Fig. 3 shows typical pixel sampling for image width w and height h. In the case of Y:Cb:Cr = 4:2:2, spatial co-siting is recommended for the sake of improved image quality on TV systems. For Y:Cb:Cr = 4:2:0, spatial centering is recommended as per the TIFF default and is most common format of the personal computer applications.

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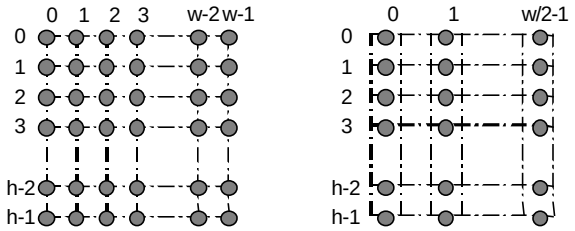
R,G,B

1) RGB 4:4:4



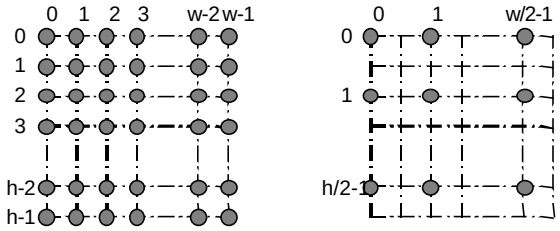
Y Cb, Cr

2) YCbCr 4:2:2 (Co-sited)



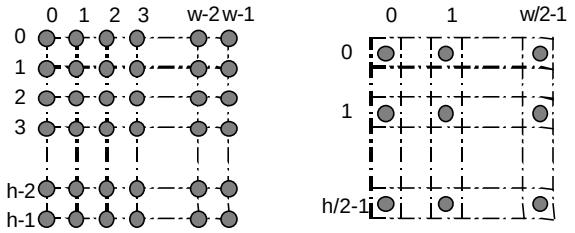
Y Cb, Cr

3) YCbCr 4:2:2 (Centered)



Y Cb, Cr

4) YCbCr 4:2:0 (Co-sited)



Y Cb, Cr

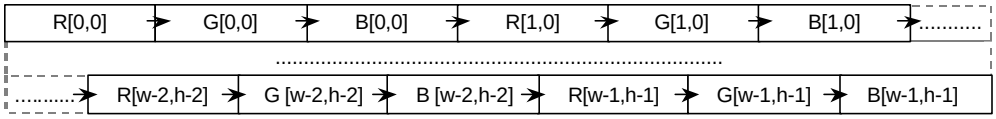
5) YCbCr 4:2:0 (Centered)

Fig. 3 Pixel Composition and Pixel Sampling

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2.4.4. Image Data Arrangement

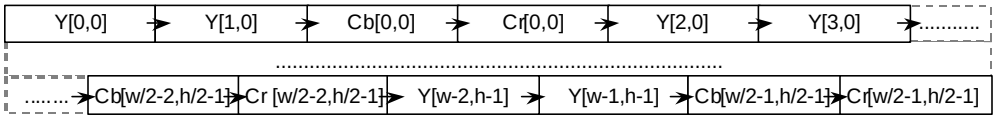
Image data must be arranged as follows. Uncompressed data shall consist of pixels with each line traced from left to right, and one screen shall consist of lines traced from top to bottom. JPEG compressed data shall consist of blocks configured of pixels traced in similar sequence. Fig. 4 shows the various data arrangements for recording in files images with pixels of width w and height h



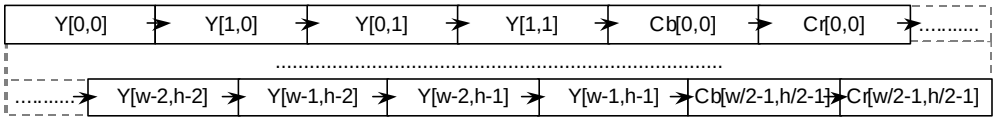
1) Uncompressed RGB Chunky (4:4:4)



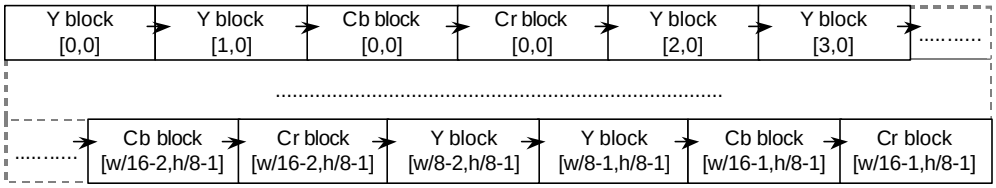
2) Uncompressed RGB Planar (4:4:4)



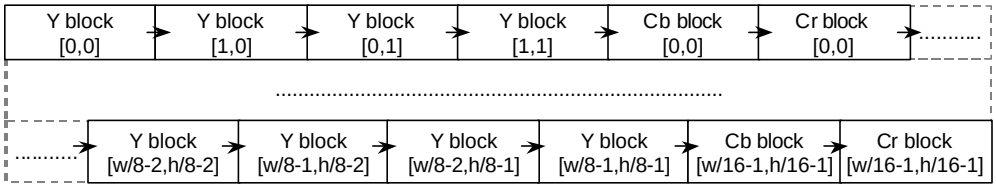
3) Uncompressed YCbCr Chunky (4:2:2)



4) Uncompressed YCbCr Chunky (4:2:0)



5) Compresed JPEG Block-Interleave (4:2:2)



6) Compressed JPEG Block-Interleave (4:2:0)

Fig. 4 Data Arrangement

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2.5. Basic Structure of Image Data

2.5.1. Basic Structure of Primary Image Data

Image data employs following existing image formats, depending on the image data type:

- RGB uncompressed data: Baseline TIFF Rev. 6.0 RGB Full Color Images [v],
- YCbCr uncompressed data: TIFF Rev. 6.0 Extensions YCbCr Images [v],
- JPEG compressed data: JPEG Baseline ADCT [iv].

For compressed data, the attribute information required by the DSC application shall be recorded in APP1. Data writing in APP1 shall be compatible with TIFF. The use of a common method of storing attribute information for both compressed and uncompressed data results in a simpler format, while the ability to add private tags for additional information takes advantage of the extensibility of the tag mechanism.

2.5.2. Basic Structure of Uncompressed RGB Data

Uncompressed RGB data is recorded in conformance with Baseline TIFF Rev. 6.0 RGB Full Color Images [v].

Attribute information is recorded in tags specified in TIFF Rev. 6.0. Attribute information specific to Exif is recorded using private tags reserved in TIFF for this standard. The private tags point to sets of this attribute information (Exif IFD).

Files are structured as follows (see Fig. 5). As in the TIFF standard, the recording location of each IFD value is not specified:

- File Header,
- 0th IFD,
- 0th IFD Value,
- 1st IFD,
- 1st IFD Value,
- 1st (Thumbnail) Image Data,
- 0th (Primary) Image Data.

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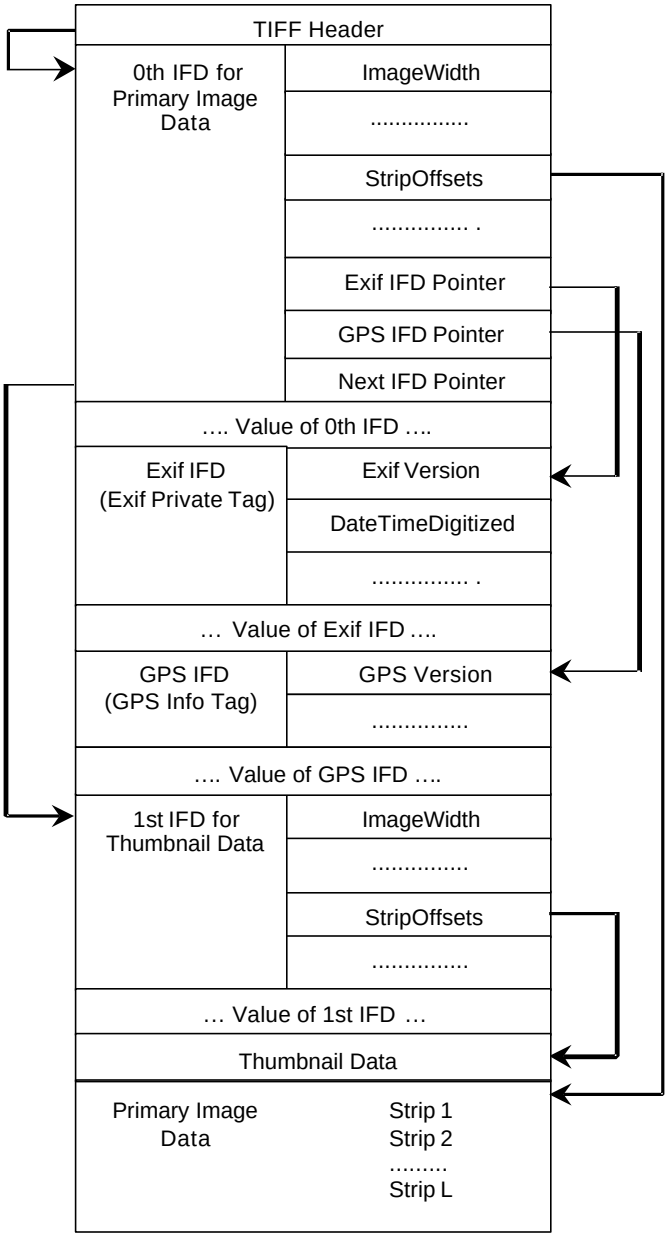


Fig. 5 Basic Structure of Uncompressed Data Files

File Headers are 8 bytes as defined in the TIFF standard, with the Offset of IFD indicating the start address of the 0th IFD (see Table 1).

The 0th IFD Offset of Next IFD indicates the start address of the 1st IFD (thumbnail images). When the 1st IFD is not recorded, the 0th IFD Offset of Next IFD terminates with 00000000.H.

On the IFD description method see section 2.6.2.

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Table 1 TIFF Headers

Name	Size (Bytes)	Value
Byte Order	2	Written as either "II" (4949.H) (little endian) or "MM" (4D4D.H) (big endian) depending on the CPU of the machine doing the recording.
42	2	002A.H (fixed)
Offset of IFD	4	0th IFD offset. If the TIFF header is followed immediately by the 0th IFD, it is written as 00000008.H.

2.5.3. Basic Structure of YCbCr Uncompressed Data

YCbCr uncompressed data is recorded in conformance with TIFF Rev. 6.0 Extensions YCbCr Images[v]. Tags for the following information are available for YCbCr uncompressed data in addition to the attribute information for RGB uncompressed data;

- RGB-YCbCr color transformation matrix coefficients (*YCbCrCoefficients*),
- Chrominance subsampling information (*YCbCrSubSampling*),
- Information on matching/nonmatching of chrominance and luminance samples (*YCbCrPositioning*).

The method of recording other attribute information is the same as for uncompressed RGB data (see section 2.5.2).

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2.5.4. Basic Structure of JPEG Compressed Data

Compressed data files are recorded in conformance with the JPEG DCT format specified in ISO/IEC 10918-1,[iv] with the Application Market Segment (APP1) inserted. APP1 is recorded immediately after the SOI marker indicating the beginning of the file (see Fig. 6). Multiple APP2 can be recorded as necessary, starting immediately after APP1. APPn other than APP1 and APP2 or COM segments are not used by Exif. However Exif readers should be designed skip over unknown APPn and COM.

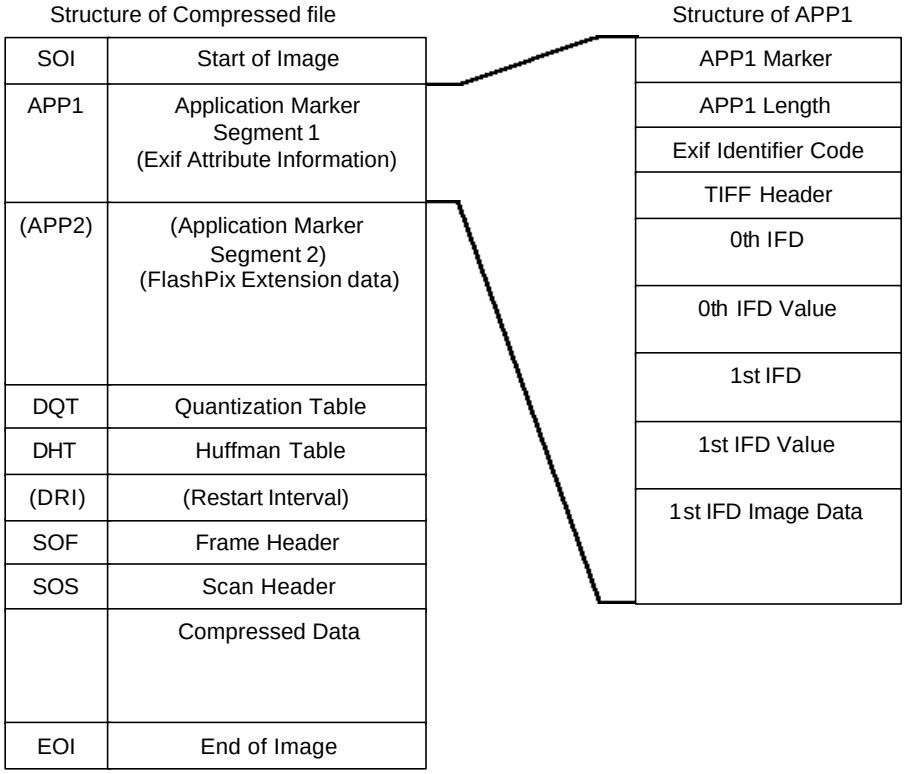


Fig. 6 Basic Structure of Compressed Data Files

Interoperability, APP1 consists of the APP1 marker, Exif identifier code, and the attribute information itself. The size of APP1 including all these elements must not exceed the 64 Kbytes specified in the JPEG standard.

Attribute information is stored in TIFF structure including a File Header, with a maximum of two IFD (0th IFD, 1st IFD). The 0th IFD records attribute information concerning the compressed image (primary image). The 1st IFD can be used to record a thumbnail image. For details see section 2.7.2.

APP2 consists of the APP2 marker, FPXR (FlashPix Ready) identifier code, and contents list for FlashPix extension recording, or stream data. A string of multiple APP2 marker segments can be used to record data exceeding 64 Kbytes. For details see section 2.7.3.

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2.5.5. Basic Structure of Thumbnail Data

Thumbnail data is recorded in the 1st IFD similarly to primary images, using two existing image formats.

No limit is placed on the size of thumbnail images. Thumbnails are not mandatory, but it is recommended that they be recorded if possible, unless hardware or other restrictions preclude this.

Thumbnail data does not necessarily have to adopt the same data structure as that used for primary images. If, however, the primary images are recorded as uncompressed RGB data or as uncompressed YCbCr data, thumbnail images cannot be recorded as JPEG compressed data (see Table 2).

Table 2 Combinations of primary image and thumbnail data structures

		Primary Image	
		Uncompressed	Compressed
Thumbnail	Uncompressed	Possible	Possible
	Compressed	Not possible	Possible

When thumbnails are recorded in uncompressed format, they are to be recorded in the 1st IFD in conformance with Baseline TIFF Rev. 6.0 RGB Full Color Images or TIFF Rev. 6.0 Extensions YCbCr Images.

An Exif-specific recording method is used to record compressed thumbnails.

In this case the *Compression* tag value is set to "6" and tags in the 1st IFD (*JPEGInterchangeFormat*, *JPEGInterchangeFormatLength*) are used to designate the location and size. The images are recorded at the designated location as a JPEG stream (from SOI to EOI) conforming to the JPEG Baseline DCT format. No APPn marker, COM marker, nor restart marker is recorded in the JPEG stream (see Fig. 7). To avoid duplicate definitions, the 1st IFD is not used to record a tag indicating a TIFF image or information recorded elsewhere as a JPEG marker segment.

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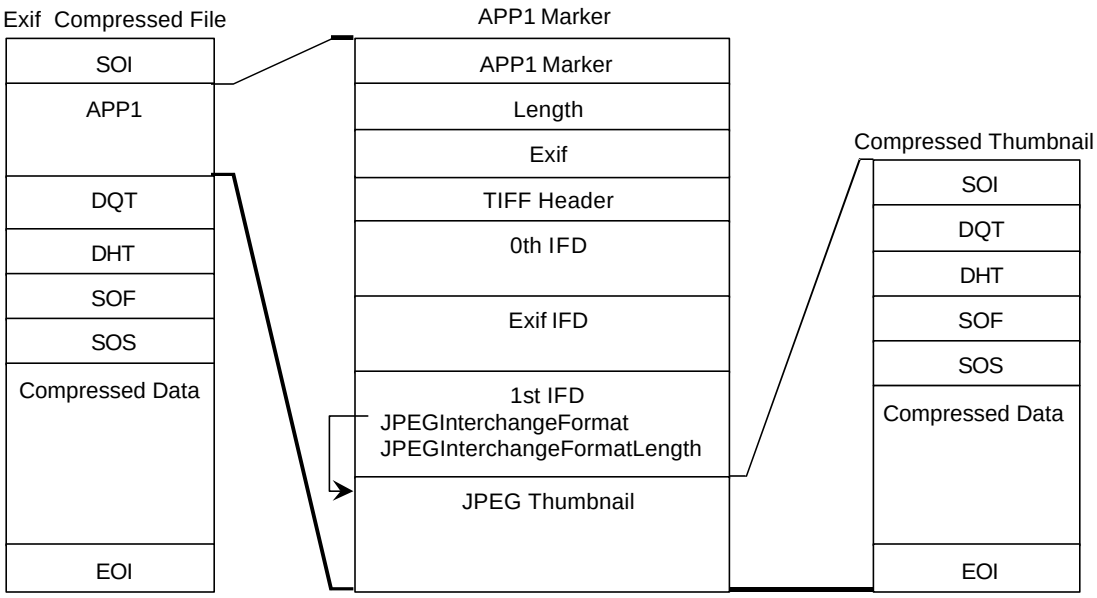


Fig. 7 Structure of Exif file with compressed thumbnail

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2.6. Tags

2.6.1. Features of Attribute Information

RGB data conforms to Baseline TIFF Rev. 6.0 RGB Full Color Images, and YCbCr data to TIFF Rev. 6.0 Extensions YCbCr Images. Accordingly, the parts that follow the TIFF structure must be recorded in conformance to the TIFF standard. In addition to the attribute information indicated as mandatory in the TIFF standard, this Exif standard adds the TIFF optional tags that can be used in a DSC or other system, Exif-specific tags for recording DSC-specific attribute information, and GPS tags for recording position information. There are also Exif-original specifications not found in the TIFF standard for compressed recording of thumbnails.

Recording of compressed data differs from uncompressed data in the following respects:

- When the primary image data is recorded in compressed form, there is no tag indicating the primary image itself or its address (pointer),
- When thumbnail data is recorded in compressed form, address and size are designated using Exif-specific tags,
- Tags that duplicate information given in the JPEG Baseline are not recorded (for either primary images or thumbnails).
- Information relating to compression can be recorded using the tags for this purpose.

2.6.2. IFD Structure

The IFD used in this standard consists of a 2-byte count (number of fields), 12-byte field Interoperability arrays, and 4-byte offset to the next IFD, in conformance with TIFF Rev. 6.0.

Each of the 12-byte field Interoperability consists of the following four elements respectively.

Bytes 0-1	Tag
Bytes 2-3	Type
Bytes 4-7	Count
Bytes 8-11	Value Offset

Each element is explained briefly below. For details see TIFF Rev. 6.0.

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Tag

Each tag is assigned a unique 2-byte number to identify the field. The tag numbers in the Exif 0th IFD and 1st IFD are all the same as the TIFF tag numbers.

Type

The following types are used in Exif:

1 = BYTE	An 8-bit unsigned integer.,
2 = ASCII	An 8-bit byte containing one 7-bit ASCII code. The final byte is terminated with NULL.,
3 = SHORT	A 16-bit (2-byte) unsigned integer,
4 = LONG	A 32-bit (4-byte) unsigned integer,
5 = RATIONAL	Two LONGs. The first LONG is the numerator and the second LONG expresses the denominator.,
7 = UNDEFINED	An 8-bit byte that can take any value depending on the field definition,
9 = SLONG	A 32-bit (4-byte) signed integer (2's complement notation),
10 = SRATIONAL	Two SLONGs. The first SLONG is the numerator and the second SLONG is the denominator.

Count

The number of values. It should be noted carefully that the count is not the sum of the bytes. In the case of one value of SHORT (16 bits), for example, the count is '1' even though it is 2 bytes.

Value Offset

This tag records the offset from the start of the TIFF header to the position where the value itself is recorded. In cases where the value fits in 4 bytes, the value itself is recorded. If the value is smaller than 4 bytes, the value is stored in the 4-byte area starting from the left, i.e., from the lower end of the byte offset area. For example, in big endian format, if the type is SHORT and the value is 1, it is recorded as 00010000.H.

Note that field Interoperability must be recorded in sequence starting from the smallest tag number. There is no stipulation regarding the order or position of tag value (Value) recording.

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2.6.3. Exif-specific IFD

A. Exif IFD

Exif IFD is a set of tags for recording Exif-specific attribute information. It is pointed to by the offset from the TIFF header (Value Offset) indicated by an Exif private tag value.

Exif IFD Pointer

Tag = 34665 (8769.H)
Type = LONG
Count = 1
Default = none

A pointer to the Exif IFD. Interoperability, Exif IFD has the same structure as that of the IFD specified in TIFF. Ordinarily, however, it does not contain image data as in the case of TIFF.

B. GPS IFD

GPS IFD is a set of tags for recording GPS information. It is pointed to by the offset from the TIFF header (Value Offset) indicated by a GPS private tag value.

GPS Info IFD Pointer

Tag = 34853 (8825.H)
Type = LONG
Count = 1
Default = none

A pointer to the GPS Info IFD. The Interoperability structure of the GPS Info IFD, like that of Exif IFD, has no image data.

C. Interoperability IFD

Interoperability IFD is composed of tags which stores the information to ensure the Interoperability and pointed by the following tag located in Exif IFD.

Interoperability IFD Pointer

Tag = 40965 A005.H
Type = LONG
Count = 1
Default = None

The Interoperability structure of Interoperability IFD is same as TIFF defined IFD structure but does not contain the

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image data characteristically compared with normal TIFF IFD.

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2.6.4. TIFF Rev. 6.0 Attribute Information

Table 3 lists the attribute information used in Exif, including the attributes given as mandatory in Baseline TIFF Rev. 6.0 RGB Full Color Images and TIFF Rev. 6.0 Extensions YCbCr Images, as well as the optional TIFF tags used by DSC and other systems. The contents are explained below.

Table 3 TIFF Rev. 6.0 Attribute Information Used in Exif

Tag Name	Field Name	Tag ID		Type	Count
		Dec	Hex		
A. Tags relating to image data structure					
Image width	ImageWidth	256	100	SHORT or LONG	1
Image height	ImageLength	257	101	SHORT or LONG	1
Number of bits per component	BitsPerSample	258	102	SHORT	3
Compression scheme	Compression	259	103	SHORT	1
Pixel composition	PhotometricInterpretation	262	106	SHORT	1
Orientation of image	Orientation	274	112	SHORT	1
Number of components	SamplesPerPixel	277	115	SHORT	1
Image data arrangement	PlanarConfiguration	284	11C	SHORT	1
Subsampling ratio of Y to C	YCbCrSubSampling	530	212	SHORT	2
Y and C positioning	YCbCrPositioning	531	213	SHORT	1
Image resolution in width direction	XResolution	282	11A	RATIONAL	1
Image resolution in height direction	YResolution	283	11B	RATIONAL	1
Unit of X and Y resolution	ResolutionUnit	296	128	SHORT	1
B. Tags relating to recording offset					
Image data location	StripOffsets	273	111	SHORT or LONG	*S
Number of rows per strip	RowsPerStrip	278	116	SHORT or LONG	1
Bytes per compressed strip	StripByteCounts	279	117	SHORT or LONG	*S
Offset to JPEG SOI	JPEGInterchangeFormat	513	201	LONG	1
Bytes of JPEG data	JPEGInterchangeFormatLength	514	202	LONG	1
C. Tags relating to image data characteristics					
Transfer function	TransferFunction	301	12D	SHORT	3 * 256
White point chromaticity	WhitePoint	318	13E	RATIONAL	2
Chromaticities of primaries	PrimaryChromaticities	319	13F	RATIONAL	6
Color space transformation matrix coefficients	YCbCrCoefficients	529	211	RATIONAL	3
Pair of black and white reference values	ReferenceBlackWhite	532	214	RATIONAL	6
D. Other tags					
File change date and time	DateTime	306	132	ASCII	20
Image title	ImageDescription	270	10E	ASCII	Any
Image input equipment manufacturer	Make	271	10F	ASCII	Any
Image input equipment model	Model	272	110	ASCII	Any
Software used	Software	305	131	ASCII	Any
Person who created the image	Artist	315	13B	ASCII	Any
Copyright holder	Copyright	3432	8298	ASCII	Any

*S Chunky format: StripsPerImage

Planar format: SamplesPerImage * StripsPerImage

StripsPerImage = floor((ImageLength + RowsPerStrip -1)/ RowsPerStrip)

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A. Tags relating to image data structure

ImageWidth

The number of columns of image data, equal to the number of pixels per row. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 256 (100.H)

Type = SHORT or LONG

Count = 1

Default = none

ImageLength

The number of rows of image data. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 257 (101.H)

Type = SHORT or LONG

Count = 1

Default = none

BitsPerSample

The number of bits per image component. In this standard each component of the image is 8 bits, so the value for this tag is 8. See also *SamplesPerPixel*. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 258 (102.H)

Type = SHORT

Count = 3

Default = 8 8 8

Compression

The compression scheme used for the image data. When a primary image is JPEG compressed, this designation is not necessary and is omitted. When thumbnails use JPEG compression, this tag value is set to 6.

Tag = 259 (103.H)

Type = SHORT

Count = 1

Default = none

1 = uncompressed

6 = JPEG compression (thumbnails only)

Other = reserved

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PhotometricInterpretation

The pixel composition. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 262 (106.H)

Type = SHORT

Count = 1

Default = none

2 = RGB

6 = YCbCr

Other = reserved

Orientation

The image orientation viewed in terms of rows and columns.

Tag = 274 (112.H)

Type = SHORT

Count = 1

Default = 1

1 = The 0th row is at the visual top of the image, and the 0th column is the visual left-hand side.

2 = The 0th row is at the visual top of the image, and the 0th column is the visual right-hand side.

3 = The 0th row is at the visual bottom of the image, and the 0th column is the visual right-hand side.

4 = The 0th row is at the visual bottom of the image, and the 0th column is the visual left-hand side.

5 = The 0th row is the visual left-hand side of of the image, and the 0th column is the visual top.

6 = The 0th row is the visual right-hand side of of the image, and the 0th column is the visual top.

7 = The 0th row is the visual right-hand side of of the image, and the 0th column is the visual bottom.

8 = The 0th row is the visual left-hand side of of the image, and the 0th column is the visual bottom.

Other = reserved

SamplesPerPixel

The number of components per pixel. Since this standard applies to RGB and YCbCr images, the value set for this tag is 3. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 277 (115.H)

Type = SHORT

Count = 1

Default = 3

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PlanarConfiguration

Indicates whether pixel components are recorded in chunky or planar format. In JPEG compressed files a JPEG marker is used instead of this tag. If this field does not exist, the TIFF default of 1 (chunky) is assumed.

Tag = 284 (11C.H)

Type = SHORT

Count = 1

1 = chunky format

2 = planar format

Other = reserved

YCbCrSubSampling

The sampling ratio of chrominance components in relation to the luminance component. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 530 (212.H)

Type = SHORT

Count = 2

[2, 1] = YCbCr4:2:2

[2, 2] = YCbCr4:2:0

Other = reserved

YCbCrPositioning

The position of chrominance components in relation to the luminance component. This field is designated only for JPEG compressed data or uncompressed YCbCr data. The TIFF default is 1 (centered); but when Y:Cb:Cr = 4:2:2 it is recommended in this standard that 2 (co-sited) be used to record data, in order to improve the image quality when viewed on TV systems. When this field does not exist, the reader shall assume the TIFF default. In the case of Y:Cb:Cr = 4:2:0, the TIFF default (centered) is recommended. If the reader does not have the capability of supporting both kinds of *YCbCrPositioning*, it shall follow the TIFF default regardless of the value in this field. It is preferable that readers be able to support both centered and co-sited positioning.

Tag = 531 (213.H)

Type = SHORT

Count = 1

Default = 1

1 = centered

2 = co-sited

Other = reserved

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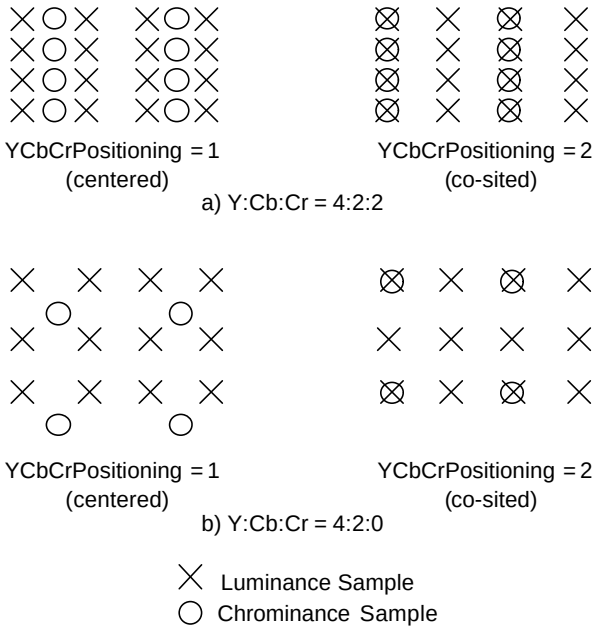


Fig. 8 YCbCrPositioning

XResolution

The number of pixels per *ResolutionUnit* in the *ImageWidth* direction. When the image resolution is unknown, 72 [dpi] is designated.

Tag = 282 (11A.H)

Type = RATIONAL

Count = 1

Default = 72

YResolution

The number of pixels per *ResolutionUnit* in the *ImageLength* direction. The same value as *XResolution* is designated.

Tag = 283 (11B.H)

Type = RATIONAL

Count = 1

Default = 72

ResolutionUnit

The unit for measuring *XResolution* and *YResolution*. The same unit is used for both *XResolution* and *YResolution*. If the image resolution in unknown, 2 (inches) is designated.

Tag = 296 (128.H)

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Type = SHORT

Count = 1

Default = 2

2 = inches

3 = centimeters

Other = reserved

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B. Tags relating to recording offset

StripOffsets

For each strip, the byte offset of that strip. It is recommended that this be selected so the number of strip bytes does not exceed 64 Kbytes. With JPEG compressed data this designation is not needed and is omitted. See also *RowsPerStrip* and *StripByteCounts*.

Tag = 273 (111.H)
Type = SHORT or LONG
Count = StripsPerImage (when PlanarConfiguration = 1)
= SamplesPerPixel * StripsPerImage (when PlanarConfiguration = 2)
Default = none

RowsPerStrip

The number of rows per strip. This is the number of rows in the image of one strip when an image is divided into strips. With JPEG compressed data this designation is not needed and is omitted. See also *RowsPerStrip* and *StripByteCounts*.

Tag
Tag = 278 (116.H)
Type = SHORT or LONG
Count = 1
Default = none

StripByteCounts

The total number of bytes in each strip. With JPEG compressed data this designation is not needed and is omitted.

Tag = 279 (117.H)
Type = SHORT or LONG
Count = StripsPerImage (when PlanarConfiguration = 1)
SamplesPerPixel * StripsPerImage (when PlanarConfiguration = 2)
Default = none

JPEGInterchangeFormat

The offset to the start byte (SOI) of JPEG compressed thumbnail data. This is not used for primary image JPEG data.

Tag = 513 (201.H)
Type = LONG
Default = none

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JPEGInterchangeFormatLength

The number of bytes of JPEG compressed thumbnail data. This is not used for primary image JPEG data. JPEG thumbnails are not divided but are recorded as a continuous JPEG bitstream from SOI to EOI. APPn and COM markers should not be recorded. Compressed thumbnails must be recorded in no more than 64 Kbytes, including all other data to be recorded in APP1.

Tag = 514 (202.H)

Type = LONG

Default = none

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C. Tags Relating to Image Data Characteristics

TransferFunction

A transfer function for the image, described in tabular style. Normally this tag is not necessary, since color space is specified in the color space information tag (*ColorSpace*).

Tag = 301 (12D.H)

Type = SHORT

Count = 3 * 256

Default = none

WhitePoint

The chromaticity of the white point of the image. Normally this tag is not necessary, since color space is specified in the color space information tag (*ColorSpace*).

Tag = 318 (13E.H)

Type = RATIONAL

Count = 2

Default = none

PrimaryChromaticities

The chromaticity of the three primary colors of the image. Normally this tag is not necessary, since color space is specified in the color space information tag (*ColorSpace*).

Tag = 319 (13F.H)

Type = RATIONAL

Count = 6

Default = none

YCbCrCoefficients

The matrix coefficients for transformation from RGB to YCbCr image data. No default is given in TIFF; but here the value given in Appendix E, "Color Space Guidelines," is used as the default. The color space is declared in a color space information tag, with the default being the value that gives the optimal image characteristics Interoperability this condition.

Tag = 529 (211.H)

Type = RATIONAL

Count = 3

Default = See Appendix E.

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ReferenceBlackWhite

The reference black point value and reference white point value. No defaults are given in TIFF, but the values below are given as defaults here. The color space is declared in a color spaœ information tag, with the default being the value that gives the optimal image characteristics Interoperability these conditions.

Tag	=	532 (214.H)	
Type	=	RATIONAL	
Count	=	6	
Default	=	[0, 255, 0, 255, 0, 255]	(when PhotometricInterpretation is RGB)
		[0, 255, 0, 128, 0, 128]	(when PhotometricInterpretation is YCbCr)

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D. Other Tags

DateTime

The date and time of image creation. In this standard it is the date and time the file was changed. The format is "YYYY:MM:DD HH:MM:SS" with time shown in 24-hour format, and the date and time separated by one blank character [20.H]. When the date and time are unknown, all the character spaces except colons (":") may be filled with blank characters, or else the Interoperability field may be filled with blank characters. The character string length is 20 bytes including NULL for termination. When the field is left blank, it is treated as unknown.

Tag = 306 (132.H)
Type = ASCII
Count = 20
Default = none

ImageDescription

A character string giving the title of the image. It may be a comment such as "1988 company picnic" or the like. Two-byte character codes cannot be used. When a 2-byte code is necessary, the Exif Private tag *UserComment* is to be used.

Tag = 270 (10E.H)
Type = ASCII
Count = Any
Default = none

Make

The manufacturer of the recording equipment. This is the manufacturer of the DSC, scanner, video digitizer or other equipment that generated the image. When the field is left blank, it is treated as unknown.

Tag = 271 (10F.H)
Type = ASCII
Count = Any
Default = none

Model

The model name or model number of the equipment. This is the model name of number of the DSC, scanner, video digitizer or other equipment that generated the image. When the field is left blank, it is treated as unknown.

Tag = 272 (110.H)
Type = ASCII

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Count = Any

Default = none

Software

This tag records the name and version of the software or firmware of the camera or image input device used to generate the image. The detailed format is not specified, but it is recommended that the example shown below be followed. When the field is left blank, it is treated as unknown.

Ex.) "Exif Software Version 1.00a"

Tag = 305 (131h)

Type = ASCII

Count = Any

Default = none

Artist

This tag records the name of the camera owner, photographer or image creator. The detailed format is not specified, but it is recommended that the information be written as in the example below for ease of Interoperability. When the field is left blank, it is treated as unknown.

Ex.) "Camera owner, John Smith; Photographer, Michael Brown; Image creator, Ken James"

Tag = 315 (13Bh)

Type = ASCII

Count = Any

Default = none

Copyright

Copyright information. In this standard the tag is used to indicate both the photographer and editor copyrights. It is the copyright notice of the person or organization claiming rights to the image. The Interoperability copyright statement including date and rights should be written in this field; e.g., "Copyright, John Smith, 19xx. All rights reserved." In this standard the field records both the photographer and editor copyrights, with each recorded in a separate part of the statement. When there is a clear distinction between the photographer and editor copyrights, these are to be written in the order of photographer followed by editor copyright, separated by NULL (in this case, since the statement also ends with a NULL, there are two NULL codes) (see example 1). When only the photographer copyright is given, it is terminated by one NULL code (see example 2). When only the editor copyright is given, the photographer copyright part consists of one space followed by a terminating NULL code, then the editor copyright is given (see example 3). When the field is left blank, it is treated as unknown.

Ex. 1) When both the photographer copyright and editor copyright are given.

Photographer copyright + NULL[00.H] + editor copyright + NULL[00.H]

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Ex. 2) When only the photographer copyright is given.

Photographer copyright + NULL[00.H]

Ex. 3) When only the editor copyright is given.

Space[20.H]+ NULL[00.H] + editor copyright + NULL[00.H]

Tag = 33432 (8298.H)

Type = ASCII

Count = Any

Default = none

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2.6.5. Exif IFD Attribute Information

The attribute information (field names and codes) recorded in the Exif IFD is given in Table 4 and Table 5 followed by an explanation of the contents.

Table 4 Exif IFD Attribute Information (1)

Tag Name	Field Name	Tag ID		Type	Count
		Dec	Hex		
A. Tags Relating to Version					
Exif version	ExifVersion	36864	9000	UNDEFINED	4
Supported FlashPix version	FlashPixVersion	40960	A000	UNDEFINED	4
B. Tag Relating to Image Data Characteristics					
Color space information	ColorSpace	40961	A001	SHORT	1
C. Tags Relating to Image Configuration					
Meaning of each component	ComponentsConfiguration	37121	9101	UNDEFINED	4
Image compression mode	CompressedBitsPerPixel	37122	9102	RATIONAL	1
Valid image width	PixelXDimension	40962	A002	SHORT or LONG	1
Valid image height	PixelYDimension	40963	A003	SHORT or LONG	1
D. Tags Relating to User Information					
Manufacturer notes	MakerNote	37500	927C	UNDEFINED	Any
User comments	UserComment	37510	9286	UNDEFINED	Any
E. Tag Relating to Related File Information					
Related audio file	RelatedSoundFile	40964	A004	ASCII	13
F. Tags Relating to Date and Time					
Date and time of original data generation	DateTimeOriginal	36867	9003	ASCII	20
Date and time of digital data generation	DateTimeDigitized	36868	9004	ASCII	20
DateTime subseconds	SubSecTime	37520	9290	ASCII	Any
DateTimeOriginal subseconds	SubSecTimeOriginal	37521	9291	ASCII	Any
DateTimeDigitized subseconds	SubSecTimeDigitized	37522	9292	ASCII	Any
G. Tags Relating to Picture-Taking Conditions					
See Table 5					
H. Tags Relating to Date and Time					
Pointer of Interoperability IFD	Interoperability IFD Pointer	40965	A005	LONG	1

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Table 5 Exif IFD Attribute Information (2)

G. Tags Relating to Picture-Taking Conditions					
Exposure time	ExposureTime	33434	829A	RATIONAL	1
F number	FNumber	33437	829D	RATIONAL	1
Exposure program	ExposureProgram	34850	8822	SHORT	1
Spectral sensitivity	SpectralSensitivity	34852	8824	ASCII	Any
ISO speed rating	ISOSpeedRatings	34855	8827	SHORT	Any
Optoelectric conversion factor	OECF	34856	8828	UNDEFINED	Any
Shutter speed	ShutterSpeedValue	37377	9201	SRATIONAL	1
Aperture	ApertureValue	37378	9202	RATIONAL	1
Brightness	BrightnessValue	37379	9203	SRATIONAL	1
Exposure bias	ExposureBiasValue	37380	9204	SRATIONAL	1
Maximum lens aperture	MaxApertureValue	37381	9205	RATIONAL	1
Subject distance	SubjectDistance	37382	9206	RATIONAL	1
Metering mode	MeteringMode	37383	9207	SHORT	1
Light source	LightSource	37384	9208	SHORT	1
Flash	Flash	37385	9209	SHORT	1
Lens focal length	FocalLength	37386	920A	RATIONAL	1
Flash energy	FlashEnergy	41483	A20B	RATIONAL	1
Spatial frequency response	SpatialFrequencyResponse	41484	A20C	UNDEFINED	Any
Focal plane X resolution	FocalPlaneXResolution	41486	A20E	RATIONAL	1
Focal plane Y resolution	FocalPlaneYResolution	41487	A20F	RATIONAL	1
Focal plane resolution unit	FocalPlaneResolutionUnit	41488	A210	SHORT	1
Subject location	SubjectLocation	41492	A214	SHORT	2
Exposure index	ExposureIndex	41493	A215	RATIONAL	1
Sensing method	SensingMethod	41495	A217	SHORT	1
File source	FileSource	41728	A300	UNDEFINED	1
Scene type	SceneType	41729	A301	UNDEFINED	1
CFA pattern	CFAPattern	41730	A302	UNDEFINED	Any

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A. Tags Relating to Version

ExifVersion

The version of this standard supported. Nonexistence of this field is taken to mean nonconformance to the standard (see section 2.2). Conformance to this standard is indicated by recording "0210" as 4-byte ASCII. Since the type is UNDEFINED, there is no NULL for termination.

Tag = 36864 (9000.H)

Type = UNDEFINED

Count = 4

Default = "0210"

FlashPixVersion

The FlashPix format version supported by a FPXR file. If the FPXR function supports FlashPix format Ver. 1.0, this is indicated similarly to *ExifVersion* by recording "0100" as 4-byte ASCII. Since the type is UNDEFINED, there is no NULL for termination.

Tag = 40960(A000.H)

Type = UNDEFINED

Count = 4

Default = "0100"

0100 = FlashPix Format Version 1.0

Other = reserved

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B. Tag Relating to Color Space

ColorSpace

The color space information tag (*ColorSpace*) is always recorded as the color space specifier.

Normally sRGB (=1) is used to define the color space based on the PC monitor conditions and environment. If a color space other than sRGB is used, Uncalibrated (=FFFF.H) is set. Image data recorded as Uncalibrated can be treated as sRGB when it is converted to FlashPix. On sRGB see Appendix E.

Tag = 40961 (A001.H)

Type = SHORT

Count = 1

1	=	sRGB
FFFF.H	=	Uncalibrated
Other	=	reserved

.

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C. Tags Relating to Image Configuration

PixelXDimension

Information specific to compressed data. When a compressed file is recorded, the valid width of the meaningful image must be recorded in this tag, whether or not there is padding data or a restart marker. This tag should not exist in an uncompressed file. For details see section 2.8.1 and Appendix F.

Tag = 40962 (A002.H)
Type = SHORT or LONG
Count = 1
Default = none

PixelYDimension

Information specific to compressed data. When a compressed file is recorded, the valid height of the meaningful image must be recorded in this tag, whether or not there is padding data or a restart marker. This tag should not exist in an uncompressed file. For details see section 2.8.1 and Appendix F. Since data padding is unnecessary in the vertical direction, the number of lines recorded in this valid image height tag will in fact be the same as that recorded in the SOF.

Tag = 40963 (A003.H)
Type = SHORT of LONG
Count = 1

ComponentsConfiguration

Information specific to compressed data. The channels of each component are arranged in order from the 1st component to the 4th. For uncompressed data the data arrangement is given in the *PhotometricInterpretation* tag. However, since *PhotometricInterpretation* can only express the order of Y,Cb and Cr, this tag is provided for cases when compressed data uses components other than Y, Cb, and Cr and to enable support of other sequences.

Tag = 37121 (9101.H)
Type = UNDEFINED
Count = 4
Default = 4 5 6 0 (if RGB uncompressed)
1 2 3 0 (other cases)

0 = does not exist
1 = Y
2 = Cb
3 = Cr
4 = R
5 = G

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6 = B

Other = reserved

CompressedBitsPerPixel

Information specific to compressed data. The compression mode used for a compressed image is indicated in unit bits per pixel.

Tag = 37122 (9102.H)

Type = RATIONAL

Count = 1

Default = none

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D. Tags Relating to User Information

MakerNote

A tag for manufacturers of Exif writers to record any desired information. The contents are up to the manufacturer.

Tag = 37500 (927C.H)

Type = UNDEFINED

Count = Any

Default = none

UserComment

A tag for Exif users to write keywords or comments on the image besides those in *ImageDescription*, and without the character code limitations of the *ImageDescription* tag.

Tag = 37510 (9286.H)

Type = UNDEFINED

Count = Any

Default = none

The character code used in the *UserComment* tag is identified based on an ID code in a fixed 8-byte area at the start of the tag data area. The unused portion of the area is padded with NULL ("00.H"). ID codes are assigned by means of registration. The designation method and references for each character code are given in Table 6 . The value of Count N is determined based on the 8 bytes in the character code area and the number of bytes in the user comment part. Since the TYPE is not ASCII, NULL termination is not necessary (see Fig. 9).

Table 6 Character Codes and their Designation

Character Code	Code Designation (8 Bytes)	References
ASCII	41.H, 53.H, 43.H, 49.H, 49.H, 00.H, 00.H, 00.H	ITU-T T.50 IA5[x]
JIS	4A.H, 49.H, 53.H, 00.H, 00.H, 00.H, 00.H, 00.H	JIS X0208-1990[xi]
Unicode	55.H, 4E.H, 49.H, 43.H, 4F.H, 44.H, 45.H, 00.H	Unicode Standard [xii]
Undefined	00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H	Undefined

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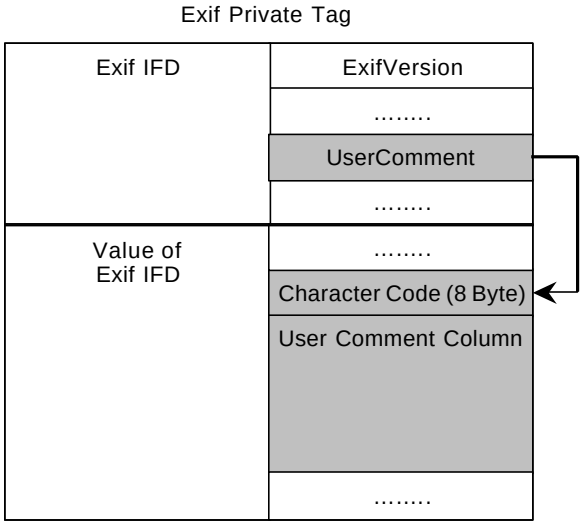


Fig. 9 User Comment Tag

The ID code for the *UserComment* area may be a Defined code such as JIS or ASCII, or may be Undefined. The Undefined name is *UndefinedText*, and the ID code is filled with 8 bytes of all "NULL" ("00.H"). An Exif reader that reads the *UserComment* tag must have a function for determining the ID code. This function is not required in Exif readers that do not use the *UserComment* tag (see Table 7).

Table 7 Implementation of Defined and Undefined Character Codes

ID Code	Exif Reader Implementation
Defined (JIS, ASCII, etc.)	Determines the ID code and displays it in accord with the reader capability.
Undefined (all NULL)	Depends on the localized PC in each country. (If a character code is used for which there is no clear specification like Shift-JIS in Japan, Undefined is used.) Although the possibility of unreadable characters exists, display of these characters is left as a matter of reader implementation.

When a *UserComment* area is set aside, it is recommended that the ID code be ASCII and that the following user comment part be filled with blank characters [20.H].

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E. Tag Relating to Related File

RelatedSoundFile

This tag is used to record the name of an audio file related to the image data. The only relational information recorded here is the Exif audio file name and extension (an ASCII string consisting of 8 characters + '.' + 3 characters). The path is not recorded. Stipulations on audio are given in section 3.6.3. File naming conventions are given in section 3.7.1.

When using this tag, audio files must be recorded in conformance to the Exif audio format. Writers are also allowed to store the data such as Audio within APP2 as FlashPix extension stream data.

Audio files must be recorded in conformance to the Exif audio format.

The mapping of Exif image files and audio files is done in any of the three ways shown in Table 8. If multiple files are mapped to one file as in [2] or [3] of this table, the above format is used to record just one audio file name. If there are multiple audio files, the first recorded file is given.

In the case of [3] in Table 8, for example, for the Exif image file "DSC00001.JPG" only "SND00001.WAV" is given as the related Exif audio file.

When there are three Exif audio files "SND00001.WAV", "SND00002.WAV" and "SND00003.WAV", the Exif image file name for each of them, "DSC00001.JPG," is indicated. By combining multiple relational information, a variety of playback possibilities can be supported. The method of using relational information is left to the implementation on the playback side. Since this information is an ASCII character string, it is terminated by NULL.

Table 8 Mapping between Image and Audio Files

	Relationship	Exif Image File	Exif Audio File
[1]	1 to 1	DSC00001.JPG	SND00001.WAV
[2]	Plural to 1	DSC00001.JPG DSC00002.JPG DSC00003.JPG	SND00001.WAV
[3]	1 to plural	DSC00001.JPG	SND00001.WAV SND00002.WAV SND00003.WAV

When this tag is used to map audio files, the relation of the audio file to image data must also be indicated on the audio file end.

Tag = 40964 (A004.H)

Type = ASCII

Count = 13

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Default = none

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F. Tags Relating to Date and Time

DateTimeOriginal

The date and time when the original image data was generated. For a DSC the date and time the picture was taken are recorded. The format is "YYYY:MM:DD HH:MM:SS" with time shown in 24-hour format, and the date and time separated by one blank character [20.H]. When the date and time are unknown, all the character spaces except colons (":") may be filled with blank characters, or else the Interoperability field may be filled with blank characters. The character string length is 20 bytes including NULL for termination. When the field is left blank, it is treated as unknown.

Tag = 36867 (9003.H)
Type = ASCII
Count = 20
Default = none

DateTimeDigitized

The date and time when the image was stored as digital data. If, for example, an image was captured by DSC and at the same time the file was recorded, then the *DateTimeOriginal* and *DateTimeDigitized* will have the same contents. The format is "YYYY:MM:DD HH:MM:SS" with time shown in 24-hour format, and the date and time separated by one blank character [20.H]. When the date and time are unknown, all the character spaces except colons (":") may be filled with blank characters, or else the Interoperability field may be filled with blank characters. The character string length is 20 bytes including NULL for termination. When the field is left blank, it is treated as unknown.

Tag = 36868 (9004.H)
Type = ASCII
Count = 20
Default = none

SubsecTime

A tag used to record fractions of seconds for the *DateTime* tag.

Tag = 37520 (9290.H)
Type = ASCII
Count = Any
Default = none

SubsecTimeOriginal

A tag used to record fractions of seconds for the *DateTimeOriginal* tag.

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Tag = 37521 (9291.H)

Type = ASCII

N = Any

Default = none

SubsecTimeDigitized

A tag used to record fractions of seconds for the *DateTimeDigitized* tag.

Tag = 37522 (9292.H)

Type = ASCII

N = Any

Default = none

Note: Recording subsecond data (*SubsecTime*, *SubsecTimeOriginal*, *SubsecTimeDigitized*)

The tag type is ASCII and the string length including NULL is variable length. When the number of valid digits is up to the second decimal place, the subsecond value goes in the Value position. When it is up to four decimal places, an address value is Interoperability, with the subsecond value put in the location pointed to by that address. (Since the count of ASCII type field Interoperability is a value that includes NULL, when the number of valid digits is up to four decimal places the count is 5, and the offset value goes in the Value Offset field. See section 2.6.2.) Note that the subsecond tag differs from the *DateTime* tag and other such tags already defined in TIFF Rev. 6.0, and that both are recorded in the Exif IFD.

Ex.: September 9, 1998, 9:15:30.130

(the number of valid digits is up to the third decimal place)

DateTime 1996:09:01 09:15:30 [NULL]

SubSecTime 130 [NULL]

If the string length is longer than the number of valid digits, the digits are aligned with the start of the area and the rest is filled with blank characters [20.H]. If the subsecond data is unknown, the Interoperability area can be filled with blank characters.

Examples when subsecond data is 0.130 seconds:

Ex. 1) '1','3','0',[NULL]

Ex. 2) '1','3','0',[20.H],[NULL]

Ex. 3) '1','3','0', [20.H], [20.H], [20.H], [20.H], [20.H], [NULL]

Example when subsecond data is unknown:

Ex. 4) [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [NULL]

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G. Tags Relating to Picture-Taking Conditions

ExposureTime

Exposure time, given in seconds (sec).

Tag = 33434 (829A.H)

Type = RATIONAL

Count = 1

Default = none

ShutterSpeedValue

Shutter speed. The unit is the APEX (Additive System of Photographic Exposure) setting (see Appendix C).

Tag = 37377 (9201.H)

Type = SRATIONAL

Count = 1

Default = none

ApertureValue

The lens aperture. The unit is the APEX value.

Tag = 37378 (9202.H)

Type = RATIONAL

Count = 1

Default = none

BrightnessValue

The value of brightness. The unit is the APEX value. Ordinarily it is given in the range of -99.99 to 99.99.

Tag = 37379 (9203.H)

Type = SRATIONAL

Count = 1

Default = none

ExposureBiasValue

The exposure bias. The unit is the APEX value. Ordinarily it is given in the range of –99.99 to 99.99.

Tag = 37380 (9204.H)

Type = SRATIONAL

Count = 1

Default = none

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MaxApertureValue

The smallest F number of the lens. The unit is the APEX value. Ordinarily it is given in the range of 00.00 to 99.99, but it is not limited to this range.

Tag = 37381 (9205.H)
Type = RATIONAL
Count = 1
Default = none

SubjectDistance

The distance to the subject, given in meters.

Tag = 37382 (9206.H)
Type = RATIONAL
Count = 1
Default = none

MeteringMode

The metering mode.

Tag = 37383 (9207.H)
Type = SHORT
Count = 1
Default = 0

0 = unknown
1 = Average
2 = CenterWeightedAverage
3 = Spot
4 = MultiSpot
5 = Pattern
6 = Partial
7 to 254 = reserved
255 = other

LightSource

The kind of light source.

Tag = 37384 (9208.H)
Type = SHORT
Count = 1
Default = 0

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0 = unknown

1 = Daylight

2 = Fluorescent

3 = Tungsten

17 = Standard light A

18 = Standard light B

19 = Standard light C

20 = D55

21 = D65

22 = D75

23 to 254 = reserved

255 = other

Flash

This tag is recorded when an image is taken using a strobe light (flash). Bit 0 indicates the flash firing status, and bits 1 and 2 indicate the flash return status (see Fig. 10).

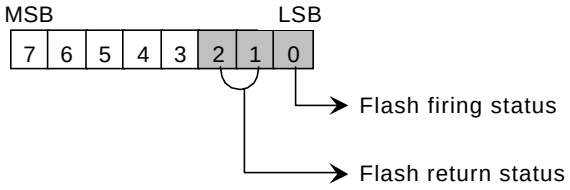


Fig. 10 Bit Coding of the Flash Tag

Tag = 37385 (9209.H)

Type = SHORT

Count = 1

Values for bit 0 indicating whether the flash fired.

0b = Flash did not fire.

1b = Flash fired.

Values for bits 1 and 2 indicating the status of returned light.

00b = No strobe return detection function

01b = reserved

10b = Strobe return light not detected.

11b = Strobe return light detected.

Resulting Flash tag values.

0000.H = Flash did not fire.

0001.H = Flash fired.

0005.H = Strobe return light not detected.

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0007.H = Strobe return light detected.

Other = reserved

FocalLength

The actual focal length of the lens, in mm. Conversion is not made to the focal length of a 35 mm film camera.

Tag = 37386 (920A.H)

Type = RATIONAL

Count = 1

Default = none

FNumber

The F number.

Tag = 33437 (829D.H)

Type = RATIONAL

Count = 1

Default = none

ExposureProgram

The class of the program used by the camera to set exposure when the picture is taken. The tag values are as follows.

Tag = 34850 (8822.H)

Type = SHORT

Count = 1

Default = 0

0 = Not defined

1 = Manual

2 = Normal program

3 = Aperture priority

4 = Shutter priority

5 = Creative program (biased toward depth of field)

6 = Action program (biased toward fast shutter speed)

7 = Portrait mode (for closeup photos with the background out of focus)

8 = Landscape mode (for landscape photos with the background in focus)

9 to 255 = reserved

SpectralSensitivity

Indicates the spectral sensitivity of each channel of the camera used. The tag value is an ASCII string compatible with the standard[xiii] developed by the ASTM Technical committee.

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Tag = 34852 (8824.H)

Type = ASCII

Count = Any

Default = none

ISOSpeedRatings

Indicates the ISO Speed and ISO Latitude of the camera or input device as specified in ISO 12232[xiv].

Tag = 34855 (8827.H)

Type = SHORT

Count = Any

Default = none

OECF

Indicates the Opto-Electoric Conversion Function (OECF) specified in ISO 14524[xv]. *OECF* is the relationship between the camera optical input and the image values.

Tag = 34856 (8828.H)

Type = UNDEFINED

Count = ANY

Default = none

When this tag records an *OECF* of m rows and n columns, the values are as in Fig. 11.

Length	Type	Meaning
2	SHORT	Columns = n
2	SHORT	Rows = m
Any	ASCII	0th column item name (NULL terminated)
:	:	:
Any	ASCII	n-1th column item name (NULL terminated)
8	SRATIONAL	OECF value [0,0]
:	:	:
8	SRATIONAL	OECF value [n-1,0]
8	SRATIONAL	OECF value [0,m-1]
:	:	:
8	SRATIONAL	OECF value [n-1,m-1]

Fig. 11 OECF Description

Table 9 gives a simple example.

Table 9 Example of Exposure and RGB Output Level

Camera log Aperture	R Output Level	G Output Level	B Output Level
-3.0	10.2	12.4	8.9
-2.0	48.1	47.5	48.3
-1.0	150.2	152.0	149.8

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FlashEnergy

Indicates the strobe energy at the time the image is captured, as measured in Beam Candle Power Seconds (BCPS).

Tag = 41483 (A20B.H)

Type = RATIONAL

Count = 1

Default = none

SpatialFrequencyResponse

This tag records the camera or input device spatial frequency table and SFR values in the direction of image width, image height, and diagonal direction, as specified in ISO 12233[xvi].

Tag = 41484 (A20CH)

Type = UNDEFINED

Count = ANY

Default = none

When the spatial frequency response for m rows and n columns is recorded, the values are as shown in Fig. 12.

Length	Type	Meaning
2	SHORT	Columns = n
2	SHORT	Rows = m
Any	ASCII	0th column item name (NULL terminated)
: Any	: ASCII	: n-1th column item name (NULL terminated)
8	RATIONAL	SFR value [0,0]
:	:	:
8	RATIONAL	SFR value [n-1,0]
8	RATIONAL	SFR value [0,m-1]
:	:	:
8	RATIONAL	SFR value [n-1,m-1]

Fig. 12 Spatial Frequency Response Description

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Table 10 gives a simple example.

Table 10 Example of Spatial Frequency Response

Spatial Frequency (lw/ph)	Along Image Width	Along Image Height
	1.00	1.00
0.2	0.90	0.95
0.3	0.80	0.85

FocalPlaneXResolution

Indicates the number of pixels in the image width (X) direction per *FocalPlaneResolutionUnit* on the camera focal plane.

Tag = 41486 (A20E.H)

Type = RATIONAL

Count = 1

Default = none

FocalPlaneYResolution

Indicates the number of pixels in the image height (Y) direction per *FocalPlaneResolutionUnit* on the camera focal plane.

Tag = 41487 (A20F.H)

Type = RATIONAL

Count = 1

Default = none

FocalPlaneResolutionUnit

Indicates the unit for measuring *FocalPlaneXResolution* and *FocalPlaneYResolution*. This value is the same as the *ResolutionUnit*.

Tag = 41488 (A210.H)

Type = SHORT

Count = 1

Default = 2 (inch)

Note on use of tags concerning focal plane resolution

These tags record the actual focal plane resolutions of the main image which is written as a file after processing instead of the pixel resolution of the image sensor in the camera. It should be noted carefully that the data from the image sensor is resampled.

These tags are used at the same time as a FocalLength tag when the angle of field of the recorded image is to be calculated precisely.

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SubjectLocation

Indicates the location of the main subject in the scene. The value of this tag represents the pixel at the center of the main subject relative to the left edge, prior to rotation processing as per the *Rotation* tag. The first value indicates the X column number and second indicates the Y row number.

Tag = 41492 (A214.H)

Type = SHORT

Count = 2

Default = none

ExposureIndex

Indicates the exposure index selected on the camera or input device at the time the image is captured.

Tag = 41493 (A215.H)

Type = RATIONAL

Count = 1

Default = none

SensingMethod

Indicates the image sensor type on the camera or input device. The values are as follows.

Tag = 41495 (A217.H)

Type = SHORT

Count = 1

Default = none

1 = Not defined

2 = One-chip color area sensor

3 = Two-chip color area sensor

4 = Three-chip color area sensor

5 = Color sequential area sensor

7 = Trilinear sensor

8 = Color sequential linear sensor

Other = reserved

FileSource

Indicates the image source. If a DSC recorded the image, this tag value of this tag always be set to 3, indicating that the image was recorded on a DSC.

Tag = 41728 (A300.H)

Type = UNDEFINED

Count = 1

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Default = 3

3 = DSC

Other = reserved

SceneType

Indicates the type of scene. If a DSC recorded the image, this tag value must always be set to 1, indicating that the image was directly photographed.

Tag = 41729 (A301.H)

Type = UNDEFINED

Count = 1

Default = 1

1 = A directly photographed image

Other = reserved

CFAPattern

Indicates the color filter array (CFA) geometric pattern of the image sensor when a one-chip color area sensor is used. It does not apply to all sensing methods.

Tag = 41730 (A302.H)

Type = UNDEFINED

Count = ANY

Fig. 13 shows how a CFA pattern is recorded for a one-chip color area sensor when the color filter array is repeated in m x n (vertical x lateral) pixel units.

Length	Type	Meaning
2	SHORT	Horizontal repeat pixel unit = n
2	SHORT	Vertical repeat pixel unit = m
1	BYTE	CFA value [0.0]
:	:	:
1	BYTE	CFA value [n-1.0]
1	BYTE	CFA value [0.m-1]
:	:	:
1	BYTE	CFA value [n-1.m-1]

Fig. 13 CFA Pattern Description

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The relation of color filter color to CFA value is shown in Table 11.

Table 11 Color Filter Color and CFA Value

Filter Color	CFA Value
RED	00.H
GREEN	01.H
BLUE	02.H
CYAN	03.H
MAGENTA	04.H
YELLOW	05.H
WHITE	06.H

For example, when the CFA pattern values are {0002.H, 0002.H, 01.H, 00.H, 02.H, 01.H}, the color filter array is as shown in Fig. 14.

G	R	G	R	……
B	G	B	G	……
G	R	G	R	……
B	G	B	G	……
:	:	:	:	

Fig. 14 Color Filter Array

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2.6.6. GPS Attribute Information

The attribute information (field names and codes) recorded in the GPS Info IFD is given in Table 12, followed by an explanation of the contents.

Table 12 GPS Attribute Information

Tag Name	Field Name	Tag ID		Type	Count
		Dec	Hex		
A. Tags Relating to GPS					
GPS tag version	GPSVersionID	0	0	BYTE	4
North or South Latitude	GPSLatitudeRef	1	1	ASCII	2
Latitude	GPSLatitude	2	2	RATIONAL	3
East or West Longitude	GPSLongitudeRef	3	3	ASCII	2
Longitude	GPSLongitude	4	4	RATIONAL	3
Altitude reference	GPSAltitudeRef	5	5	BYTE	1
Altitude	GPSAltitude	6	6	RATIONAL	1
GPS time (atomic clock)	GPSTimeStamp	7	7	RATIONAL	3
GPS satellites used for measurement	GPSSatellites	8	8	ASCII	Any
GPS receiver status	GPSStatus	9	9	ASCII	2
GPS measurement mode	GPSMeasureMode	10	A	ASCII	2
Measurement precision	GPSDOP	11	B	RATIONAL	1
Speed unit	GPSSpeedRef	12	C	ASCII	2
Speed of GPS receiver	GPSSpeed	13	D	RATIONAL	1
Reference for direction of movement	GPSTrackRef	14	E	ASCII	2
Direction of movement	GPSTrack	15	F	RATIONAL	1
Reference for direction of image	GPSImgDirectionRef	16	10	ASCII	2
Direction of image	GPSImgDirection	17	11	RATIONAL	1
Geodetic survey data used	GPSMapDatum	18	12	ASCII	Any
Reference for latitude of destination	GPSDestLatitudeRef	19	13	ASCII	2
Latitude of destination	GPSDestLatitude	20	14	RATIONAL	3
Reference for longitude of destination	GPSDestLongitudeRef	21	15	ASCII	2
Longitude of destination	GPSDestLongitude	22	16	RATIONAL	3
Reference for bearing of destination	GPSDestBearingRef	23	17	ASCII	2
Bearing of destination	GPSDestBearing	24	18	RATIONAL	1
Reference for distance to destination	GPSDestDistanceRef	25	19	ASCII	2
Distance to destination	GPSDestDistance	26	1A	RATIONAL	1

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A. Tags Relating to GPS

GPSVersionID

Indicates the version of *GPSInfoIFD*. The version is given as 2.0.0.0. This tag is mandatory when *GPSInfo* tag is present. (Note: The *GPSVersionID* tag is given in bytes, unlike the *ExifVersion* tag. When the version is 2.0.0.0, the tag value is 02000000.H.)

Tag = 0 (0.H)
Type = BYTE
Count = 4
Default = 2.0.0.0
2.0.0.0 = Version 2.0
Other = reserved

GPSLatitudeRef

Indicates whether the latitude is north or south latitude. The ASCII value 'N' indicates north latitude, and 'S' is south latitude.

Tag = 1 (1.H)
Type = ASCII
Count = 2
Default = none
'N' = North latitude
'S' = South latitude
Other = reserved

GPSLatitude

Indicates the latitude. The latitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. When degrees, minutes and seconds are expressed, the format is dd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format is dd/1,mmmm/100,0/1.

Tag = 2 (2.H)
Type = RATIONAL
Count = 3
Default = none

GPSLongitudeRef

Indicates whether the longitude is east or west longitude. ASCII 'E' indicates east longitude, and 'W' is west

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longitude.

Tag = 3 (3.H)

Type = ASCII

Count = 2

Default = none

'E' = East longitude

'W' = West longitude

Other = reserved

GPSLongitude

Indicates the longitude. The longitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. When degrees, minutes and seconds are expressed, the format is ddd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format is ddd/1,mmmm/100,0/1.

Tag = 4 (4.H)

Type = RATIONAL

Count = 3

Default = none

GPSAltitudeRef

Indicates the altitude used as the reference altitude. In this version the reference altitude is sea level, so this tag must be set to 0. The reference unit is meters. Note that this tag is BYTE type, unlike other reference tags.

Tag = 5 (5.H)

Type = BYTE

Count = 1

Default = 0

0 = Sea level

Other = reserved

GPSAltitude

Indicates the altitude based on the reference in *GPSAltitudeRef*. Altitude is expressed as one RATIONAL value. The reference unit is meters.

Tag = 6 (6.H)

Type = RATIONAL

Count = 1

Default = none

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GPSTimeStamp

Indicates the time as UTC (Coordinated Universal Time). TimeStamp is expressed as three RATIONAL values giving the hour, minute, and second.

Tag = 7 (7.H)
Type = RATIONAL
Count = 3
Default = none

GPSSatellites

Indicates the GPS satellites used for measurements. This tag can be used to describe the number of satellites, their ID number, angle of elevation, azimuth, SNR and other information in ASCII notation. The format is not specified. If the GPS receiver is incapable of taking measurements, value of the tag must be set to NULL.

Tag = 8 (8.H)
Type = ASCII
Count = Any
Default = none

GPSStatus

Indicates the status of the GPS receiver when the image is recorded. 'A' means measurement is in progress, and 'V' means the measurement is Interoperability.

Tag = 9 (9.H)
Type = ASCII
Count = 2
Default = none
'A' = Measurement in progress
'V' = Measurement Interoperability
Other = reserved

GPSMeasureMode

Indicates the GPS measurement mode. '2' means two-dimensional measurement and '3' means three-dimensional measurement is in progress.

Tag = 10 (A.H)
Type = ASCII
Count = 2
Default = none
'2' = 2-dimensional measurement
'3' = 3-dimensional measurement

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Other = reserved

GPSDOP

Indicates the GPS DOP (data degree of precision). An HDOP value is written during two-dimensional measurement, and PDOP during three-dimensional measurement.

Tag = 11 (B.H)

Type = RATIONAL

Count = 1

Default = none

GPSSpeedRef

Indicates the unit used to express the GPS receiver speed of movement. 'K' 'M' and 'N' represents kilometers per hour, miles per hour, and knots.

Tag = 12 (C.H)

Type = ASCII

Count = 2

Default = 'K'

'K' = Kilometers per hour

'M' = Miles per hour

'N' = Knots

Other = reserved

GPSSpeed

Indicates the speed of GPS receiver movement.

Tag = 13 (D.H)

Type = RATIONAL

Count = 1

Default = none

GPSTrackRef

Indicates the reference for giving the direction of GPS receiver movement. 'T' denotes true direction and 'M' is magnetic direction.

Tag = 14 (E.H)

Type = ASCII

Count = 2

Default = 'T'

'T' = True direction

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'M' = Magnetic direction

Other = reserved

GPSTrack

Indicates the direction of GPS receiver movement. The range of values is from 0.00 to 359.99.

Tag = 15 (F.H)

Type = RATIONAL

Count = 1

Default = none

GPSImgDirectionRef

Indicates the reference for giving the direction of the image when it is captured. 'T' denotes true direction and 'M' is magnetic direction.

Tag = 16 (10.H)

Type = ASCII

Count = 2

Default = 'T'

'T' = True direction

'M' = Magnetic direction

Other = reserved

GPSImgDirection

Indicates the direction of the image when it was captured. The range of values is from 0.00 to 359.99.

Tag = 17 (11.H)

Type = RATIONAL

Count = 1

Default = none

GPSMapDatum

Indicates the geodetic survey data used by the GPS receiver. If the survey data is restricted to Japan, the value of this tag is 'TOKYO' or 'WGS-84'. If a *GPS Info* tag is recorded, it is strongly recommended that this tag be recorded.

Tag = 18 (12.H)

Type = ASCII

Count = Any

Default = none

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GPSDestLatitudeRef

Indicates whether the latitude of the destination point is north or south latitude. The ASCII value 'N' indicates north latitude, and 'S' is south latitude.

Tag = 19 (13.H)

Type = ASCII

Count = 2

Default = none

'N' = North latitude

'S' = Sourth latitude

Other = reserved

GPSDestLatitude

Indicates the latitude of the destination point. The latitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. When degrees, minutes and seconds are expressed, the format is dd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format is dd/1,mmmm/100,0/1.

Tag = 20 (14.H)

Type = RATIONAL

Count = 3

Default = none

GPSDestLongitudeRef

Indicates whether the longitude of the destination point is east or west longitude. ASCII 'E' indicates east longitude, and 'W' is west longitude.

Tag = 21 (15.H)

Type = ASCII

Count = 2

Default = none

'E' = East longitude

'W' = West longitude

Other = reserved

GPSDestLongitude

Indicates the longitude of the destination point. The longitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. When degrees, minutes and seconds are expressed, the format is ddd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format is ddd/1,mmmm/100,0/1.

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Tag = 22 (16.H)

Type = RATIONAL

Count = 3

Default = none

GPSDestBearingRef

Indicates the reference used for giving the bearing to the destination point. 'T' denotes true direction and 'M' is magnetic direction.

Tag = 23 (17.H)

Type = ASCII

Count = 2

Default = 'T'

'T' = True direction

'M' = Magnetic direction

Other = reserved

GPSDestBearing

Indicates the bearing to the destination point. The range of values is from 0.00 to 359.99.

Tag = 24 (18.H)

Type = RATIONAL

Count = 1

Default = none

GPSDestDistanceRef

Indicates the unit used to express the distance to the destination point. 'K', 'M' and 'N' represent kilometers, miles and knots.

Tag = 25 (19.H)

Type = ASCII

Count = 2

Default = 'K'

'K' = Kilometers

'M' = Miles

'N' = Knots

Other = reserved

GPSDestDistance

Indicates the distance to the destination point.

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Tag = 26 (1A.H)

Type = RATIONAL

Count = 1

Default = none

Note: When the tag Type is ASCII, it must be terminated with NULL.

It must be noted carefully that since the value count includes the terminator NULL, the total count is the number of data+1. For example, *GPSLatitudeRef* cannot have any values other than Type ASCII 'N' or 'S'; but because the terminator NULL is added, the value of N is 2.

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2.6.7. Interoperability IFD Attribute Information

The attached information(field name, code) stored in Interoperability IFD is listed in Table 12-2 and the meaning will be explained also.

Table 13 Interoperability IFD Attribute Information

Tag Name	Field Name	Tag ID		Type	Count
		Dec	Hex		
A. Attached Information Related to Interoperability					
Interoperability Identification	Interoperability Index	0	0	ASCII	Any

A. Tags Relating to Interoperability

The rules for Exif image files defines the description of the following tag only. Other tags stored in Interoperability IFD may be defined dependently to each Interoperability rule.

Interoperability Index

Indicates the identification of the Interoperability rule.

Use “R98” for stating ExifR98 Rules. Four bytes used including the termination code(NULL). See the separate volume of Recommended Exif Interoperability Rules (ExifR98) for other tags used for ExifR98.

Tag = 1 1.H

Type = ASCII

Count = Any

Default = none

"R98" = Recommended Exif Interoperability Rules (ExifR98)

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2.6.8. Tag Support Levels

The tags and their support levels are given here.

A. Primary Image (0th IFD) Support Levels

The support levels of primary image (0th IFD) tags are given in Table 14, Table 15, Table 16 and Table 17.

Table 14 Tag Support Levels (1) - 0th IFD TIFF Tags -

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
Image width	ImageWidth	256	100	M	M	M	J
Image height	ImageLength	257	101	M	M	M	J
Number of bits per component	BitsPerSample	258	102	M	M	M	J
Compression scheme	Compression	259	103	M	M	M	J
Pixel composition	PhotometricInterpretation	262	106	M	M	M	J
Image title	ImageDescription	270	10E	R	R	R	R
Manufacturer of image input equipment	Make	271	10F	R	R	R	R
Model of image input equipment	Model	272	110	R	R	R	R
Image data location	StripOffsets	273	111	M	M	M	N
Orientation of image	Orientation	274	112	R	R	R	R
Number of components	SamplesPerPixel	277	115	M	M	M	J
Number of rows per strip	RowsPerStrip	278	116	M	M	M	N
Bytes per compressed strip	StripByteCounts	279	117	M	M	M	N
Image resolution in width direction	XResolution	282	11A	M	M	M	M
Image resolution in height direction	YResolution	283	11B	M	M	M	M
Image data arrangement	PlanarConfiguration	284	11C	O	M	O	J
Unit of X and Y resolution	ResolutionUnit	296	128	M	M	M	M
Transfer function	TransferFunction	301	12D	R	R	R	R
Software used	Software	305	131	O	O	O	O
File change date and time	DateTime	306	132	R	R	R	R
Person who created the image	Artist	315	13B	O	O	O	O
White point chromaticity	WhitePoint	318	13E	O	O	O	O
Chromaticities of primaries	PrimaryChromaticities	319	13F	O	O	O	O
Offset to JPEG SOI	JPEGInterchangeFormat	513	201	N	N	N	N
Bytes of JPEG data	JPEGInterchangeFormatLength	514	202	N	N	N	N
Color space transformation matrix coefficients	YCbCrCoefficients	529	211	N	N	O	O
Subsampling ratio of Y to C	YCbCrSubSampling	530	212	N	N	M	J
Y and C positioning	YCbCrPositioning	531	213	N	N	M	M
Pair of black and white reference values	ReferenceBlackWhite	532	214	O	O	O	O
Copyright holder	Copyright	33432	8298	O	O	O	O
Exif tag	Exif IFD Pointer	34665	8769	M	M	M	M
GPS tag	GPSInfo IFD Pointer	34853	8825	O	O	O	O

Notation
M : Mandatory (must be recorded)
R : Conditionally mandatory (must be recorded if hardware permits)
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

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Table 15 Tag Support Levels (2) - 0th IFD Exif Private Tags –

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
Exposure time	ExposureTime	33434	829A	O	O	O	O
F number	FNumber	33437	829D	O	O	O	O
Exposure program	ExposureProgram	34850	8822	O	O	O	O
Spectral sensitivity	SpectralSensitivity	34852	8824	O	O	O	O
ISO speed ratings	ISOSpeedRatings	34855	8827	O	O	O	O
Optoelectric coefficient	OECF	34856	8828	O	O	O	O
Exif Version	ExifVersion	36864	9000	M	M	M	M
Date and time original image was generated	DateTimeOriginal	36867	9003	O	O	O	O
Date and time image was made digital data	DateTimeDigitized	36868	9004	O	O	O	O
Meaning of each component	ComponentsConfiguration	37121	9101	N	N	N	M
Image compression mode	CompressedBitsPerPixel	37122	9102	N	N	N	O
Shutter speed	ShutterSpeedValue	37377	9201	O	O	O	O
Aperture	ApertureValue	37378	9202	O	O	O	O
Brightness	BrightnessValue	37379	9203	O	O	O	O
Exposure bias	ExposureBiasValue	37380	9204	O	O	O	O
Maximum lens aperture	MaxApertureValue	37381	9205	O	O	O	O
Subject distance	SubjectDistance	37382	9206	O	O	O	O
Metering mode	MeteringMode	37383	9207	O	O	O	O
Light source	LightSource	37384	9208	O	O	O	O
Flash	Flash	37385	9209	O	O	O	O
Lens focal length	FocalLength	37386	920A	O	O	O	O
Manufacturer notes	MakerNote	37500	927C	O	O	O	O
User comments	UserComment	37510	9286	O	O	O	O
DateTime subseconds	SubSecTime	37520	9290	O	O	O	O
DateTimeOriginal subseconds	SubSecTimeOriginal	37521	9291	O	O	O	O
DateTimeDigitized subseconds	SubSecTimeDigitized	37522	9292	O	O	O	O
Supported FlashPix version	FlashPixVersion	40960	A000	M	M	M	M
Color space information	ColorSpace	40961	A001	M	M	M	M
Valid image width	PixelXDimension	40962	A002	N	N	N	M
Valid image height	PixelYDimension	40963	A003	N	N	N	M
Related audio file	RelatedSoundFile	40964	A004	O	O	O	O
Interoperability tag	Interoperability IFD Pointer	40965	A005	N	N	N	O
Flash energy	FlashEnergy	41483	A20B	O	O	O	O
Spatial frequency response	SpatialFrequencyResponse	41484	A20C	O	O	O	O
Focal plane X resolution	FocalPlaneXResolution	41486	A20E	O	O	O	O
Focal plane Y resolution	FocalPlaneYResolution	41487	A20F	O	O	O	O
Focal plane resolution unit	FocalPlaneResolutionUnit	41488	A210	O	O	O	O
Subject location	SubjectLocation	41492	A214	O	O	O	O
Exposure index	ExposureIndex	41493	A215	O	O	O	O
Sensing method	SensingMethod	41495	A217	O	O	O	O
File source	FileSource	41728	A300	O	O	O	O
Scene type	SceneType	41729	A301	O	O	O	O
CFA pattern	CFAPattern	41730	A302	O	O	O	O

Notation
M : Mandatory (must be recorded)
R : Conditionally mandatory (must be recorded if hardware permits)
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

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Table 16 Tag Support Levels (3) - 0th IFD GPS Info Tags -

Tag Name	Field Name	Tag ID		Uncompressed			Comp-ressed
		Dec	Hex	Chunky	Planar	YCC	
GPS tag version	GPSVersionID	0	0	O	O	O	O
North or South Latitude	GPSLatitudeRef	1	1	O	O	O	O
Latitude	GPSLatitude	2	2	O	O	O	O
East or West Longitude	GPSLongitudeRef	3	3	O	O	O	O
Longitude	GPSLongitude	4	4	O	O	O	O
Altitude reference	GPSAltitudeRef	5	5	O	O	O	O
Altitude	GPSAltitude	6	6	O	O	O	O
GPS time (atomic clock)	GPSTimeStamp	7	7	O	O	O	O
GPS satellites used for measurement	GPSSatellites	8	8	O	O	O	O
GPS receiver status	GPSStatus	9	9	O	O	O	O
GPS measurement mode	GPSMeasureMode	10	A	O	O	O	O
Measurement precision	GPSDOP	11	B	O	O	O	O
Speed unit	GPSSpeedRef	12	C	O	O	O	O
Speed of GPS receiver	GPSSpeed	13	D	O	O	O	O
Reference for direction of movement	GPSTrackRef	14	E	O	O	O	O
Direction of movement	GPSTrack	15	F	O	O	O	O
Reference for direction of image	GPSImgDirectionRef	16	10	O	O	O	O
Direction of image	GPSImgDirection	17	11	O	O	O	O
Geodetic survey data used	GPSMapDatum	18	12	O	O	O	O
Reference for latitude of destination	GPSDestLatitudeRef	19	13	O	O	O	O
Latitude of destination	GPSDestLatitude	20	14	O	O	O	O
Reference for longitude of destination	GPSDestLongitudeRef	21	15	O	O	O	O
Longitude of destination	GPSDestLongitude	22	16	O	O	O	O
Reference for bearing of destination	GPSDestBearingRef	23	17	O	O	O	O
Bearing of destination	GPSDestBearing	24	18	O	O	O	O
Reference for distance to destination	GPSDestDistanceRef	25	19	O	O	O	O
Distance to destination	GPSDestDistance	26	1A	O	O	O	O

Table 17 Tag Support Levels (4) - 0th IFD Interoperability Tag -

Tag Name Field Name		Tag ID		Uncompressed			Comp-ressed
		Dec	Hex	Chunky	Planar	YCC	
Interoperability Identification	Interoperability Index	0	0	N	N	N	O

Notation
M : Mandatory (must be recorded)
R : Conditionally mandatory (must be recorded if hardware permits)
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

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B. Thumbnail (1st IFD) Support Levels

The support levels of thumbnail (1st IFD) tags are shown in Table 18.

Table 18 Tag Support Levels (5) - 1st IFD TIFF Tag -

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2.7. JPEG Marker Segments Used in Exif

In addition to the compressed data (Interoperability coded data), a compressed file contains one each of the marker segments APP1, DQT, DHT, SOF and SOS. The compressed data begins with an SOI and ends with an EOI marker. A restart marker (DRI, RSTm) can be inserted optionally. Another option is to have two or more APP2 marker segments. APPn other than APP1 and APP2 or COM segments are not used by Exif. However Exif readers should be designed skip over unknown APPn and COM.

APP1 must be recorded immediately after SOI, and if there is an APP2 it follows after APP1. DQT, DHT, DRI and SOF come after APP2 and before SOS, in any order.

The marker segments used in Exif are listed in Table 19.

Table 19 Marker Segments

	Marker Name	Marker Code	Description
SOI	Start of Image	FFD8.H	Start of compressed data
APP1	Application Segment 1	FFE1.H	Exif attribute information
APP2	Application Segment 2	FFE2.H	Exif extended data
DQT	Define Quantization Table	FFDB.H	Quantization table definition
DHT	Define Huffman Table	FFC4.H	Huffman table definition
DRI	Define Restart Interoperability	FFDD.H	Restart Interoperability definition
SOF	Start of Frame	FFC0.H	Parameter data relating to frame
SOS	Start of Scan	FFDA.H	Parameters relating to components
EOI	End of Image	FFD9.H	End of compressed data

The data structures of markers defined in JPEG Baseline DCT and used in Exif compressed files, as well as the APP1 and APP2 data structures defined specifically for this standard, are explained below.

2.7.1. JPEG Marker Segments

The data structure of JPEG marker segments other than APP1 and APP2 is noted below.

A. Start of compressed data (SOI: Start of Image)

SOI is a marker code indicating the start of compressed data (see Fig. 15).

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	D8	SOI

Fig. 15 SOI Structure

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B. Quantization table definition (DQT: Define Quantization Table)

DQT is a marker code defining a quantization table.

As many as three kinds of tables can be recorded with a precision of 8 bits (Pq=0). All quantization tables must be defined in one DQT marker segment; recording of multiple DQT markers is not allowed. The table may have any values (see Fig. 16). DQT, DHT, DRI and SOF may line up in any order, but must be recorded after APP1 (or APP2 if any) and before SOS.

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	DB	DQT
+02	00	Length of field
	C5	2+(1+64)*3=197 (Bytes)
+04	00	Y: Pq=0, Nq=0
+05	:	Quantization table Y:Q0
	:	:
	:	:
	:	Quantization table Y:Q63
+45	01	Cb: Pq=0, Nq=1
+46	:	Quantization table Cb:Q0
	:	:
	:	:
	:	Quantization table Cb:Q63
+86	02	Cr: Pq=0, Nq=1
+87	:	Quantization table Cr:Q0
	:	:
	:	:
	:	Quantization table Cr:Q63

Fig. 16 DQT Structure (with three quantization tables)

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C. Huffman table definition (DHT: Define Huffman Table)

DHT is a marker code defining a Huffman table.

In this standard a single component shall have a Huffman table consisting of a set of DC and AC, and each component must be mapped to one or another of the Huffman tables defined by DHT. All Huffman tables must be recorded in one DHT marker segment; recording of multiple DHT markers is not allowed. A Huffman table may have any values, or the JPEG reference values may be used as the base table (see Fig. 17).

DQT, DHT, DRI and SOF may line up in any order, but must be recorded after APP1 (or APP2 if any) and before SOS.

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	C4	DHT
+02	01 A2	Length of field 2+(1+16+12+1+16+162)*2 = 418 Bytes
+04	00	Table number Y-DC : 00
+05	: : :	DHT parameter
+21	10	Table number Y-AC : 10
+22	: : :	DHT parameter
+D4	01	Table number C-DC : 01
+D5	: : :	DHT parameter
+F1	11	Table number C-AC : 11
+F2	: : :	DHT parameter

Fig. 17 DHT Structure

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D. Restart Interoperability definition (DRI: Define Restart Interoperability)

DRI is a marker defining the Interoperability at which restart markers are inserted (see Fig. 18). The recording of DRI and insertion of restart markers are optional. If restart markers are inserted, DRI shall be recorded and its values shall be 4 MCU (Minimum Coding Unit), i.e., 64 pixel units, regardless of whether 4:2:2 or 4:2:0 is used for color sampling (see Appendix F). Only one DRI shall be recorded.

DQT, DHT, DRI and SOF may line up in any order, but must be recorded after APP1 (or APP2 if any) and before SOS.

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+00	DD	DRI
+02	00	Length of field
		2+2 = 4 (Bytes)
+04	XX	00
	YY	04

Fig. 18 DRI Structure

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E. Frame header (SOF: Start of Frame)

SOF is a marker code indicating the start of a frame segment and giving various parameters for that frame (see Fig. 19).

DQT, DHT, DRI and SOF may line up in any order, but must be recorded after APP1 (or APP2 if any) and before SOS.

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+00	C0	SOF
+02	00 11	Length of field 2+1+2+2+1+2*3 = 17 (Bytes)
+04	08	Data precision (bits)
+05	XX YY	Vertical lines XXYY (Hex) lines
+07	WW ZZ	Horizontal lines WWZZ (Hex) pixels
+09	03	Components
+0A	01	Component number (1:Y)
+0B	21or22	H0 = 2, V0 = 1(4:2:2) or 2(4:2:0)
+0C	00	Quantization designation
+0D	02	Component number (2:Cb)
+0E	11	H1 =1, V1 = 1
+0F	01	Quantization designation
+10	03	Component number (3:Cr)
+11	11	H2 =1, V2 = 1
+12	02	Quantization designation

Fig. 19 SOF Structure

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F. Scan header (SOS: Start of Scan)

SOS is a marker code giving various scan-related parameters (see Fig. 20).

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+00	DA	SOS
+02	00	Length of field
	0C	2+1+3*2+3 = 12 (Bytes)
+04	03	Components in scan
+05	01	Component selector Y : 01
+06	00	Huffman table selector Y : 00
+07	02	Component selector Cb : 02
+08	11	Huffman table selector C : 11
+09	03	Component selector Cr : 03
+0A	11	Huffman table selector C : 11
+0B	00	Scan start position in block
+0C	3F	Scan end position in block
+0D	00	Successive approximation Bit position

Fig. 20 SOS Structure

G. Compressed data

Compressed data is byte data block Interoperability at the required ratio of Y:Cb:Cr and Huffman encoded. An EOB (End of Block) is inserted in each block when the last value of its DCT coefficient is 0. If restart marker insertion is defined in DRI, restart markers are inserted at 4 MCU Interoperability.

H. End of compressed data (EOI : End of Image)

EOI is a marker code indicating the end of Interoperability coded data, and is paired with SOI (see Fig. 21). No specification is made regarding data arrays that come after EOI.

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	D9	EOI

Fig. 21 EOI Structure

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2.7.2. Interoperability Structure of APP1 in Compressed Data

APP1 consists of an APP1 marker indicating that it is an application area, a length code indicating its size, and primary image attribute information patterned after the TIFF structure. The APP1 segment cannot record more than 64 Kbytes, a limitation that must be kept in mind when recording thumbnail images.

APP1 also records attribute information for JPEG compressed images. The features of this marker segment are described below.

A. Order of APP1 recording

APP1 is recorded immediately after the SOI marker indicating the start of the file (see Fig. 6).

B. APP1 Interoperability structure

APP1 consists of an APP1 marker, Exif ID code and the attribute information itself (see Fig. 22).

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	E1	APP1
+02		Length of field
+04	45	'E'
+05	78	'x'
+06	69	'i'
+07	66	'f'
+08	00	NULL
+09	00	Padding
+0A		Attribute information

Fig. 22 Basic Structure of APP1 Marker Segment

C. Exif ID code

The Exif ID code indicates that the APP1 segment Interoperability is Exif format. After a 4-byte code, 00.H is recorded in 2 bytes. The reason for recording this code is to avoid duplication with other applications making use of JPEG application marker segments (APPn).

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D. Attribute information

Attribute information is recorded in 2 IFDs (0th IFD, 1st IFD) following the TIFF structure, including the File Header. The 0th IFD records compressed image attributes (the image itself). The 1st IFD can be used for thumbnail images.

E. TIFF header

The TIFF header in APP1 constitutes 8 bytes of data, including the byte order and the Offset of IFD indicating the first IFD. The Offset is referenced to the address of the first byte of the Byte Order. For example, the Offset of IFD address in the TIFF Header is 4 (see Table 1).

F. Relation to JPEG marker segments

Attribute information is recorded in essentially the same format as that used to record uncompressed data attribute information. In order to avoid duplication, however, attribute information recorded in a JPEG marker segment is not recorded in APP1.

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2.7.3. Interoperability Structure of APP2 in Compressed Data

APP2 consists of an APP2 marker indicating that it is an application area, a length code indicating its size, and FlashPix (see Appendix F) extensions. If there is no need to record extensions, this marker segment can be omitted.

There are two kinds of APP2 marker segments for recording FlashPix extensions.

One is a Contents List Segment recording a storage and stream list making up the extended data. One file contains only one contents list segment.

The second is a Stream Data Segment storing the data for each of the streams listed in the Contents List Segment. If necessary, there can be two or more APP2 marker segments for storing stream data.

In addition there is an APP2 segment reserved for FlashPix use, which is specified in the FlashPix standard.

The contents of data that can be recorded as stream data is left for future specification. It may include one or more Audio data.

A. Order of APP2 recording.

APP2 segments follow after the APP1 segment, in the order of Contents List Segment and Stream Data Segments. If there are two or more stream data segments, their order is as given in the contents list (see Fig. 6).

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B. APP2 Interoperability structure

APP2 consists of an APP2 marker, ID code (FPXR), and Contents List or Stream Data (see Fig. 23).

Address Offset (Hex)	Code (Hex)	Meaning
+00	FF	Marker Prefix
+01	E2	APP2
+02		Length of field
+04	46	'F'
+05	50	'P'
+06	58	'X'
+07	52	'R'
+08	00	NULL
+09	00	Version
+0A		Contents List or Stream Data

Fig. 23 Basic Structure of APP2 Marker Segment

C. FPXR ID code

The FPXR ID code indicates that the APP2 segment contains FPXR data. It is a 4-byte code followed by 00.H recorded in 1 byte. The reason for recording this code is to avoid duplication with other applications making use of JPEG application marker segments (APPn). The subsequent byte gives the version number (00.H).

D. Contents list structure

The contents list segment lists the storages and streams to be created when the file is converted to a FlashPix image file. The first two bytes give the number of Interoperability.

The Interoperability fields on the contents list are as follows.

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Entity size

Indicates the size of the stream, or else FFFFFFFF.H (in the case of a storage). It is recorded in big endian format.

Default value

A fixed value not set explicitly in the stream data segment but used as the default for each byte.

Storage / Stream name

The name of the storage and stream added for transformation to FlashPix. It is given as the full path name from the FlashPix source image object root storage. "/" represents a directory separator and must be the first character of the property value. This name is a 16-bit character string from the Unicode code page, with NULL termination. It is recorded in little endian format.

Entity class ID

The storage ClassID, given only in the case of a storage Interoperability. It is written as 16-bytes in little endian format.

The data structure of the Contents List Segment is given in Fig. 24.

Address Offset (Hex)	Bytes (Hex)	Code (Hex)	Meaning
+00	1	FF	Marker Prefix
+01	1	E2	APP2
+02	2		Length of field
+04	4		"FPXR"
+08	1	00	NULL
+09	1	00	Version
+0A	1	01	Contents List
+0B	2		Interoperability Count
+0C	4		Entity size 1
+11	1		Default value 0
+12	m_0		Storage or Stream name 0
+12+m_0	(n_0)		(Entity Class ID 0)
+12+m_0+n_0	4		Entity size 1
:	1		Default value 1
:	m_1		Storage or Stream name 1
:	(n_1)		(Entity Class ID 1)
:	:	:	:
:	:	:	:
:	4		Entity size l
:	1		Default value l
:	m_l		Storage or Stream name l
:	(n_l)		(Entity Class ID l)

Fig. 24 Contents List Segment Structure

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E. Stream Data Segment structure

A stream data segment records part or all of the stream listed in the contents list segment. Because of the 64-Kbyte size limit of a JPEG marker segment, a stream longer than this must be recorded in two or more stream data segments. Instead of writing stream data directly in multiple stream data segments, the segments may be filled based on a fixed default. A stream data segment contains the following data.

Index into Contents Lists

The order of Interoperability recorded in a contents list segment starting from 0.

Offset into the full FlashPix stream

The offset to the first byte of stream data in the FlashPix stream.

Stream Data

The actual data stream recorded as extended data in the transformation to FlashPix. The length of this data is indicated by the length code in the stream data segment.

The data structure of a Stream Data Segment is given in Fig. 25.

Address Offset (Hex)	Bytes (Hex)	Code (Hex)	Meaning
+00	1	FF	Marker Prefix
+01	1	E2	APP2
+02	2		Length of field
+04	4		"FPXR"
+08	1	00	NULL
+09	1	00	Version
+0A	1	02	Stream Data
+0B	2	N	Index to Contents List
+0C	4	(Offset)	Offset to FlashPix stream
+11	Variable	(value)	Stream Data

Fig. 25 Stream Data Segment Structure

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F. Reserved Segment (*Reserved for future use by the FlashPix format)*

This marker segment is reserved for future use. An example is given in Fig. 26.

Address Offset (Hex)	Bytes (Hex)	Code (Hex)	Meaning
+00	1	FF	Marker Prefix
+01	1	E2	APP2
+02	2		Length of field
+04	4		"FPXR"
+08	1	00	NULL
+09	1	00	Version
+0A	1	03	Reserved for FlashPix
+0B	: :	: :	

Fig. 26 Structure of Data Segment Reserved for FlashPix

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2.8. Data Description

2.8.1. Stipulations on Compressed Image Size

The JPEG format is adopted for compressed images. Since JPEG compresses images in blocks of 8 x 8 pixels, preferably the pixel number set as the width and height of the image should be exact multiples of the MCU (multiples of 16 for width, and multiples of 8 for height if Y:Cb:Cr = 4:2:2, or 16 if Y:Cb:Cr = 4:2:0). It is not required, however, that all image data be fit within this range.

If a restart marker is inserted every 4 MCU for the sake of transformation to FlashPix, the width of the image must be an exact multiple of 4 MCU (64 pixels). There is no such restriction on height.

Specifications on inserting data to adjust the recorded image size relative to the valid image size, or padding, are given below.

A. Image size recording procedure in the Exif writer

An Exif writer shall record a compressed image with the image width information and height information set in accord with the stipulations below, and padded as necessary.

When the image is padded in the direction of width, the padding data must be appended at the right edge. Padding in the direction of height must be appended at the bottom edge.

The data used for padding is not specified.

Stipulations on image width

Image width information consists of the valid image width tag (*PixelXDimension*), SOF marker information, and JPEG compressed data. Of these three, the recording of a valid image width tag is mandatory.

Image width is padded to the right in the following cases. The value used for padding is not specified.

- When the image width is not an exact multiple of 16 and the JPEG block has unused capacity to be filled.
- When the image width is not a multiple of 64 and the insufficiency must be made up in order to insert restart markers.

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The method of describing the various image width data with and without padding is given in Fig. 27. It must be noted carefully that the value of SOF is used in some cases to describe the valid image width, and in others to describe the image width after padding.

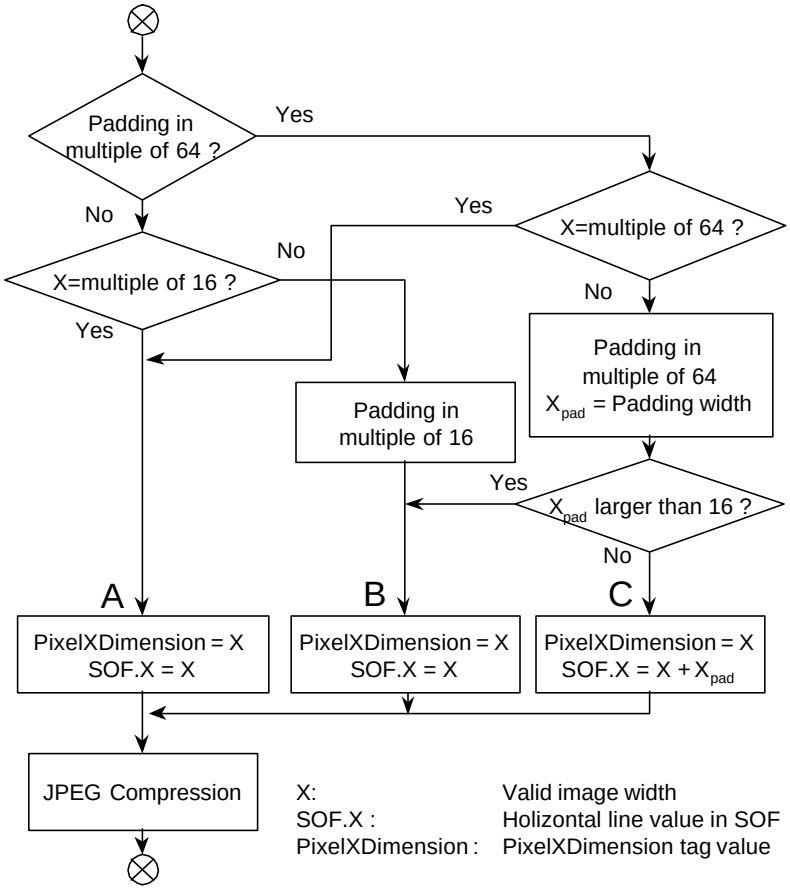


Fig. 27 Image Data Width Description

Table 20 gives examples of information recorded in the direction of image width and padding data width, for each of cases A, B, and C of Fig. 27.

Table 20 Typical Width Direction Information and Padding Data

	Valid Image Width	PixelXDimension	SOF Information	Compressed Data	Padding Width
A	640	640	640	640	0
B	634	634	634	640	6 (< 1MCU)
C	620	620	640	640	20 (> 1MCU)

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Stipulations on image height

Image height information consists of the valid image height tag (*PixelYDimension*), SOF marker information, and JPEG compressed data. Of these three, the recording of a valid image height tag is mandatory.

The image height is padded in the following case. The padding value is not specified.

- When the image height is not an exact multiple of 16 and the JPEG block has unused capacity to be filled.

Insertion of a restart marker does not require padding. The method of recording the various image height data with and without padding is given in Fig. 28. The SOF marker always has the same value as the effective image height tag.

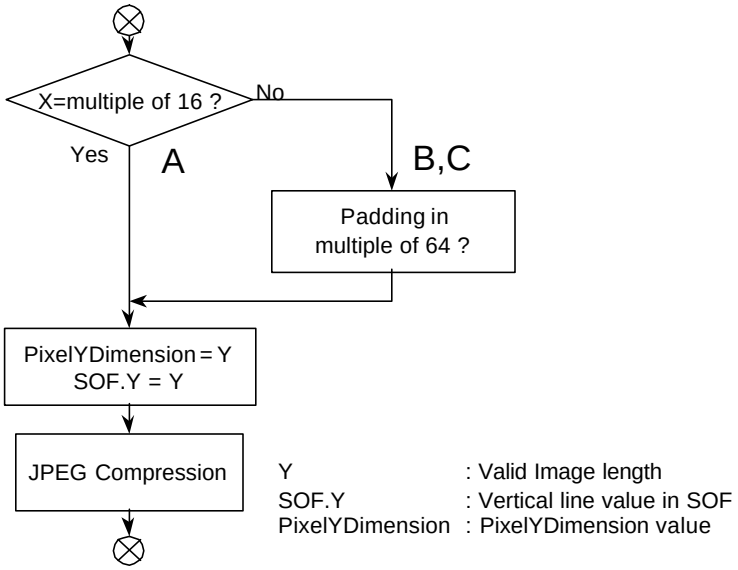


Fig. 28 Image Data Height Description

Table 21 gives examples of information recorded in the direction of image height and padding data height, for each of cases A, B, and C of Fig. 28.

Table 21 Typical Height Direction Information and Padding Data (when Y:Cb:Cr = 4:2:2)

	Valid Image Height	Valid Image Height Tag	SOF Information	Compressed Data	Padding Height
A	480	480	480	480	0
B	474	474	474	480	6 (< 1MCU)
C	460	460	460	464	4 (< 1MCU)

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B. Image size reproduction procedure in the Exif reader

It is recommended that the Exif reader (and in particular, dedicated software) follow the procedure shown in Fig. 29 for reproducing images. First it expands the image based on the SOF information. Next it trims the image on the right and lower edges in accord with information in the valid image width tag and height tag, and reproduces the valid image data. If the SOF information and the valid image width and height tag information are the same, trimming is unnecessary.

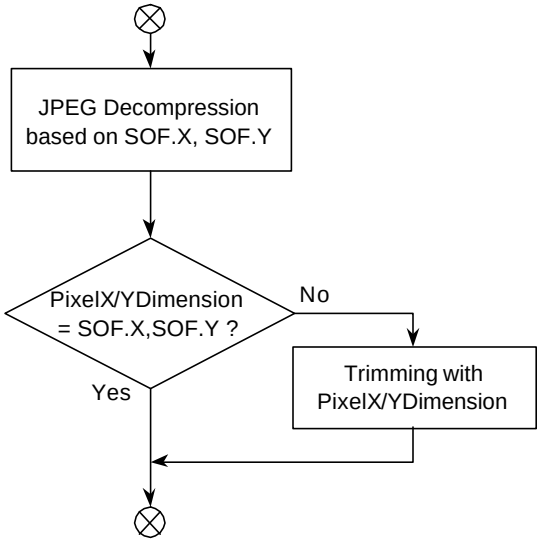


Fig. 29 Procedure for Image Data Reproduction

Some off-the-shelf software lacks a function for handling valid image width and height tags. If the valid image width differs from the number of horizontal pixels recorded in the SOF, padding data may be displayed. The padding data values should be chosen with this possibility in mind.

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2.8.2. Stipulations on Thumbnails

A. Exif writer

The recording of thumbnail images is an optional specification of the Exif reader. It is therefore allowable to have Exif files with and without thumbnails. For details see section 2.5.5.

B. Exif reader

This format is designed so that the primary image will be reproduced intact whether or not thumbnail images are recorded in the file. It is assumed that even when functions are provided for viewing images on the camera or player, for viewing the process of image transfer from camera to PC, or for using thumbnails as an index display in the camera software or other image software, there will still be cases where the file is viewed without thumbnails. The creation and displaying of thumbnails can therefore be performed or not at the discretion of the user.

2.8.3. File Name Stipulations

A. Exif writer

The file name and characters used for file names are not specified, other than to stipulate the use of ASCII alphanumerics. (File names in Japanese or other character sets are not to be used.) File names shall be 8 characters or fewer, not including the extension. (Long file names are not to be used.) The file name extensions are ".JPG" for compressed data files and ".TIF" for uncompressed data files.

2.8.4. Byte Order Stipulations

A. Exif Reader

It is recommended that the Exif reader be able to reproduce Exif files recorded in both little endian and big endian formats.

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3. Exif Audio File Specification

3.1. Outline of the Exif Audio File Specification

This chapter gives details of the audio file specification, covering the following items:

- Format version definition,
- Specifications relating to audio data,
- Basic structure of audio data,
- Chunks,
- File naming conventions.

3.2. Format Version

The version of the format specified here is recorded as 4 bytes (see section 3.6.3). The address bytes are recorded as A1, A2, B1, B2, starting with the lowest number. A1 and A2 store the upper part of the standard version, with the lower part stored in B1 and B2. When changes are made to the version number of this standard, the following rules apply:

- When the changes are such that data readers can properly recognize conventional information and skip the data that was recorded using newly added functions, the lower part of the version (B1, B2) is changed,
- When there is a possibility that a data reader implementing the old standard may operate incorrectly due to the new specifications, the upper part of the version (A1, A2) is changed.

Players should be able to play back files of versions earlier than the supported standard.

3.3. Definition of Terms

Terms and notation are used as follows in this standard:

- Text enclosed in " " is a character string, and " "Z means a character string ending in NULL (00.H),
- ".H" appended to a numerical value means it is hexadecimal notation.
- Unless otherwise indicated, other numerical values are given in decimal notation.

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3.4. Specifications Relating to Audio Data

3.4.1. Sampling Frequency

The sampling frequency shall be any of 8.000 kHz, 11.025 kHz, 22.050 kHz or 44.100 kHz. Only 8.000 kHz shall be used for μ–LAW PCM in accord with ITU-T G.711.

3.4.2. Bit Size

The bit size shall be 8 bits or 16 bits. Only 8 bits shall be used for μ-LAW PCM in accord with ITU-T G.711; and only 4 bits shall be used for IMA-ADPCM in accord with the IMA (Interoperability Multimedia Association) specification.

3.4.3. Channels

The number of channels is either monaural or stereo (2 ch).

3.4.4. Compression Schemes

The following three compressions schemes are specified here:

- Uncompressed audio data: PCM ,
- Uncompressed audio data: μ-Law PCM (conforming to ITU-T G.711 [viii]) ,
- Compressed data: IMA-ADPCM [ix] .

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3.5. Basic Structure of Audio Data

Exif audio files are based on the RIFF WAVE Form Audio File format [vii] adopted as a Windows™ standard audio file format, with the addition of various DSC attribute information as needed. Exif audio files are data-compatible with WAVE Form Audio files and can be played on accessories supplied with Windows™.

Of the general attribute information required by DSC applications, the common attributes are recorded on an *INFO list*, and the Exif-specific attributes are recorded in Exif chunks. The Exif chunks are provided to enable the addition of information as necessary, taking advantage of chunk extensibility. The method of recording data in the Exif-specific chunks is patterned after that for the *INFO list*.

3.5.1. Basic Structure of WAVE Form Audio Files

The WAVE Form Audio File format is based on the *RIFF (Resource Interoperability File Format)* tagged file structure.

A *RIFF* file consists of basic data blocks called chunks.

(1) *Chunk*

Using C language syntax, a chunk can be defined as a structure, like that in Equation 1. The chunk structure can also be expressed in graphical form as in Fig. 30.

```
typedef struct {
        unsigned long   ckID;           // 4-character code
        unsigned long   ckSize;         // Size of member <ckData>
        unsigned char   ckData[ckSize]; // The data in the chunk
} CK;       - - - [Equation 1]
```

Address Offset (Hex)	Meaning
+00	ckID (4 Bytes)
+04	ckSize (4 Bytes)
+08	ckData[ckSize]

Fig. 30 Chunk Structure

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Explanation

- *ckID* (chunk ID, a 4-character code) consists of from one to four ASCII alphanumerics, left-justified and filled with blank characters if less than four characters in length. Blanks cannot be inserted between characters. This four-character code identifies the contents of the chunk data, described later. Software processing the chunk is allowed to skip a chunk with an unknown chunk ID.

- *ckSize* (chunk Size) is a 32-bit unsigned integer giving the size (bytes) of the *ckData*[*ckSize*] (chunk Data). This size does not include padding bytes following the ckID, *ckSize* itself and *ckData*. The byte order is little endian (LSB first, MSB last). In the case of *RIFF* files, values of more than one byte are all written in little endian order. If two or more chunks follow in sequence, the value of chSize must be read properly in order to know the start address (ckID) of the next chunk.

- *ckData*[*ckSize*] (chunk Data) is the actual data included in that chunk, and may be recorded as binary data of either fixed length or variable length. The start of *ckData* is aligned with the *RIFF* file start position in word (16-bit) units. If the data size is an odd number of bytes, a padding byte with the value '0' is appended after the *ckData*. This padding byte is not included in the *ckSize* (chunk Size).

- *ckData*[*ckSize*] (chunk Data) can itself have a particular structure rather than being a simple byte array. That is, *ckData* itself can include a chunk (sub-chunk). In other words, chunks can be arranged hierarchically. Only certain chunks are allowed to contain sub-chunks. These are the *RIFF* chunk and *LIST* chunk described later below. Generally two or more sub-chunks may be contained in these chunks. All other chunks store only one binary data element in the *ckData*.

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(2) *RIFF Form*

A *"RIFF* form" is a chunk with "*RIFF*" as its chunk ID (ckID); it is also used to mean a file format with the *RIFF* structure (*RIFF* file).

A *"RIFF* chunk" *ckData* (chunk data) consists of a 4-character code at the beginning called the *formType* (form type), followed by a sub-chunk.

A *RIFF* chunk is at the top of the chunk hierarchy. A *RIFF* form must have this chunk, but can have only one. All other chunks are sub-chunks of the *RIFF* chunk.

A form type is generally a code identifying the data contents, among other things. It is also possible to tell from this code what kind of sub-chunk a chunk contains. A form type must be registered. A registered form type is written in all upper-case letters.

Along with a form type, a chunk ID (ckID) must also be registered. A chunk ID in all upper-case letters indicates a general-purpose chunk that can be used with various form types. A chunk ID used with a specific form type is written in all lower-case letters.

An illustration of the *RIFF* chunk is given in Fig. 31.

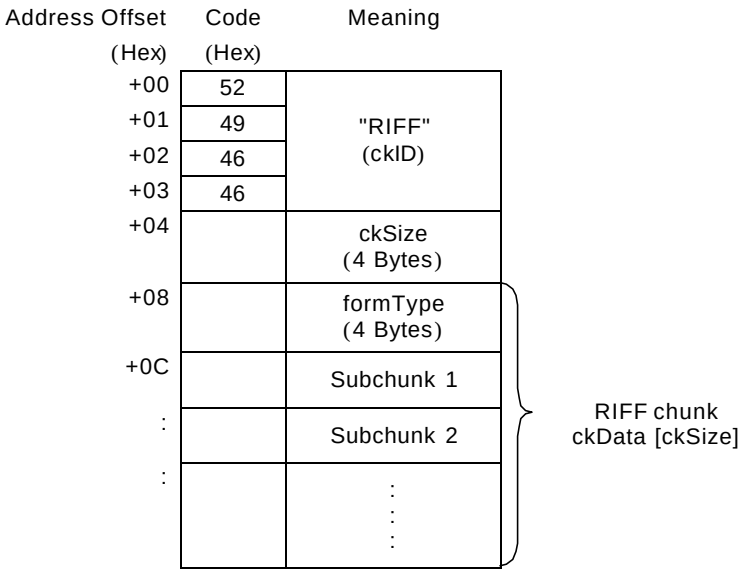


Fig. 31 RIFF Chunk Structure

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Note:

Representative form types are given in Table 22. These are written in all upper-case letters because they are registered form types.

Table 22 Representative Form Types

Form Type	Name
PAL	Palette file form
RDIB	RIFF DIB (Device Independent Bitmap) form
RMID	RIFF MIDI form
RMMP	RIFF multimedia movie form
WAVE	WAVE Form Audio File format

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(3) WAVE Form Audio File Format

The *WAVE* Form is one kind of *RIFF* form. It is a file for handling digitized sound data. The form type is *WAVE*, in upper-case letters.

The file extension for a *WAVE* Form Audio File is ".WAV".

The data structure of the *WAVE* Form Audio File format is shown in Fig. 32.

As is evident from Fig. 32, the chunk data (*ckData* [*ckSize*]) of a *RIFF* chunk generally consists of the *formType* ("*WAVE*"), *fmt-ck* (format chunk), *fact-ck* (fact chunk), and *data-ck* (data chunk). *fmt-ck* and *data-ck* are mandatory chunks, but *fact-ck* may be mandatory or not, depending on the format type (audio coding format) of the *WAVE* Form.

In addition to these, optional sub-chunks may be recorded and can store various attribute information. These optional sub-chunks are not shown in Fig. 32.

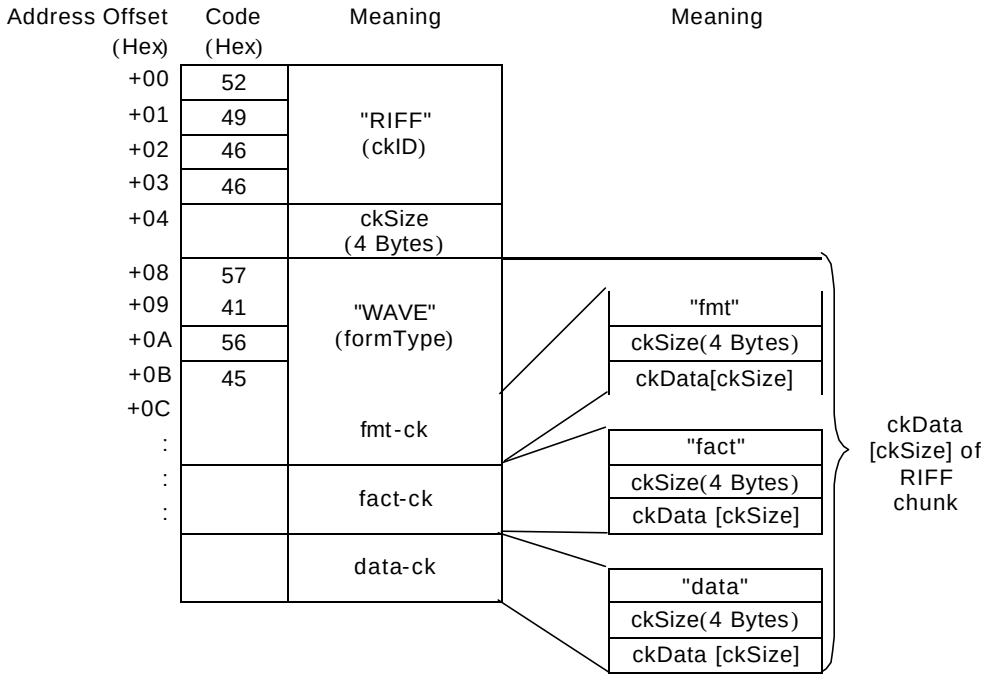


Fig. 32 Data Structure of the WAVE Form Audio File Format

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<fmt-ck>

fmt-ck (format chunk) contains format information designating the format of audio data included in the *data-ck* (data chunk) described later below. The *ckID* (chunk ID) of *fmt-ck* is "fmt."

"fmt " is 3 characters long, so a blank character (20.H) goes at the end.

fmt-ck is mandatory and must always be recorded before *data-ck*.

Since *fmt-ck* has the chunk structure, *ckSize* and *ckData*[*ckSize*] are included as its members; but the contents of the *ckData* depend on the format type (audio coding format). This *ckData* consists of the structure given in Equation 2, and the byte array given in Equation 3.

```
struct{
        unsigned  int     wFormatTag;         // Format type
        unsigned  int     nChannels;          // Number of channels
        unsigned long     nSamplesPerSec;     // Sampling rate
        unsignrd long     nAvgBytesPerSec;    // Average bytes per second
        unsigned  int     nBlockAlign;        // Block alignment
        unsigned  int     wBitsPerSample;     // Bits per sample
        unsigned  int     cbSize;             // Additional bytes
} WAVEFORMATEX;                                                    - - -[Equation 2]
unsigned  char    extByte[cbSize];            // Additional byte array    - - -[Equation 3]
```


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The meaning of each member of the format information is given in Table 23.

Table 23 Format Information Members

Member	Description
wFormatTag	An unsigned 16-bit integer indicating the format type (audio coding format) of the WAVE Form. Typical format types are given below. PCM (Pulse Code Modulation) format: 0001.H μ-Law format (ITU-T G.711): 0007.H IMA-ADPCM (DVI-ADPCM) format: 0011.H
nChannels	An unsigned 16-bit integer indicating the number of channels. Monaural is 1 and stereo is 2.
nSamplesPerSec	An unsigned 32-bit integer indicating the sampling rate (samples per second). Audio is played in each channel at this rate. In PCM format the common values of this member are 8.0kHz, 11.025kHz, 22.05kHz, and 44.1kHz.
nAvgBytesPerSec	An unsigned 32-bit integer indicating the average bytes per second, a value transferred to the data in data-ck. In PCM format, nAvgBytesPerSec is equivalent to the equation below. nChannels * wBitsPerSample/8
nBlockAlign	An unsigned 16-bit integer indicating the (byte unit) block alignment in data-ck. In PCM format, nBlockAlign is equivalent to the equation below. nChannels * wBitsPerSample/8
wBitsPerSample	An unsigned 16-bit integer indicating the bits per sample of each channel. In PCM format, this value is 8 or 16. In the case of compressed sound data, when this value cannot be defined it becomes '0'.
cbSize	An unsigned 16-bit integer indicating the size (in bytes) of the additional format information extByte[cbSize] appended after the WAVEFORMATEX structure. This information is used to store attributes added in non-PCM formats. If additional information is not needed, it becomes '0'. In PCM format, this member is not needed (the cbSize field itself is not necessary).
extByte[cbSize]	A byte array representing the additional format information appended after the WAVEFORMATEX structure. The meaning of this information depends on the format type. If the value of cbSize is 0, this field does not exist. In PCM format, both the cbSize field and extByte[cbSize] field are unnecessary.

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The *fmt-ck* structure can be illustrated as in Fig. 33.

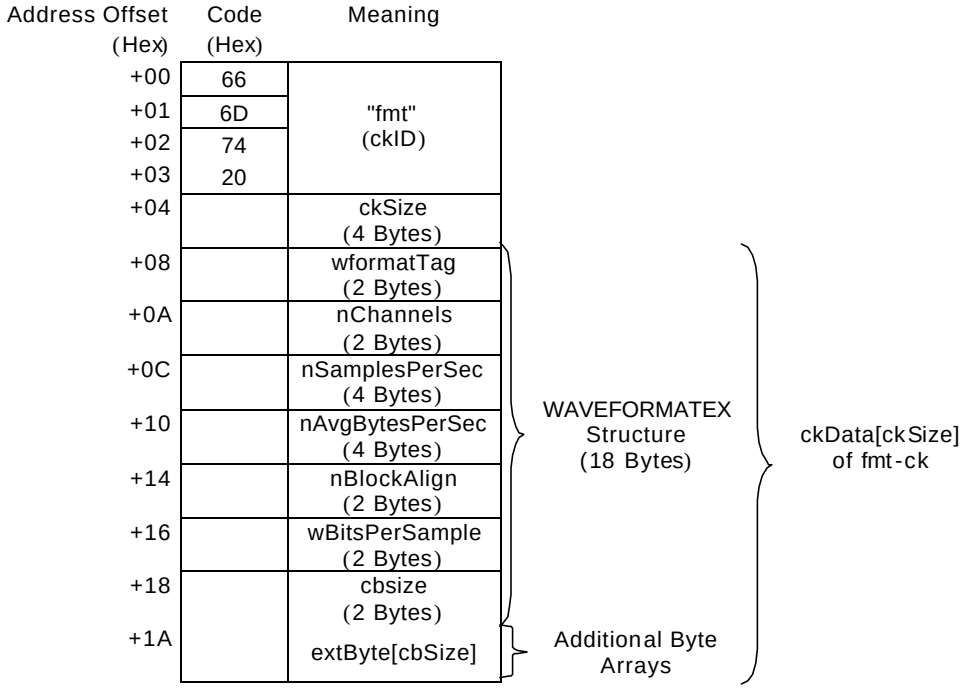


Fig. 33 fmt-ck Structure

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<fact-ck>

fact-ck (fact chunk) is used to store file-dependent information relating to the *WAVE* file contents. The *ckID* (chunk ID) of *fact-ck* is "fact".

It is assumed that *fact-ck* will be extended in the future to store information needed by *WAVE* files at that time, but currently only one information member is defined.

The information that can be stored in *fact-ck* at the present time is defined in [Equation 4].

```
unsigned long   dwSampleLength;              // Sample length - - - [Equation 4]
```

Table 24 fact-ck Member

Member	Description
dwSampleLength	An unsigned 32-bit integer indicating the number of audio data samples (sample length). When this information is combined with nSamplePerSec in fmt-ck, the data length can be expressed in seconds (recording time).

Since the only information defined presently is dwSampleLength, the value of *ckSize* (chunk Size) for *fact-ck* is '00000004.H'; but *ckSize* may change in the future as information is added (in which case it will be larger than '00000004.H'). Programs must be able to skip over fields they cannot Interoperability and go on to process the next chunk. For this reason the capability of correctly reading the value of *ckSize* is a necessary requirement.

The structure of *fact-ck* is illustrated in Fig. 34. The value of *ckSize* is fixed at '00000004.H' (this value is used in Write processing).

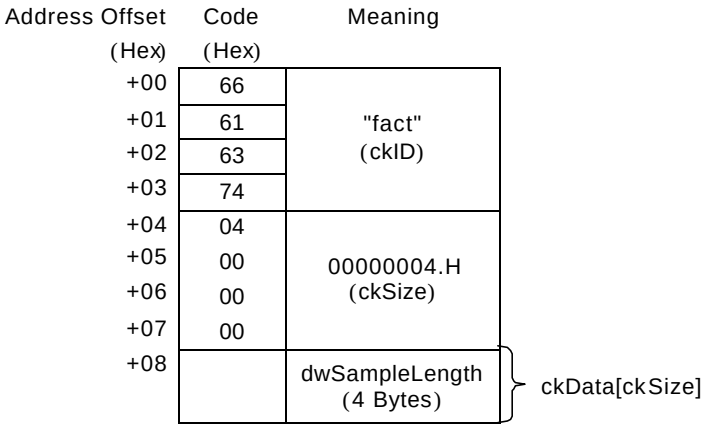


Fig. 34 fact-ck Structure

<data-ck>

data-ck (data chunk) is a chunk for storing audio data. Its *ckID* (chunk ID) is "data".

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The *ckData* (chunk Data) of *data-ck* consists of the audio data only. In some cases the chunk is filled out with padding bytes.

The audio data is coded based on the format type. The information in *fmt-ck* is used when the audio data is played back.

The *ckSize* (chunk Size) of *data-ck* is the size of the coded audio data only. The structure of *data-ck* is illustrated in Fig. 35.

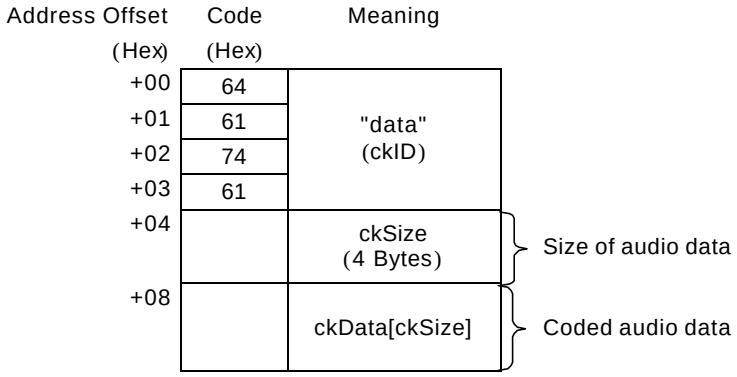


Fig. 35 data-ck Structure

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3.5.2. Basic Structure of PCM Audio Data

PCM audio data has linear quantization (A/D conversion) characteristics, and is not encoded for compression. It therefore does not need to be decompressed for playback, but can simply be played by reading it directly.

The basic structure of audio data when the format type is PCM (Pulse Code Modulation) format is shown in Fig. 36.

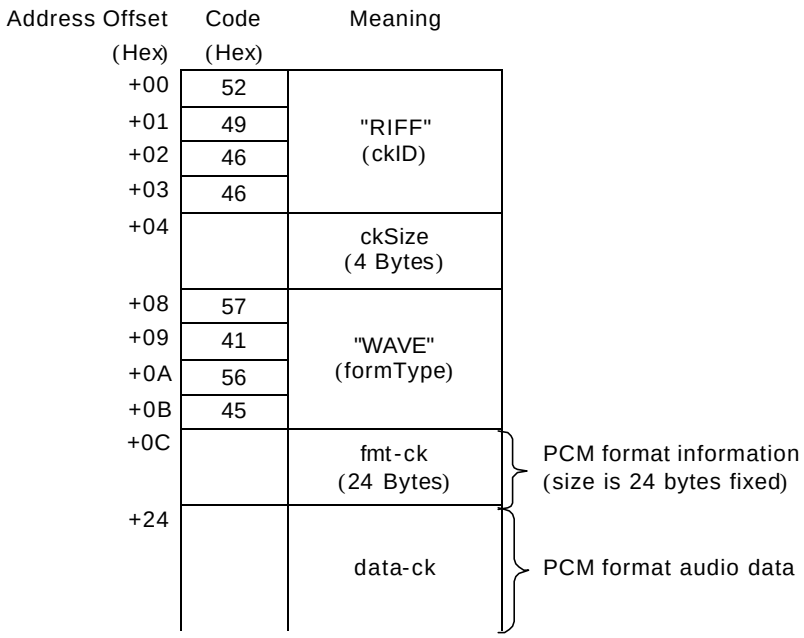


Fig. 36 Basic Structure of PCM Format

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The specific values stored in *fmt-ck* in the case of PCM format are as shown in Table 25.

Table 25 PCM Format fmt-ck Information

PCM (Pulse Code Modulation) Format	
Members	Code
ckSize (fmt-ck) wFormatTag	00000010.H (16 Bytes, since cbSize is unnecessary) 0001.H (PCM format)
nChannels	The values of each mode are as follows. 0001.H (monaural) or 0002.H (stereo)
nSamplesPerSec	The values of each mode are as follows. 00001F40.H (8.0 kHz) 00002B11.H (11.025 kHz) 00005622.H (22.05 kHz) 0000AC44.H (44.10 kHz)
nAvgBytesPerSec	The values of each mode are as follows. 00001F40.H (8.0 kHz, 8-bit monaural) 00003E80.H (8.0 kHz, 8-bit stereo) 00003E80.H (8.0 kHz, 16-bit monaural) 00007D00.H (8.0 kHz, 16-bit stereo) 00002B11.H (11.025 kHz, 8-bit monaural) 00005622.H (11.025 kHz, 8-bit stereo) 00005622.H (11.025 kHz, 16-bit monaural) 0000AC44.H (11.025 kHz, 16-bit stereo) 00005622.H (22.05 kHz, 8-bit monaural) 0000AC44.H (22.05 kHz, 8-bit stereo) 0000AC44.H (22.05 kHz, 16-bit monaural) 00015888.H (22.05 kHz, 16-bit stereo) 0000AC44.H (44.10 kHz, 8-bit monaural) 00015888.H (44.10 kHz, 8-bit stereo) 00015888.H (44.10 kHz, 16-bit monaural) 0002B110.H (44.10 kHz, 16-bit stereo) Definition: nSamplesPerSec * nBlockAlign
nBlockAlign	The values of each mode are as follows. 0001.H (8-bit monaural) 0002.H (8-bit stereo) 0002.H (16-bit monaural) 0004.H (16-bit stereo) Definition: nChannels * wBitsPerSample/8
wBitsPerSample	The values of each mode are as follows. 0008.H (8bit) or 0010.H (16bit)
cbSize	Not used
extByte[cbSize]	Not used

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In the case of PCM format audio data, the data format of each sample is 8-bit or 16-bit integer. These sample data formats and their values are given in Table 26.

Table 26 Sample Data Formats and Values

Sample Size	Data Format	Minimum	Interoperability	Maximum
8-bit PCM	Unsigned Integer	0 (00.H)	128 (80.H)	255 (FF.H)
16-bit PCM	Signed Integer	-32768 (8000.H)	0 (0000.H)	32767 (7FFF.H)

The PCM format audio data contained in *data-ck* is packed as shown in Fig. 37. Here the left-hand byte stores the lower address and the right-hand byte holds the upper address.

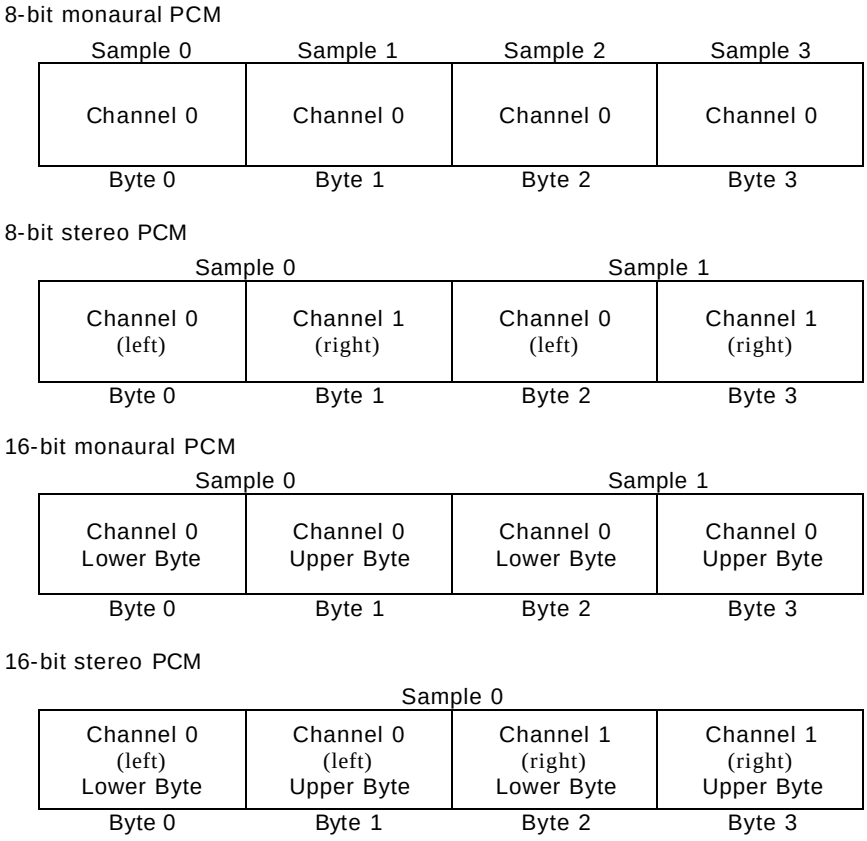


Fig. 37 Packing of PCM Audio Data

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3.5.3. Basic Structure of μ-Law Audio Data

Each of the audio data samples of μ-Law audio data has nonlinear (logarithmic) quantization characteristics. For this reason 16 bits of data can be represented in an 8-bit size. In playback, either the data is first converted to linear 16-bit data and then put through a linear D/A converter, or else the analog signal is derived by going through an 8-bit nonlinear D/A converter with characteristics opposite the μ-Law quantization characteristics. Details of the nonlinear quantization characteristics and of the conversion between 8-bit μ-Law data and 16-bit linear data are given in the ITU-T G.711 [viii] standard.

When the format type is μ-Law (ITU-T G.711) format, the basic structure is expressed as in Fig. 38.

The two differences from PCM format are the larger size of *fmt-ck* (the cbSize file exists) and the existence of *fact-ck*.

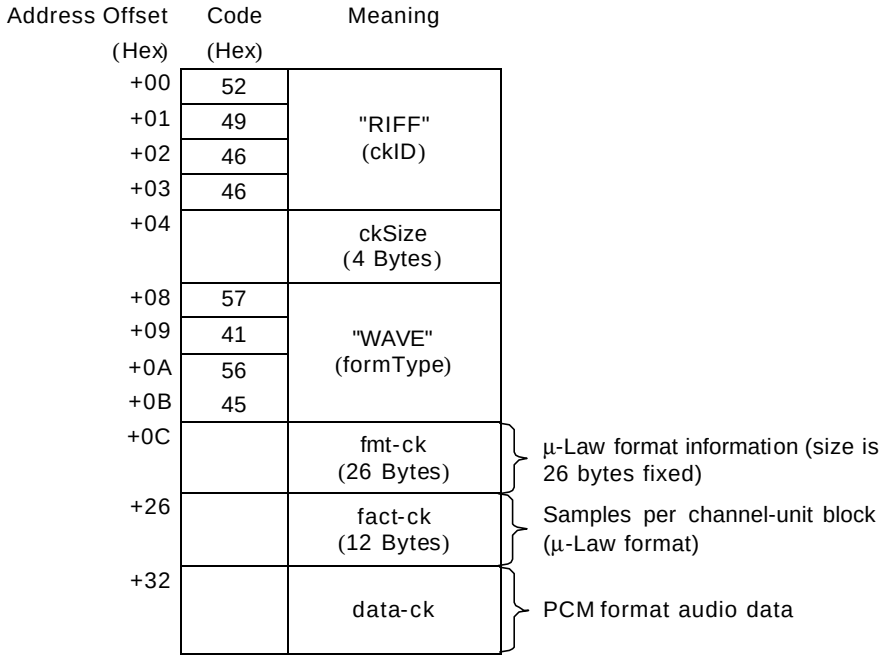


Fig. 38 Basic Structure of μ-Law Format

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The specific values of the information stored in *fmt-ck* and *fact-ck* in the case of the μ-Law format are given in Table 27.

Table 27 fmt-ck and fact-ck Information in μ-Law Format

μ-Law (ITU-T G.711) Format	
Members	Code
ckSize(fmt-ck)	00000012.H (18 bytes, WAVEFORMATEX only)
wFormatTag	0007.H (μ-Law format)
nChannels	The values of each mode are as follows. 0001.H (monaural) or 0002.H (stereo)
nSamplesPerSec	00001F40.H (8.0kHz)
nAvgBytesPerSec	The values of each mode are as follows. 00001F40.H (8.0kHz, 8-bit monaural) 00003E80.H (8.0kHz, 8-bit stereo) Definition: nSamplesPerSec * nBlockAlign
nBlockAlign	The values of each mode are as follows. 0001.H (8bit monaural) 0002.H (8bit stereo) Definition: nChannels * wBitsPerSample/8
wBitsPerSample	0008.H (8bit)
cbSize	0000.H (extByte[cbSize] does not exist)
extByte[cbSize]	Not used
dwSampleLength	It is recommended that the actual number of samples that can be played be recorded here. Definition: (ckSize_of_data-ck) / nBlockAlign

The μ-Law audio data contained in *data-ck* is packed as shown in Fig. 39. Here the left-hand byte stores the lower address and the right-hand byte holds the upper address.

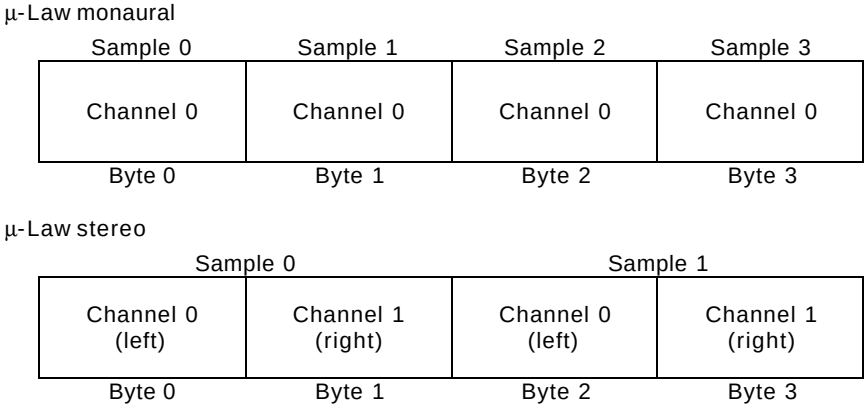


Fig. 39 Packing of μ-Law Audio Data

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3.5.4. Basic Structure of IMA-ADPCM Audio Data

IMA-ADPCM audio data is 4-bit data obtained by compressing 16-bit linear PCM audio data. IMA-ADPCM, as seen in its other name DVI-ADPCM, uses a compression algorithm originally developed by the Intel DVI Group (DVI: Digital Video Interoperability). It was later adopted by the IMA (Interoperability Multimedia Association) as a standard audio data format.

Details of the IMA-ADPCM algorithm are given in the IMA Digital Audio Doc-Pac[xvii] and other documents.

When the format type is IMA-ADPCM (DVI-ADPCM), the basic structure is as shown in Fig. 40.

A *fact-ck* is recorded as with the μ-Law format, but a difference from that format is the larger *fmt-ck* size (in addition to a cbSize field there is a wSamplesPerBlock field).

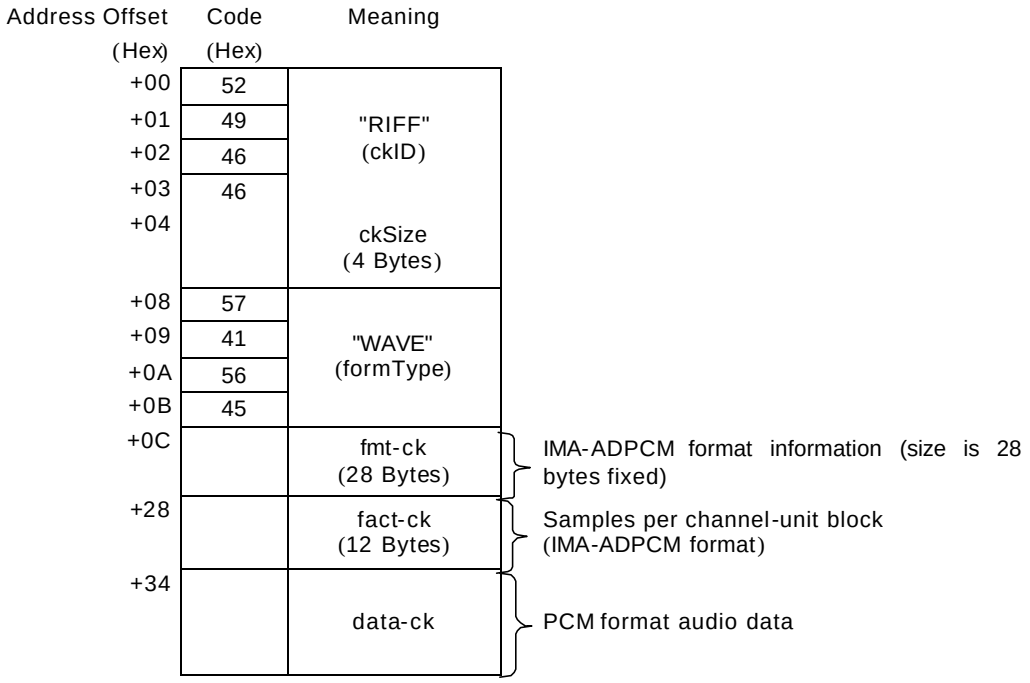


Fig. 40 Basic Structure of IMA-ADPCM Format

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The specific values of the information stored in *fmt-ck* and *fact-ck* in the case of the IMA-ADPCM format are given in Table 28 and Table 29.

Table 28 IMA-ADPCM Format fmt-ck and fact-ck Information (1)

IMA-ADPCM (DVI-ADPCM) Format	
Members	Code
ckSize(fmt-ck)	00000014.H (20 bytes)
wFormatTag	0011.H (IMA-ADPCM format)
nChannels	0001.H (monaural) or 0002.H (stereo)
nSamplesPerSec	The values of each mode are as follows. 00001F40.H (8.0 kHz) 00002B11.H (11.025 Hz) 00005622.H (22.050 Hz) 0000AC44.H (44.10 Hz)
nAvgBytesPerSec	The values of each mode are as follows. 00000FD7.H (8.0 kHz, 4-bit monaural) 00001FAE.H (8.0 kHz, 4-bit stereo) 000015D4.H (11.025 kHz, 4-bit monaural) 00002BA9.H (11.025 kHz, 4-bit stereo) 00002B5C.H (22.05 kHz, 4-bit monaural) 000056B9.H (22.05 kHz, 4-bit stereo) 0000566D.H (44.10 kHz, 4-bit monaural) 0000ACDB.H (44.10 kHz, 4-bit stereo) Definition: nSamplesPerSec*nBlockAlign/wSamplesPerBlock
nBlockAlign	The values of each mode are as follows. 0100.H (8.0 kHz, 4-bit monaural) 0200.H (8.0 kHz, 4-bit stereo) 0100.H (11.025 kHz, 4-bit monaural) 0200.H (11.025 kHz, 4-bit stereo) 0200.H (22.05 kHz, 4-bit monaural) 0400.H (22.05 kHz, 4-bit stereo) 0400.H (44.10 kHz, 4-bit monaural) 0800.H (44.10 kHz, 4-bit stereo) Although the definition is (N+1) * 4 * nChannels, the use of 256 * nChannels * max (1,nSamplesPerSec / 11.025kHz) is recommended.
wBitsPerSample	0004.H (4 bits)
cbSize	0002.H

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Table 29 IMA-ADPCM Format fmt-ck and fact-ck Information (2)

IMA-ADPCM (DVI-ADPCM) Format	
extByte[cbSize]	The values of each mode are as follows. 01F9.H (8.0 kHz, 4-bit monaural) 01F9.H (8.0 kHz, 4-bit stereo) 01F9.H (11.025 kHz, 4-bit monaural) 01F9.H (11.025 kHz, 4 bit stereo) 03F9.H (22.05 kHz, 4-bit monaural) 03F9.H (22.05 kHz, 4-bit stereo) 07F9.H (44.10 kHz, 4-bit monaural) 07F9.H (44.10 kHz, 4-bit stereo) If the definition is, wSamplesPerBlock (an unsigned 16-bit integer indicating the samples per channel-unit block), and X = (nBlockAlign -(4 * nChannels))* 8 Y = wBitsPerSample * nChannels then, wSamplesPerBlock =(X/Y)+1
dwSampleLength	It is recommended that the actual number of samples that can be played back be recorded. The definition is as follows. If X = ckSize_of_data-ck/nBlockAlign then, dwSampleLength = (X+1) * wSamplesPerBlock

The IMA-ADPCM audio data contained in *data-ck* is packed as shown in Fig. 41, Fig. 42, and Fig. 43 when it is recorded.

A feature of this format is the existence of a header at the start of each block. The header records the initial sample value for that block and a step (quantization table) index. The audio data in each channel is independent, so the number of header words is the same as the number of channels.

A header word consists of 4 bytes, and is defined as in [equation 5]. The existence of a header means IMA-ADPCM audio data can be played from any block. In other words, random access is possible on a per-block basis.

In Fig. 41 to Fig. 43, the left-hand byte stores the lower address and the right-hand byte holds the upper address.

```
typedef struct {
        signed int    iSamp0;              // Initial sample value of the block
        unsigned char  bStepTableIndex;    // Step table index
        unsigned char  bReserved;          // reserved byte
} IMA_ADPCMBLOCKHEADER;                                    - - -[Equation 5]
```


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In Fig. 41 to Fig. 43, N, M, and P have the following significance.

N = (nBlockAlign/(4*nChannels)) - 1 - - -[Equation 6]

M = 0, 1, 2, 3, ... , N-1 - - -[Equation 7]

P = (M * 8) + 1 - - -[Equation 8]

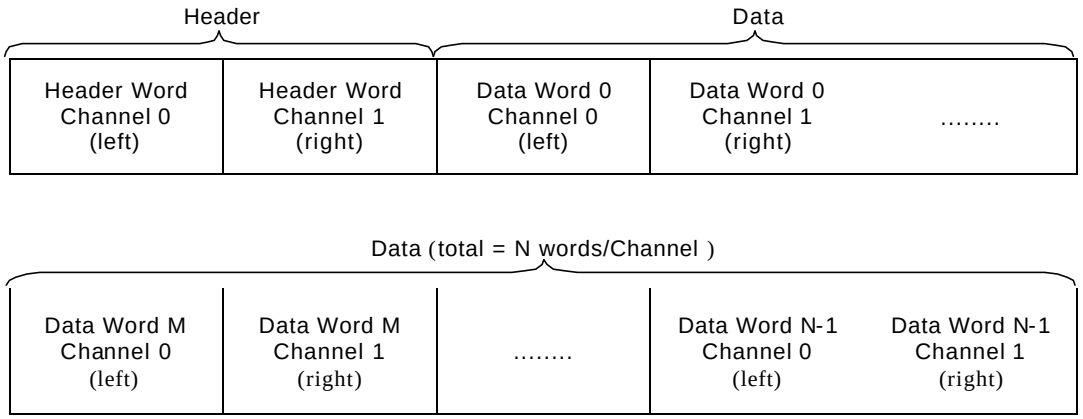


Fig. 41 Packing of IMA-ADPCM Audio Data

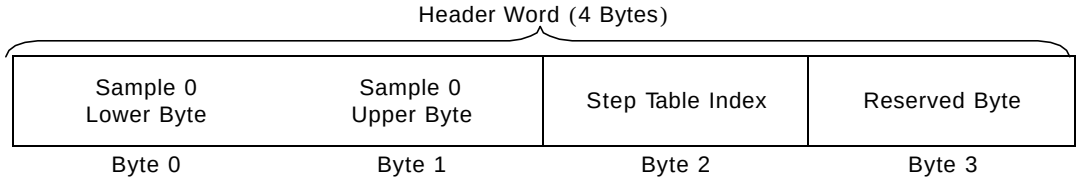


Fig. 42 Header Word of IMA-ADPCM Audio Data

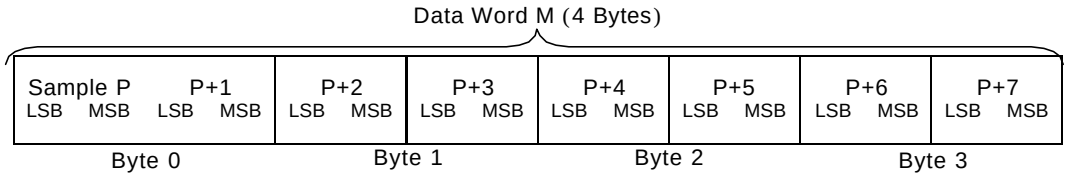


Fig. 43 Data Word M of IMA-ADPCM Audio Data

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3.6. Chunks Used

The chunks used in Exif audio files are described here.

3.6.1. WAVE Form Audio File Basic Chunks

The basic chunks of a WAVE Form Audio File, as is evident from the basic structure of the *WAVE* file shown in Fig. 32, are the four below.

- RIFF chunk
- fmt chunk
- fact chunk
- data chunk

[Additional Explanation]

- The fmt chunk, fact chunk and data chunk are sub-chunks of the *RIFF* chunk. A *WAVE* file consists of one *RIFF* chunk, with specific information recorded in the sub-chunks.
- Only when the form type is PCM (Pulse Code Modulation) format, the fact chunk is unnecessary. With non-PCM formats such as μ-Law and IMA-ADPCM, it is mandatory, which is why *fact-ck* is included in the basic chunks here.
- It is possible to add other optional sub-chunks as well.
- At the head of the chunk data (*ckData*) of the *RIFF* chunk there is a form type called "*WAVE*".

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3.6.2. LIST Chunk and INFO List

A *WAVE* form and other *RIFF* forms store a variety of information in sub-chunks of the *RIFF* chunk. These sub-chunks in many cases are specific to each form type; but there are also general-purpose chunks for storing additional information regardless of the data specified for a given form type.

One of these general-purpose chunks is the *LIST* chunk. Here the use of the *LIST* chunk is explained.

(1) LIST Chunk

The *LIST* chunk is a general-purpose chunk that can be used with the files of many different form types. The *LIST* chunk is a pre-registered general-purpose chunk, so its *ckID* (chunk ID) is written in upper-case letters.

Included in the *LIST* chunk is a sub-chunk list (series of sub-chunks) and sequence designation.

The *LIST* chunk *ckData* (chunk data) consists of a four-character code at the beginning called a listType (list type), followed by the sub-chunk list.

This structure resembles that of the *RIFF* chunk, but the *LIST* chunk is always farther down the hierarchy than the *RIFF* chunk.

The list type is used to identify the list contents. For this reason there are list types that are used only with certain form types. If a list type is encountered that cannot be Interoperability, that *LIST* chunk can be ignored.

The list type must be registered. A general-purpose list type that is registered and can be used with various form types is written in all upper-case letters.

A list type that can be used only with a specific form type is written in lower-case letters.

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The *LIST* chunk structure is illustrated in Fig. 44.

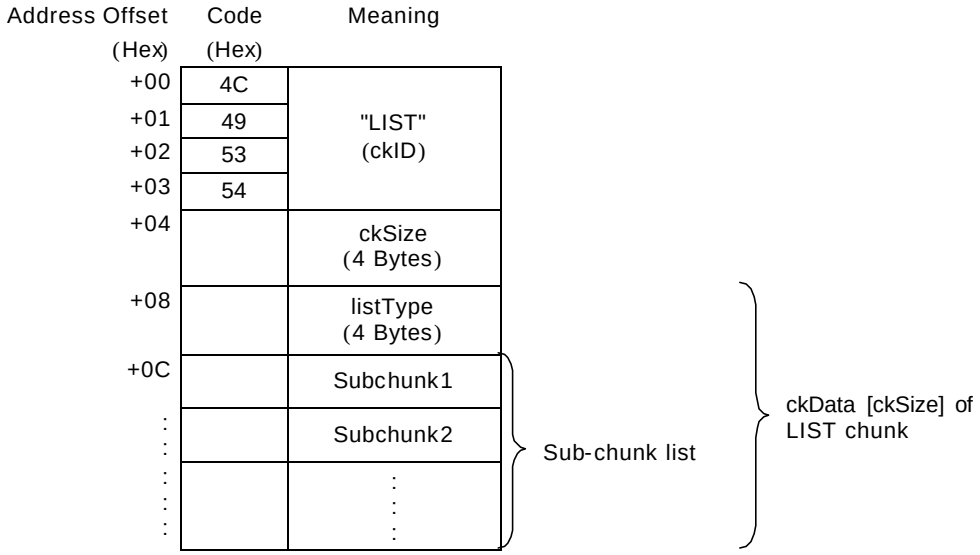


Fig. 44 LIST Chunk Structure

(2) INFO List

An "*INFO list*" is a *LIST* chunk having the registered, general-purpose listType "*INFO*".

The need for information such as title, copyright and comments is similar in each of the form types. The *INFO list* is used for storing these kinds of information.

The information itself in an *INFO list* is stored in the sub-chunk lists. These sub-chunks use only pre-registered, general-purpose chunks, described later below.

The *INFO list* information is supplementary and has no influence on the Interoperability of the main data, such as WAVE form audio data. It can therefore be skipped without problem. If an unknown chunk is included on the *INFO list*, as when a new chunk has been defined, it is to be ignored.

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The *INFO list* chunks currently defined are given in Table 30. These pre-registered chunks are stored as ASCII text strings terminated by NULL (the final byte is '00.H').

Table 30 INFO List Chunks

Channel ID	Description
IARL	Archival Location. Indicates where the subject of the file is archived.
IART	Artist. Lists the artist of the original subject of the file.
ICMS	Commissioned. Lists the name of the person or organization that commissioned the subject of the file.
ICMT	Comments. Provides general comments about the file or the subject of the file.
ICOP	Copyright. Records the copyright information for the file.
ICRD ICRP	Creation date. Indicates the date the subject of the file was created. Cropped. Indicates whether an image has been cropped
IDIM	Dimensions. Specifies the size of the original subject of the file.
IDPI	Dots Per Inch. Stores the dots per inch (DPI) setting of the digitizer used to produce the file.
IENG	Engineer. Stores the name of the engineer who worked on the file.
IGNR	Genre. Describes the genre of the original work.
IKEY	Keywords. Provides a list of keywords that refer to the file or subject of the file.
ILGT	Lightness. Describes the changes in lightness settings on the digitizer required to produce the file.
IMED	Medium. Describes the original subject of the file, such as, "computer image," "drawing," "lithograph," and so forth.
INAM	Name. Stores the title of the subject of the file.
IPLT	Palette Setting. Specifies the number of colors requested when digitizing an image.
IPRD	Product. Specifies the name of the title the file was originally intended for, such as "Encyclopedia of Pacific Northwest Geography."
ISBJ	Subject. Describes the file contents, such as "Aerial view of Seattle."
ISFT	Software. Identifies the name of the software package used to create the file.
ISHP	Sharpness. Identifies the changes in sharpness for the digitizer required to produce the file.
ISRC	Source. Identifies the name of the person or organization who supplied the original subject of the file.
ISRF	Source Form. Identifies the original form of the material that was digitized, such as "slide," "paper," "map," and so forth.
ITCH	Technician. Identifies the technician who digitized the subject file.

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A typical *INFO list* is shown in Fig. 45.

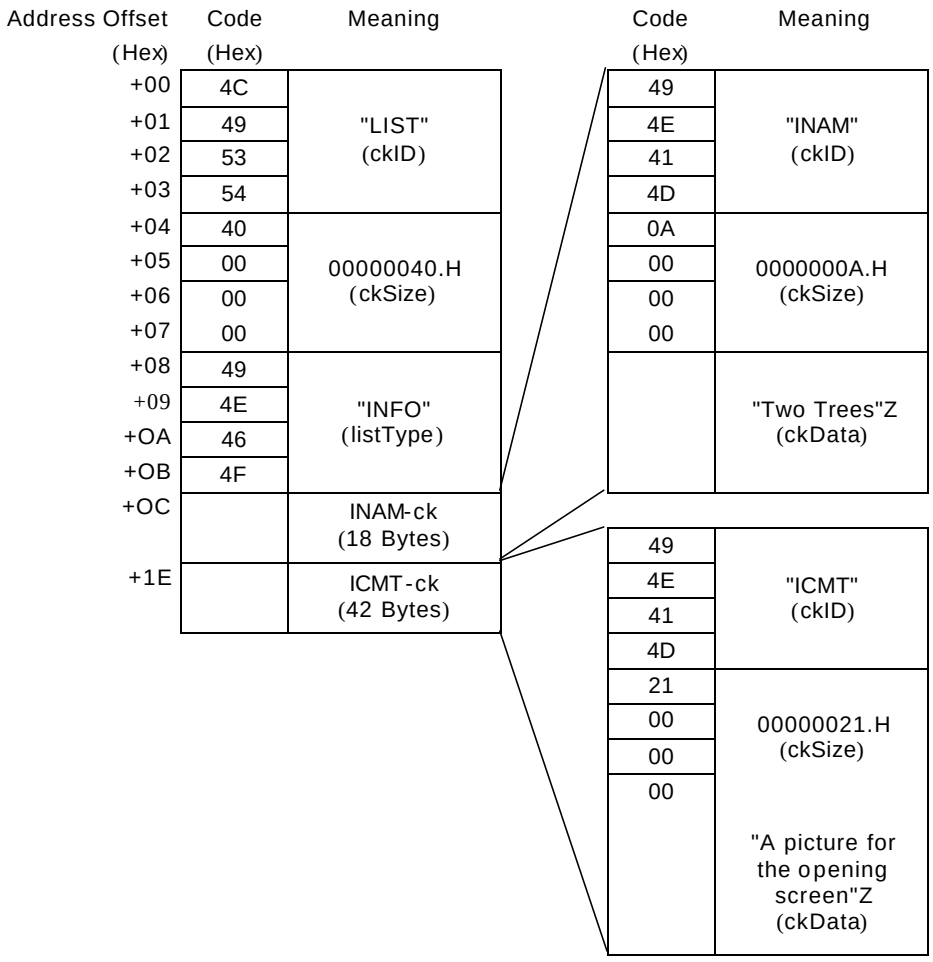


Fig. 45 Typical INFO List

The following points need to be observed in using the *INFO list*. They are explained in reference to Fig. 45.

- The 'Z' at the end of the text string information in the *INAM* and *ICMT* chunks means NULL termination. The actual code appended is '00.H'.
- The chunk data (*ckData*) in each chunk must be an even number of bytes. If the data itself is an odd number of bytes, it must be padded by one additional byte.
- In the example in Fig. 45, the *ICMT* chunk has 33 bytes of information including the NULL termination, so a padding byte '00.H' must be appended. No padding is necessary with the *INAM* chunk information, since the size including NULL termination is 10 bytes.
- The value of the chunk size (*ckSize*) of the *ICMT* chunk does not include the padding byte. However, the chunk size of the *LIST* chunk that is its parent chunk must include the padding bytes in the sub-chunks. If this

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rule is not observed, it will not be possible to determine the start address of a chunk following after this *LIST* chunk.

(3) INFO List used by Exif audio files

The *INFO list* used with Exif audio files is as follows.

The chunks that can be included on the *INFO list* are those given in Table 30; but of these, only the following are used with Exif audio files.

[Chunks Used with Exif]

INAM

Records the title of the Exif audio file. The title is written in an ASCII string and terminated with NULL. Recording this information is optional.

Ex.) "Exif Audio File Example"Z

IGNR

Records the genre of the Exif audio file subject. The genre name is written in an ASCII string and terminated with NULL. Recording this information is optional.

Ex.) "narration"Z

ICRD

Records the date the Exif audio file was created. It is written as a fixed-length ASCII string, in the format year-month-day. That is, the year, month, and day are separated by a hyphen. The year is four digits, while month and day are two digits each. If the number of the month or the day is less than 10, the first digit is 0. The order must be year-month-day. Since this information is written as an ASCII string, it must be terminated with NULL. This chunk is fixed-length (the chunk data is 11 bytes, and a padding byte is added to make it an even byte number). Recording this information is optional.

Ex.) "1997-04-08"Z (Note: =April 8, 1997)

ICMT

Records a general comment on the Exif audio file or its subject. Comments are written in ASCII text terminated with NULL. If there are two or more comments, each statement ends with a period. A carriage return or line feed character must not be used. Recording this information is optional.

Ex.) "Recorded by Digital Still Camera"Z

IART

Records the name of the Exif audio file creator. The name is written in an ASCII string and terminated with NULL.

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Recording this information is optional.

Ex.) "Taro Yamada"Z

ICOP

Records copyright information for the Exif audio file. The copyright is written in ASCII text and terminated with NULL. In case of multiple copyright information, each is separated by a semicolon followed by one blank space (20.H). Recording this information is optional.

Ex.) "Copyright Exif Corporation 1997."Z

[Notes and Additional Information]

- A camera shall not record chunks other than those listed above.
- If a camera encounters an unknown chunk when reading the *INFO list*, it shall skip that chunk. It is possible that the *INFO list* will be expanded in the future, and this provision ensures that compatibility will be maintained.
- Information shall be recorded in accord with the general *INFO list* stipulations.
- All the information on the *INFO list* is optional, and does not have to be recorded.
- The *INFO list* used for Exif audio files consists of pre-registered, general-purpose chunks only, which means this information can be read by commercial "RIFF Form Reader" software (such as the utility software provided with Windows™).

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3.6.3. Chunks for Attribute Information Specific to Exif Audio Files

Recording of attribute information specific to Exif audio files is done as follows.

Exif-specific attributes are those not defined for ordinary WAVE Form Audio Files but only for Exif audio files. This is auxiliary information with no influence on Interoperability of the audio data itself. For this reason an Exif audio file can still be compatible with a standard WAVE Form Audio File.

The attributes specific to Exif audio files are recorded as follows.

(1) LIST chunk is used.

The compatibility noted above is realized by using a pre-registered, general-purpose *LIST* chunk to record the attribute information specific to Exif audio files. Since it can be used with all the *LIST* chunk form types, this chunk can be put in the WAVE Form Audio File. The individual information is recorded in sub-chunks of the *LIST* chunk.

(2) A dedicated list type "exif" is defined.

The information in the *LIST* chunk is explicitly labeled as information specific to Exif audio files by defining a dedicated list type. The following is used as this list type.

- Dedicated Exif list type: "exif" (all lower-case letters)

The attributes specific to Exif audio files cannot be used in the WAVE Form Audio File format, so it is all written in lower-case letters.

Hereafter, the notation "exif list" is used to mean the *LIST* chunk whose list type is exif.

(3) A dedicated chunk is defined for each of the attributes.

Since there are no corresponding existing chunks, a dedicated chunk is defined to record the attribute information specific to Exif audio files. The information items and their chunks are described below.

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[Information items and chunks]

ever

Records the version information (number) of this standard.

As with Exif image files, it is recorded in 4 bytes. The address bytes are recorded as A1, A2, B1, B2, starting with the lowest number. A1 and A2 store the upper part of the standard version, with the lower part stored in B1 and B2. A1, A2, B1 and B2 are ASCII numerals giving the version number, but NULL termination is unnecessary. This chunk is mandatory.

On the conventions for version number updating, see section 3.2.

Ex.) "0200" (Note: =Version 2.00)

erel

Records information pointing to an Exif image file related to the Exif audio file recorded in this chunk. Recording this information makes it possible for a camera or application software to map an image to sound during playback.

The relational information consists of the name of the corresponding Exif image file, given as an 8-character file name plus 3-character extension in ASCII format. The path is not written. Stipulations on images are given in section 2.6.5. File naming rules are covered in section 3.7.1.

The mapping of Exif image files and audio files is done in any of the three ways shown in Table 31. If multiple files are mapped to one file as in [2] or [3] of Table 31, the above format is used to record just one destination file name. If there are multiple destination files, the first recorded file is given.

In the case of [2] in Table 31, for the Exif audio file "SND00001.WAV" only "DSC00001.JPG" is given as the related image file. When there are three Exif image files "DSC00001.JPG," "DSC00002.JPG" and "DSC00003.JPG," the related Exif audio file name for each of them, "SND00001.WAV," is indicated. By combining multiple relational information, a variety of playback possibilities can be supported. The method of using relational information is left to the implementation on the playback side. Since this information is an ASCII character string, it is terminated by NULL. If there is a related Exif image file, this chunk is mandatory.

Ex.) "DSC00001.JPG"Z

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Table 31 Mapping between Image and Audio Files

	Relationship	Exif Image File	Exif Audio File
[1]	1 to 1	DSC00001.JPG	SND00001.WAV
[2]	Many to 1	DSC00001.JPG DSC00002.JPG DSC00003.JPG	SND00001.WAV
[3]	1 to many	DSC00001.JPG	SND00001.WAV SND00002.WAV SND00003.WAV

etim

Records the time of Exif audio file creation. This is defined as the time the recording of audio data was started. Time is expressed as a variable-length ASCII string. In order to conform as closely as possible to the Exif image file, time is recorded in the format "hour:minute:second.subsecond," with a colon in between each time unit and a period before the subsecond position.

Hour, minute and second are written as two digits each, with the first digit a zero if the value is one digit. Subseconds can be expressed to any desired decimal place. If there is no subsecond information, the string ends with a period only.

The order of time units is hour, minute, second, subsecond. The information is written as an ASCII string, so it must be terminated with NULL. Recording this information is optional.

Ex.) "10:05:10.130"Z

ecor

Records the name of the manufacturer of the equipment on which the Exif audio file was created. The manufacturer name is written in an ASCII string and terminated with NULL. Recording this information is optional.

Ex.) "Digital Still Camera Corporation"Z

emdl

Records the model name of the equipment on which the Exif audio file was created. The model name is written in an ASCII string and terminated with NULL. Recording this information is optional.

Ex.) "DSCamera1000"Z

emnt

As with Exif image files, this chunk is used by the writer manufacturer to record design information, version history and other maker-specific information. The contents and format of the information are up to each manufacturer.

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Other manufacturers see this information only as a byte array of the size determined by the chunk size (*ckSize*).

Recording this information is optional.

eucm

Records user comment information that cannot be recorded on, or is not suitable for, the *INFO list*. Basically this is text information. Character code information is included so languages that do not use ASCII can be used here. Recording this chunk is optional.

Recording of user comments is discussed below. The structure of the user comment chunk is shown in Fig. 46.

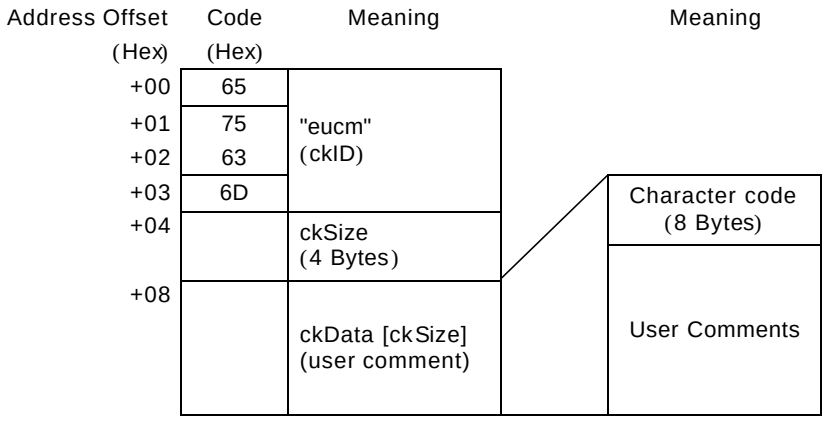


Fig. 46 Structure of User Comment Chunk

As seen in Fig. 46, the chunk data area storing the user comment starts with an 8-byte character code area, where the character code is given. The rest of the chunk data area is the user comment area, used for writing comments. The currently defined character codes are shown in Table 32. A registration system is used for character codes to avoid duplication. When a character code is registered, a standard document is indicated in the reference column to indicate the character format specification. If a character code is used for which there is no clear specification like Shift-JIS in Japan, Undefined is designated.

The character code is written from the start of the character code area, and the unused portion is padded with NULL ('00.H'). In order to match the format of the actual comments in the user comment part to that of the Exif image file *UserComment* tag, NULL termination is not used even if the comment is written in ASCII text. In accord with the chunk specification, however, a padding byte ('00.H') is used if the chunk data is not an even number of bytes.

Table 32 Character Codes and Character Code Designation

Character Code	Code Designation (8 Bytes)	Reference
ASCII	41.H, 53.H, 43.H, 49.H, 49.H, 00.H, 00.H, 00.H	ITU-T T.50 IA5[x]
JIS	4A.H, 49.H, 53.H, 00.H, 00.H, 00.H, 00.H, 00.H	JIS X0208-1990[xi]
Unicode	55.H, 4E.H, 49.H, 43.H, 4F. H, 44.H, 45.H, 00.H	Unicode Standard [xii]
Undefined	00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H	Undefined

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[Notes and Additional Information]

- The above chunks incorporated in exif list are used with a specific form type ('*WAVE*') and are therefore written in all lower-case letters.
- Only the *ever* chunk is mandatory; the others are optional. If an Exif image file related to an audio file exists, the *erel* chunk is also mandatory.
- When the exif list is read by a camera, information that cannot be recognized may be encountered, such as the *emnt* chunk or an Undefined string in the *eucm* chunk. In that case the chunk is to be skipped.
- An Exif reader and writer must conform to the stipulations for an ordinary *LIST* chunk.
- A general-purpose RIFF Form Reader will ignore the exif list. A dedicated Exif reader is required for reading the exif list.
- Fig. 47 shows the exif list structure and a coding example. The *ever* chunk is mandatory and has a fixed length (chunk data is 4 bytes). The *erel* chunk data is 13 bytes (odd), so a padding byte is added. The *erel* chunk is also fixed length.

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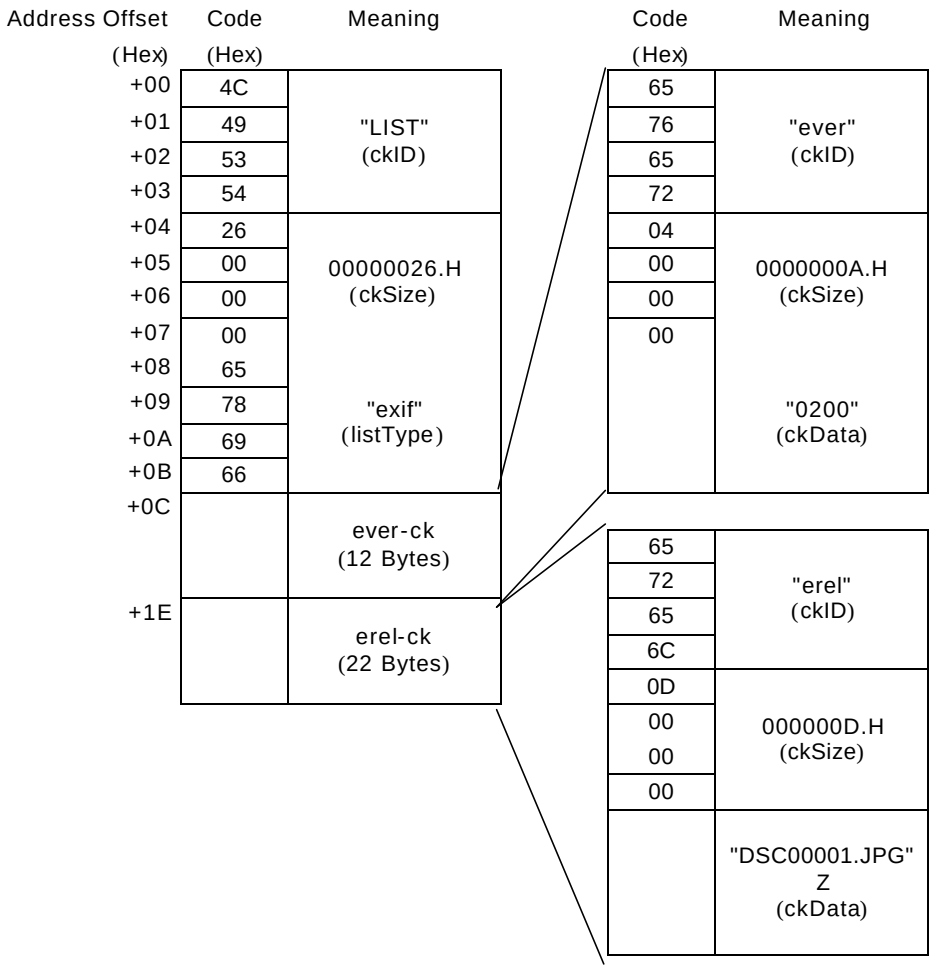


Fig. 47 exif List Structure and Typical Coding

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3.7. Data Description

3.7.1. File Naming Stipulation

The file name and characters used for file names are not specified, other than to stipulate the use of ASCII alphanumerics. (File names in Japanese or other character sets are not to be used.) File names shall be 8 characters or fewer, not including the extension. (Long file names are not to be used.) The file extension is ".WAV" (to match the WAVE Form Audio File extension) regardless of the audio data format type.

Typical Exif Audio File Fig. 48 shows the configuration of a typical Exif audio file.

The shaded parts of Fig. 48 are the mandatory elements of an Exif audio file. The hatching (*fact-ck* only) means that this chunk is not required if the audio data is PCM (Pulse Code Modulation) format, but is mandatory for all non-PCM formats (μ-Law, IMA-ADPCM), etc. The non-shaded elements are optional.

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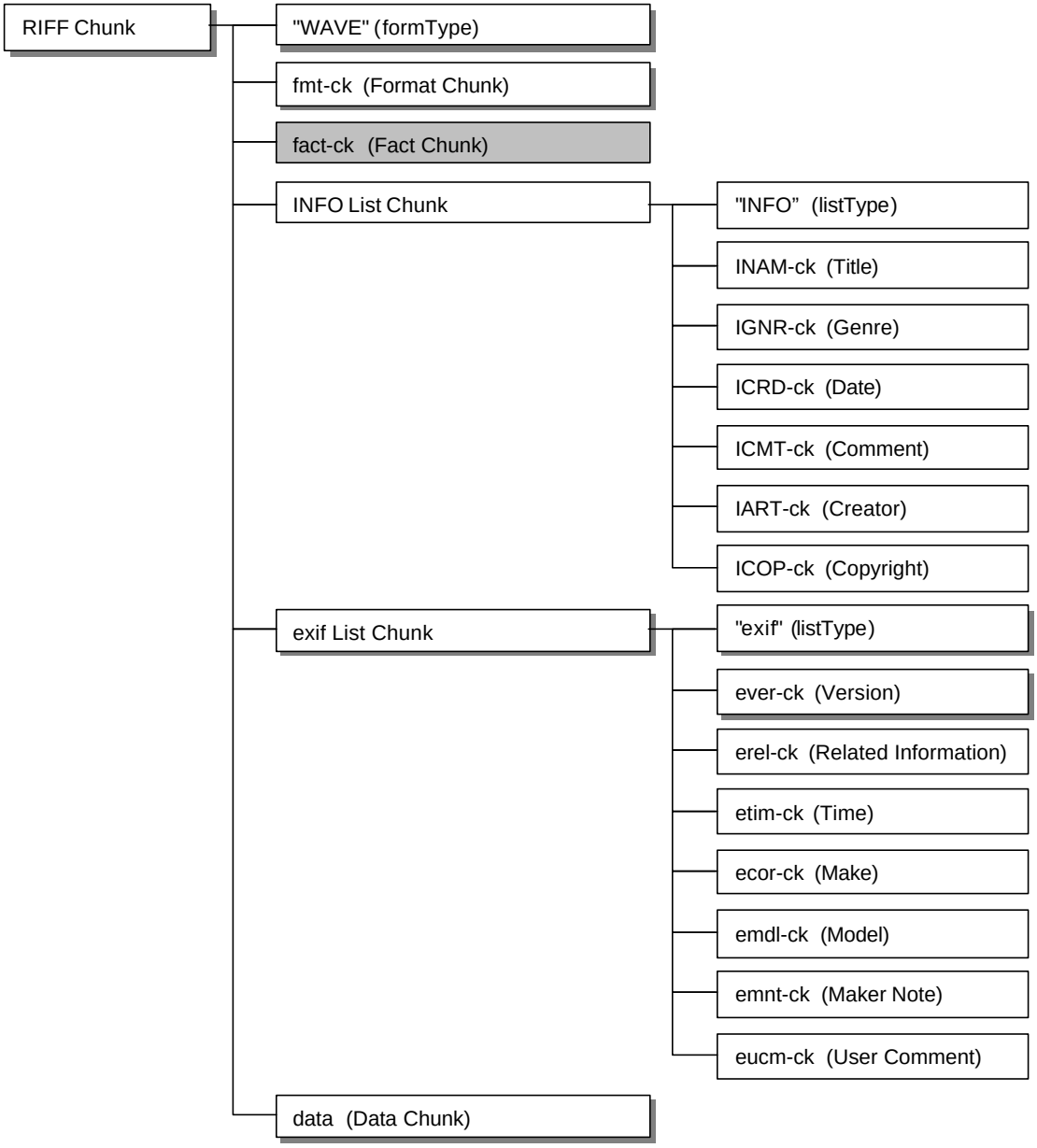


Fig. 48 Exif Audio File Configuration

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The means of recording the data of each element is given in the section for that element.

Fig. 49 shows the most common Exif audio file data structure. Exif audio file data is recorded in accord with the structure shown in Fig. 49. Each sub-chunk is recorded in accord with its stipulations. Optional chunks may be omitted.

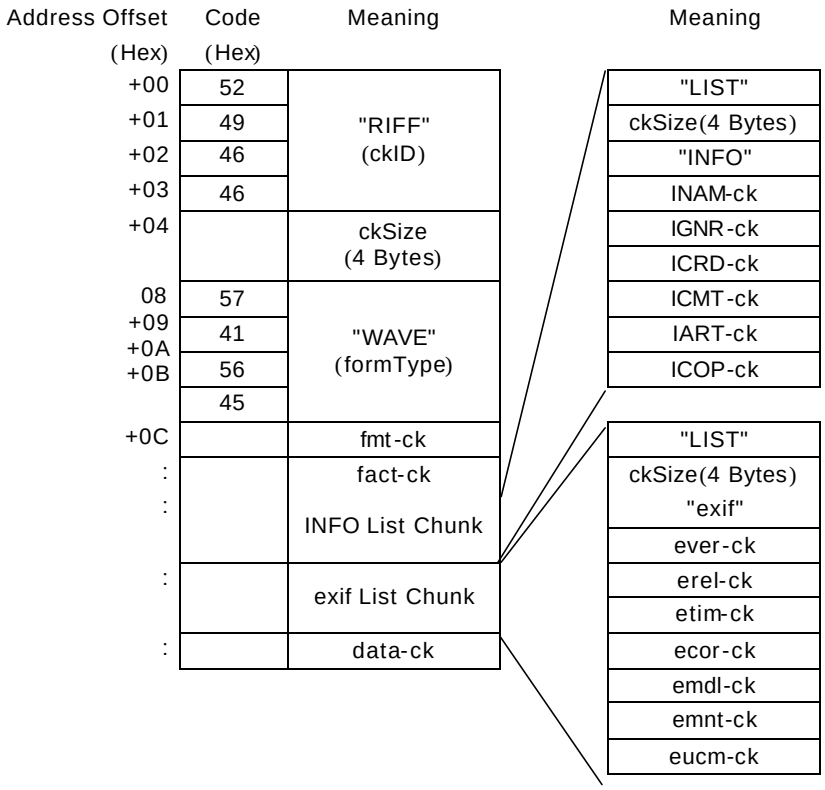


Fig. 49 Data Structure of a Typical Exif Audio File

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Appendix A Image File Description Examples

A.1 Uncompressed RGB File

Table 33 Uncompressed RGB File Description Sample Contents

Primary Image	
Pixels	640 (W) x 480 (H)
Image Title	Exif_TIFF_RGB
Image Input Equipment Manufacturer	DSCompany
Image Input Equipment Model Name	Example
Orientation	Normal
Strips	96
Lines per Strip	5
Bytes per Strip	9600
Image Resolution	72 dpi (Width), 72 dpi (Length)
Image Data Arrangement	Chunky
File Change Date and Time	1997:09:01 12:00:00.000
Copyright	Copyright, ABCDE,1997
Exif-specific Information	
Version	Ver. 2.0
Date and Time of Original Image Creation	1997:09:01 12:00:00.000
Date and Time of File Creation	1997:09:01 12:00:00.000
Thumbnail	
Pixels	80 (W) x 60 (H)
Orientation	Normal
Strips	1
Lines per Strip	60
Bytes per Strip	14400
Image Resolution	72 dpi (Width), 72 dpi (Length)

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Table 34 Uncompressed RGB File Description Sample

Header	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0000	Byte Order	4D4D ("MM")			
	0002	42	002A			
	0004	0th IFD Offset	00000008			
	Offset (Hex)	**Name**	**Interoperability Number (Hex)**			
	0008	Number of Interoperability	0014			
0th IFD	**Offset (Hex)**	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageWidth	0100	0004	00000001	00000280
	0016	ImageLength	0101	0004	00000001	000001E0
	0022	BitsPerSample	0102	0003	00000003	000000FE
	002E	Compression	0103	0003	00000001	00010000
	003A	PhotometricInterpretation	0106	0003	00000001	00020000
	0046	ImageDescription	010E	0002	0000000E	00000104
	0052	Make	010F	0002	00000009	00000112
	005E	Model	0110	0002	00000008	0000011C
	006A	StripOffsets	0111	0004	00000060	00000124
	0076	Orientation	0112	0003	00000001	00010000
	0082	SamplesPerPixel	0	0003	00000001	00030000
	008E	RowsPerStrip	0116	0004	00000001	00000005
	009A	StripByteCounts	0117	0004	00000060	000002A4
	00A6	XResolution	011A	0005	00000001	00000424
	00B2	YResolution	011B	0005	00000001	0000042C
	00BE	PlanarConfiguration	011C	0003	00000001	00010000
	00CA	ResolutionUnit	0128	0003	00000001	00020000
	00D6	DateTime	0132	0002	00000014	00000434
	00E2	Copyright	8298	0002	00000015	00000484
	00EE	Exif IFD Pointer	8769	0004	00000001	0000045E
	Offset (Hex)	**Name**	**Offset (Hex)**			
	00FA	Next IFD Offset	000004EC			
Value longer than 4byte of 0th IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	00FE	BitPerSample Value	000800080008			
	0104	ImageDescription Value	"Exif_TIFF_RGB"00			
	0112	Make Value	"DSCompany"00			
	011C	Model Value	"Example"00			
	0124	StripOffsets Value	offset0,offset1,offset2.....offset95			
	02A4	StripByteCounts Value	count0, count1, count2....count95			
	0424	XResolution Value	0000004800000001			
	042C	YResolution Value	0000004800000001			
	0434	DateTime Value	"1997:09:01 12:00:00"00			
	0448	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Interoperability Number (Hex)**			
	045E	Exif IFD Number	0008			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	0460	ExifVersion	9000	0007	00000004	"0200"
	046C	DateTimeOriginal	9003	0002	00000014	000004C4

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	0478	DateTimeDigitized	9004	0002	00000014	000004D8
	0484	SubSecTime	9290	0002	00000004	"000"00
	0490	SubSecTimeOriginal	9291	0002	00000004	"000"00
	049C	SubSecTimeDigitized	9292	0002	00000004	"000"00
	04A8	FlashPixVersion	A000	0007	00000004	"0100"
	04B4	Colorspace	A001	0003	00000001	0001
	Offset (Hex)	**Name**	**Offset (Hex)**			
	04C0	Next IFD Offset	00000000			
Value longer than 4byte of Exif IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	04C4	SubSecTimeOriginal Value	"1997:09:01 12:00:00"00			
	04D8	SubSecTimeDigitized Value	"1997:09:01 12:00:00"00			
1st IFD	**Offset (Hex)**	**Name**	**Interoperability Number (Hex)**			
	04EC	Number Of Interoperability	000D			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex)**
	04EE	ImageWidth	0100	0004	00000001	00000050
	04FA	ImageLength	0101	0004	00000001	0000003C
	0506	BitsPerSample	0102	0003	00000003	0000058E
	0512	Compression	0103	0003	00000001	00010000
	051E	PhotometricInterpretation	0106	0003	00000001	00020000
	052A	StripOffsets	0111	0004	00000001	000005A4
	0536	SamplesPerPixel	011	0003	00000001	00030000
	0542	RowsPerStrip	0116	0004	00000001	0000003C
	054E	StripByteCounts	0117	0004	00000001	00003840
	055A	XResolution	011A	0005	00000001	00000594
	0566	YResolution	011B	0005	00000001	0000059C
	0572	PlanarConfiguration	011C	0003	00000001	00010000
	057E	ResolutionUnit	0128	0003	00000001	00020000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	058A	Next IFD Offset	00000000			
Value longer than 4byte of 1st IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	058E	BitPerSample Value	000800080008			
	0594	XResolution Value	0000004800000001			
	059C	YResolution Value	0000004800000001			
	05A4	Thumbnail Image Data Strip	:			
Primary Image	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	3DE4	Primary Image Data Strip0	:			
	6364	Primary Image Data Strip1	:			
	:	:	:			
	:	:	:			
	0E2864	Primary Image Data Strip95	:			

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A.2 Uncompressed YCbCr File

Table 35 Uncompressed YCbCr File Description Sample Contents

Primary Image	
Pixels	640 (W) x 480 (H)
Image Title	Exif_TIFF_YCC
Image Input Equipment Manufacturer	DSCompany
Image Input Equipment Model Name	Example
Orientation	Normal
Strips	69
Lines per Strip	7
Bytes per Strip	8960
Image Resolution	72 dpi (Width), 72 dpi (Length)
Image Data Arrangement	Chunky
File Change Date and Time	1997:09:01 12:00:00
Pixel Composition	Subsampling = 4:2:2 Chrominance Subsampling point matches luminance point
Copyright	Copyright, ABCDE,1997
Exif-specific Information	
Version	Ver. 2.0
Date and Time of Original Image Creation	1997:09:01 12:00:00
Date and Time of File Creation	1997:09:01 12:00:00
Shutter Speed	59/10 (equivalent to 1/60 sec.)
Aperture	50/10 (equivalent to F:5.6)
Brightness	80/10
Exposure Bias	0/0
Maximum Lens Aperture	200/10
Subject Distance	20/10
Metering Mode	MultiSpot
Light Source	Daylight
Flash ON/OFF	ON
GPS Information	
Version	Ver. 2.0
Measurement Position	North Latitude 35 deg. 48 min. 8 sec., East Longitude 139 deg. 34 min. 55 sec.
Altitude	30.48 meters above sea level
GPS Time	0:00:00
GPS Receiver Movement	Moving at 1km/h at 0 deg. true direction
Image Direction	0 deg. true direction
Geodetic Data Used for Measurement	TOKYO
Thumbnail	
Pixels	80 (W) x 60 (H)
Orientation	Normal
Strips	1
Lines per Strip	60
Bytes per Strip	9600
Image Resolution	72 dpi (Width), 72 dpi (Length)

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Table 36 Uncompressed YCbCr File Description Sample

Header	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0000	Byte Order	4D4D ("II")			
	0002	42	2A00			
	0004	0th IFD Offset	08000000			
	Offset (Hex)	**Name**	**Interoperability Number (Hex)**			
	0008	Number of Interoperability	1700			
0th IFD	**Offset (Hex)**	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageWidth	0001	0400	01000000	80020000
	0016	ImageLength	0101	0400	01000000	E0010000
	0022	BitsPerSample	0201	0300	03000000	22010000
	002E	Compression	0301	0300	01000000	01000000
	003A	PhotometricInterpretation	0601	0300	01000000	06000000
	0046	ImageDescription	0E01	0200	0E000000	28010000
	0052	Make	0F01	0200	09000000	36010000
	005E	Model	1001	0200	08000000	40010000
	006A	StripOffsets	1101	0400	45000000	48010000
	0076	Orientation	1201	0300	01000000	01000000
	0082	SamplesPerPixel	1501	0300	01000000	03000000
	008E	RowsPerStrip	1601	0400	01000000	07000000
	009A	StripByteCounts	1701	0400	45000000	5C020000
	00A6	XResolution	1A01	0500	01000000	70030000
	00B2	YResolution	1B01	0500	01000000	78030000
	00BE	PlanarConfiguration	1C01	0300	01000000	01000000
	00CA	ResolutionUnit	2801	0300	01000000	02000000
	00D6	DateTime	3201	0200	14000000	80030000
	00E2	YCbCrSubSampling	1202	0300	02000000	02000100
	00EE	YCbCrPositioning	1302	0300	01000000	02000000
	00FA	Copyright	9882	0200	15000000	94030000
	0106	Exif IFD Pointer	6987	0400	01000000	AA030000
	0112	GPS IFD Offset	2588	0400	01000000	10050000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	011E	Next IFD Offset	7E060000			
Value longer than 4byte of 0th IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0122	BitPerSample Value	080008000800			
	0128	ImageDescription Value	"Exif_TIFF_YCC"00			
	0136	Make Value	"DSCompany"00			
	0140	Model Value	"Example"00			
	0148	StripOffsets Value	(offset0,offset1,offset2.....offset95)			
	025C	StripByteCounts Value	(count0, count1, count2....count95)			
	0370	XResolution Value	4800000001000000			
	037C	YResolution Value	4800000001000000			
	0380	DateTime Value	"1997:09:01 12:00:00"00			
	0394	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Interoperability Number (Hex)**			
	03AA	Exif IFD Number	1400			

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	Offset (Hex)	Name	Tag ID (Hex)	Type (Hex)	Count (Hex)	ValueOffset (Hex or "ASCII")
	03AC	ExposureTime	9A82	0500	01000000	A0040000
	03B8	FNumber	9D82	0500	01000000	A8040000
	03C4	ExifVersion	0090	0700	04000000	"0200"
	03D0	DateTimeOriginal	0390	0200	14000000	B0040000
	03DC	DateTimeDigitized	0490	0200	14000000	C4040000
	03E8	ShutterSpeedValue	0192	0A00	01000000	D8040000
	03F4	ApertureValue	0292	0500	01000000	E0040000
	0400	BrightnessValue	0392	0A00	01000000	E8040000
	040C	ExposureBiasValue	0492	0A00	01000000	F0040000
	0418	MaxApertureRatioValue	0592	0500	01000000	F8040000
	0424	SubjectDistance	0692	0500	01000000	00050000
	0430	MeteringMode	0792	0300	01000000	01000000
	043C	LightSource	0892	0300	01000000	01000000
	0448	Flash	0992	0300	01000000	01000000
	0454	FocalLength	0A92	0500	01000000	08050000
	0460	SubSecTime	9092	0200	04000000	"000"00
	046C	SubSecTimeOriginal	9192	0200	04000000	"000"00
	0478	SubSecTimeDigitized	9292	0200	04000000	"000"00
	0484	FlashPixVersion	A000	0700	04000000	"0100"
	0490	ColorSpace	A001	0300	01000000	01000000
	Offset (Hex)	**Name**			**Offset (Hex)**	
	049C	Next IFD Offset			00000000	
Value longer than 4 Bytes of Exif IFD	**Offset (Hex)**	**Name**			**Data (Hex or "ASCII")**	
	04A0	ExposureTime Value			010000003C000000	
	04A8	FNumber Value			0400000001000000	
	04B0	DateTimeOriginal Value			"1997:09:01 12:00:00"00	
	04C4	DateTimeDigitized Value			"1997:09:01 12:00:00"00	
	04D8	ShutterSpeed Value			0600000001000000	
	04E0	ApertureValue Value			0400000001000000	
	04E8	BrightnessValue Value			0000000001000000	
	04F0	ExposureBiasValue Value			0000000001000000	
	04F8	MaxApertureRatio Value			0100000001000000	
	0500	SubjectDistance Value			0F0000000A000000	
	0508	FocalLength Value			3200000001000000	
GPS IFD	**Offset (Hex)**	**Name**			**Interoperability Number (Hex)**	
	0510	GPS IFD Number			0013	
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	0512	GPSVersionIF	0000	0100	04000000	02000000
	051E	GPSLatitudeRef	0100	0200	02000000	"N"000000
	052A	GPSLatitude	0200	0500	03000000	FA050000
	0536	GPSLongitudeRef	0300	0200	02000000	"E"000000
	0542	GPSLongitude	0400	0500	03000000	12060000
	054E	GPSAltitudeRef	0500	0100	01000000	00000000
	055A	GPSAltitude	0600	0500	01000000	2A060000
	0566	GPSTimeStamp	0700	0500	03000000	32060000
	0572	GPSSatellites	0800	0200	0D000000	4A060000
	057E	GPSStatus	0900	0200	02000000	"A"000000
	058A	GPSMeasureMode	0A00	0200	02000000	"2"000000
	0596	GPSDOP	0B00	0500	01000000	58060000

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	05A2	GPSSpeedRef	0C00	0200	02000000	"K"000000
	05AE	GPSSpeed	0D00	0500	01000000	60060000
	05BA	GPSTrackRef	0E00	0200	02000000	"T"000000
	05C6	GPSTrack	0F00	0500	01000000	68060000
	05D2	GPSImgDirectionRef	1000	0200	02000000	"T"000000
	05DE	GPSImgDirection	1100	0500	01000000	70060000
	05EA	GPSMapDatum	1200	0200	06000000	78060000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	05F6	Next IFD Offset	00000000			
Value longer than 4 Bytes of GPS IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	05FA	GPSLatitude Value	230000000100000030000000010000000800000001000000			
	0612	GPSLongitude Value	8B0000000100000022000000010000003700000001000000			
	062A	GPSAltitude Value	E80B000064000000			
	0632	GPSTimeStamp Value	0000000001000000000000000100000000000000001000000			
	064A	GPSSatellites Value (Last Byte is padded)	"2,7,14,15,16"0000			
	0658	GPSDOP Value	0100000001000000			
	0660	GPSSpeed Value	0000000001000000			
	0668	GPSTrack Value	0000000001000000			
	0670	GPSImgDirection Value	0000000001000000			
	0678	GPSMapDatum Value	"TOKYO"00			
1st IFD	**Offset (Hex)**	**Name**	**Interoperability Number (Hex)**			
	067E	Number Of Interoperability	0F00			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	0680	ImageWidth	0001	0400	01000000	50000000
	068C	ImageLength	0101	0400	01000000	3C000000
	0698	BitsPerSample	0201	0300	03000000	38070000
	06A4	Compression	0301	0300	01000000	01000000
	06B0	PhotometricInterpretation	0601	0300	01000000	06000000
	06BC	StripOffsets	1101	0400	01000000	4E070000
	06C8	SamplesPerPixel	1501	0300	01000000	03000000
	06D4	RowsPerStrip	1601	0400	01000000	3C000000
	06E0	StripByteCounts	1701	0400	01000000	80250000
	06EC	XResolution	1A01	0500	01000000	3E070000
	06F8	YResolution	1B01	0500	01000000	46070000
	0704	PlanarConfiguration	1C01	0300	01000000	01000000
	0710	ResolutionUnit	2801	0300	01000000	02000000
	071C	YCbCrSubSampling	1202	0300	02000000	02000100
	0728	YCbCrPositioning	1302	0300	01000000	02000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	0734	Next IFD Offset	00000000			
Value longer than 4byte of 1st IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0738	BitPerSample Value	080008000800			
	073E	XResolution Value	4800000001000000			
	0746	YResolution Value	4800000001000000			
	074E	(Thumbnail Image Data Strip)				
Primary Image Data	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	2CCE	Image Data Strip0	:			

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4FCE	Image Data Strip1	:
:	:	:
:	:	:
0978CE	Image Data Strip68	:

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A.3 JPEG Compressed (4:2:2) File

Table 37 JPEG Compressed (4:2:2) File Description Sample Contents

Primary Image	
Recording Format	JPEG
Subsampling	YCC 4:2:2
Restart Markers	Inserted
Quantization Tables	3
Pixels	640 (W) x 480 (H)
Image Title	Exif_JPEG_422
Image Input Equipment Manufacturer	DS Company
Image Input Equipment Model Name	Example
Orientation	Normal
Image Resolution	72 dpi (Width), 72 dpi (Length)
File Change Date and Time	1997:09:01 12:00:00
Copyright	Copyright, ABCDE,1997
Exif-specific Information	
Version	Ver. 2.0
Date and Time of Original Image Creation	1997:09:01 12:00:00
Date and Time of File Creation	1997:09:01 12:00:00
Components	Y,Cb,Cr
Image Compression Mode	2bit/pel
Shutter Speed	59/10 (equivalent to 1/60 sec.)
Aperture	50/10 (equivalent to F:5.6)
Brightness	80/10
Exposure Bias	0/0
Maximum Lens Aperture	200/10
Subject Distance	20/10
Metering Mode	MultiSpot
Light Source	Daylight
Flash ON/OFF	ON
Thumbnails	
Recording Format	JPEG
Subsampling	YCC 4:2:2
Pixels	80 (W) x 60 (H)
Image Resolution	72 dpi (Width), 72 dpi (Length)

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Table 38 JPEG Compressed (4:2:2) File JPEG Stream Description Sample

Offset (Hex)	Maker Segment	Name	Code (Hex)	Comment
0000	SOI	SOI Marker	FFD8	Start of Image
0002	APP1	APP1 Marker	FFE1	
0004		APP1 Length	291C	
0006		Identifier	"Exif"00	
000B		Pad	00	
000C		APP1 Body		See Next Table
0E39	DQT	DQT Marker	FFDB	Define Quantization Table
0E3B		DQT Length	00C5	
0E3D		Pq, Tq	00	
0E3E		table elements	100B0C0E.....	64 Bytes of Data
0E7E		Pq,Tq	01	
0E7F		table elements	0F101016....	64 Bytes of Data
0EBF		Pq,Tq	02	
0EC0		table elements	0F101016....	64 Bytes of Data
0F00	DHT	DHT Marker	FFC4	
0F02		DHT Length	01A2	
0F04		Th	00	Table 0 for DC
0F05		Li	00010501....	
0F15		Vij	00010203....	
0F21		Th	10	Table 0 for AC
0F22		Li	00020103....	
0F32		Vij	01020300....	
0FD4		Th	01	Table 1 for DC
0FD5		Li	00030101....	
0FE5		Vij	00010203....	
0FF1		Th	11	Table 1 for AC
0FF2		Li	00020102....	
1002		Vij	00010203....	
10A4	DRI	DRI Marker	FFDD	
10A6		DRI Length	0004	
10A8		Ri	0004	
10AA	SOF0	SOF0 Marker	FFC0	
10AC		SOF0 Length	0011	
10AE		P	08	
10AF		Y	01E0	
10B1		X	0280	
10B3		Nf	03	
10B4		C1	01	
10B5		H1,V1	21	
10B6		Tq1	00	
10B7		C2	02	
10B8		H2,V2	11	
10B9		Tq2	01	
10BA		C3	03	
10BB		H3,V3	11	
10BC		Tq3	02	
10BD	SOS	SOS Marker	FFDA	
10BF		SOS Length	000C	
10C1		Ns	03	
10C2		Cs1	01	

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10C3		Td1,Ta1	00	
10C4		Cs2	02	
10C5		Td2,Ta2	11	
10C6		Cs3	03	
10C7		Td3,Ta3	11	
10C8		Ss	00	
10C9		Se	3F	
10CA		Ah,Al	00	
10CB	Image Data		F36A....	Compressed Data
111C4	EOI		FFD9	

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Table 39 JPEG Compressed (4:2:2) File APP1 Description Sample

	Offset (Hex)	Name	Data (Hex or "ASCII")			
Header	0000	Byte Order	4D4D ("II")			
	0002	42	2A00			
	0004	0th IFD Offset	08000000			
	Offset (Hex)	**Name**	**Interoperability Number (Hex)**			
	0008	Number of Interoperability	0B00			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageDescription	0E01	0200	0E000000	92000000
	0016	Make	0F01	0200	09000000	A0000000
	0022	Model	1001	0200	08000000	AA000000
	002E	Orientation	1201	0300	01000000	01000000
0th IFD	003A	XResolution	1A01	0500	01000000	B2000000
	0046	YResolution	1B01	0500	01000000	BA000000
	0052	ResolutionUnit	2801	0300	01000000	02000000
	005E	DateTime	3201	0200	14000000	C2000000
	006A	YCbCrPositioning	1302	0300	01000000	02000000
	0076	CopyRight	9882	0200	15000000	D6000000
	0082	Exif IFD Pointer	6987	0400	01000000	EC000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	008E	Next IFD Offset	C402			
	Offset (Hex)	**Name**	**Data (Hex or "ASCII")**			
	0092	ImageDescription Value	"Exif_JPEG_422"00			
Value longer than 4byte of 0th IFD	00A0	Make Value	"DSCompany"00			
	00AA	Model Value	"Example"00			
	00B2	XResolution Value	4800000001000000			
	00BA	YResolution Value	4800000001000000			
	00C2	DateTime Value	"1997:09:01 12:00:00"00			
	00D6	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Interoperability Number (Hex)**			
	00EC	Exif IFD Number	1900			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	00EE	ExposureTime	9A82	0500	01000000	1E020000
	00FA	FNumber	9D82	0500	01000000	26020000
	0106	ExifVersion	0090	0700	04000000	"0200"
	0112	DateTimeOriginal	0390	0200	14000000	2E020000
	011E	DateTimeDigitized	0490	0200	14000000	42020000
	012A	ComponentsConfiguration	0191	0700	04000000	01020000
	0136	CompressedBitsPerPixel	0292	0500	01000000	56020000
	0142	ShutterSpeedValue	0192	0A00	01000000	5E020000
	014E	ApertureValue	0292	0500	01000000	66020000
	015A	BrightnessValue	0392	0A00	01000000	6E020000
	0166	ExposureBiasValue	0492	0A00	01000000	76020000
	0172	MaxApertureRatioValue	0592	0500	01000000	7E020000
	017E	SubjectDistance	0692	0500	01000000	86020000
	018A	MeteringMode	0792	0300	01000000	01000000

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	0196	LightSource	0892	0300	01000000	01000000
	01A2	Flash	0992	0300	01000000	00000000
	01AE	FocalLength	0A92	0500	01000000	8E020000
	01BA	UserComments	8692	0700	2E000000	96020000
	01C6	SubSecTime	9092	0200	04000000	"000"00
	01D2	SubSecTimeOriginal	9192	0200	04000000	"000"00
	01DE	SubSecTimeDigitized	9292	0200	04000000	"000"00
	01EA	FlashPixVersion	A000	0700	04000000	"0100"
	01F6	Colorspace	A001	0300	01000000	01000000
	0202	Pixel X Dimension	A002	0400	01000000	80020000
	020E	Pixel Y Dimension	A003	0400	01000000	E0010000
	Offset (Hex)	**Name**			**Offset (Hex)**	
	021A	Next IFD Offset			00000000	
Value longer than 4 Bytes of Exif IFD	**Offset (Hex)**	**Name**			**Data (Hex or "ASCII")**	
	021E	ExposureTime Value			010000003C000000	
	0226	FNumber Value			0400000001000000	
	022E	DateTimeOriginal Value			"1997:09:01 12:00:00"00	
	0242	DateTimeDigitized Value			"1997:09:01 12:00:00"00	
	0256	CompressedBitsPerPixel Value			0200000001000000	
	025E	ShutterSpeedValue Value			0600000001000000	
	0266	ApertureValue Value			0400000001000000	
	026E	BrightnessValue Value			0000000001000000	
	0276	ExposureBiasValue Value			0000000001000000	
	027E	MaxApertureRatioValue Value			0100000001000000	
	0286	SubjectDistance Value			0F0000000A000000	
	028E	FocalLength Value			3200000001000000	
	0296	UserComment Value (46 Bytes)			4A49530000000000....	
1st IFD	**Offset (Hex)**	**Name**			**Interoperability Number (Hex)**	
	02C4	Number Of Interoperability			0700	
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	02C6	Compression	0301	0300	01000000	01000000
	02D2	XResolution	1A01	0500	01000000	1E030000
	02DE	YResolution	1B01	0500	01000000	26030000
	02EA	ResolutionUnit	2801	0300	01000000	02000000
	02F6	JPEGInterchangeFormat	0102	0400	01000000	2D0E0000
	0302	JPEGInterchangeFormatLength	0202	0400	01000000	FF0A0000
	030E	YCbCrPositioning	1302	0300	01000000	02000000
	Offset (Hex)	**Name**			**Offset (Hex)**	
	031A	Next IFD Offset			00000000	
Value longer than 4byte of 1st IFD	**Offset (Hex)**	**Data (Hex or "ASCII")**			**Name**	
	031E	4800000001000000			XResolution Value	
	0326	4800000001000000			YResolution Value	
Thumbnail Image Data	**Offset (Hex)**	**Name**			**Data**	
	032E	Thumbnail Data			(JPEG Stream)	

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A.4 JPEG Compressed (4:2:0) File

Table 40 JPEG Compressed (4:2:0) File Description Sample Contents

Primary Image	
Recording Format	JPEG
Subsampling	YCC 4:2:0
Restart Markers	Inserted
Quantization Tables	2
Pixels	620 (W) x 475 (H)
Image Title	620x475
SOF Recorded Pixels	640x475
DCT Data	640x480
Image Title	Exif_JPEG_420
Image Input Equipment Manufacturer	DSCompany
Image Input Equipment Model Name	Example
Orientation	Normal
Image Resolution	72 dpi (Width), 72 dpi (Length)
File Change Date and Time	1997:09:01 12:00:00
Copyright	Copyright, ABCDE,1997
Exif-specific Information	
Version	Ver. 2.0
Date and Time of Original Image Creation	1997:09:01 12:00:00
Date and Time of File Creation	1997:09:01 12:00:00
Components	Y,Cb,Cr
Image Compression Mode	2bit/pel
Shutter Speed	59/10 (equivalent to 1/60 sec.)
Aperture	50/10 (equivalent to F:5.6)
Brightness	80/10
Exposure Bias	0/0
Maximum Lens Aperture	200/10
Subject Distance	20/10
Metering Mode	MultiSpot
Light Source	Daylight
Flash ON/OFF	ON
Thumbnails	
Recording Format	TIFF
Subsampling	YCC 4:2:0
Pixels	80x60
Image Resolution	72 dpi (Width), 72 dpi (Length)

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Table 41 JPEG Compressed (4:2:0) File JPEG Stream Description Sample

Offset (Hex)	Maker Segment	Name	Code (Hex)	Comment
0000	SOI	SOI Marker	FFD8	Start of Image
0002	APP1	APP1 Marker	FFE1	
0004		APP1 Length	1FBC	
0006		Identifier	"Exif"00	
000B		Pad	00	
000C		APP1 Body		See Next Table
1FC0	DQT	DQT Marker	FFDB	Define Quantization Table
1FC2		DQT Length	0084	
1FC4		Pq, Tq	00	
1FC5		table elements	08060607....	64 Bytes of Data
2005		Pq,Tq	01	
2006		table elements	0909090C....	64 Bytes of Data
2046	DHT	DHT Marker	FFC4	
2048		DHT Length	01A2	
204A		Th	00	Table 0 for DC
204B		Li	00010501....	
205B		Vij	00010203....	
2067		Th	10	Table 0 for AC
2068		Li	00020103....	
2078		Vij	01020300....	
211A		Th	01	Table 1 for DC
211B		Li	00030101....	
212B		Vij	00010203....	
2137		Th	11	Table 1 for AC
2138		Li	00020102....	
2148		Vij	00010203....	
21EA	DRI	DR Marker	FFDD	
21EC		DRI Length	0004	
21EE		Ri	0004	
21F0	SOF0	SOF0 Marker	FFC0	
21F2		SOF0 Lentth	0011	
21F4		P	08	
21F5		Y	01DB	
21F7		X	0280	
21F9		Nf	03	
21FA		C1	01	
21FB		H1,V1	22	
21FC		Tq1	00	
21FD		C2	02	
21FE		H2,V2	11	
21FF		Tq2	01	
2200		C3	03	
2201		H3,V3	11	
2202		Tq3	01	
2203	SOS	SOS Marker	FFDA	
2205		SOS Length	000C	
2207		Ns	03	
2208		Cs1	01	
2209		Td1,Ta1	00	
220A		Cs2	02	

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220B		Td2,Ta2	11	
220C		Cs3	03	
220D		Td3,Ta3	11	
220E		Ss	00	
220F		Se	3F	
2210		Ah,Al	00	
2211	Image Data		F9FE....	Compressed Data
13BA4	EOI		FFD9	

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Table 42 JPEG Compressed (4:2:0) File APP1 Description Sample

Header	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0000	Byte Order	4D4D ("II")			
	0002	42	2A00			
	0004	0th IFD Offset	08000000			
	Offset (Hex)	**Name**	**Interoperability Number (Hex)**			
	0008	Number of Interoperability	0B00			
0th IFD	**Offset (Hex)**	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	000A	ImageDescription	0E01	0200	0E000000	92000000
	0016	Make	0F01	0200	09000000	A0000000
	0022	Model	1001	0200	08000000	AA000000
	002E	Orientation	1201	0300	01000000	01000000
	003A	XResolution	1A01	0500	01000000	B2000000
	0046	YResolution	1B01	0500	01000000	BA000000
	0052	ResolutionUnit	2801	0300	01000000	02000000
	005E	DateTime	3201	0200	14000000	C2000000
	006A	YCbCrPositioning	1302	0300	01000000	02000000
	0076	Copyright	9882	0200	15000000	D6000000
	0082	Exif IFD Pointer	6987	0400	01000000	EC000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	008E	Next IFD Offset	C402			
Value longer than 4byte of 0th IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	0092	ImageDescription Value	"Exif_JPEG_420"00			
	00A0	Make Value	"DSCompany"00			
	00AA	Model Value	"Example"00			
	00B2	XResolution Value	4800000001000000			
	00BA	YResolution Value	4800000001000000			
	00C2	DateTime Value	"1997:09:01 12:00:00"00			
	00D6	Copyright Value (Last Byte is Padded)	"Copyright,ABCDE,1997"0000			
Exif IFD	**Offset (Hex)**	**Name**	**Interoperability Number (Hex)**			
	00EC	Exif IFD Number	1900			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	00EE	ExposureTime	9A82	0500	01000000	1E020000
	00FA	FNumber	9D82	0500	01000000	26020000
	0106	ExifVersion	0090	0700	04000000	"0200"
	0112	DateTimeOriginal	0390	0200	14000000	2E020000
	011E	DateTimeDigitized	0490	0200	14000000	42020000
	012A	ComponentsConfiguration	0191	0700	04000000	01020300
	0136	CompressedBitsPerPixel	0292	0500	01000000	56020000
	0142	ShutterSpeedValue	0192	0A00	01000000	5E020000
	014E	ApertureValue	0292	0500	01000000	66020000
	015A	BrightnessValue	0392	0A00	01000000	6E020000
	0166	ExposureBiasValue	0492	0A00	01000000	76020000
	0172	MaxApertureRatioValue	0592	0500	01000000	7E020000
	017E	SubjectDistance	0692	0500	01000000	86020000
	018A	MeteringMode	0792	0300	01000000	01000000

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	0196	LightSource	0892	0300	01000000	01000000
	01A2	Flash	0992	0300	01000000	00000000
	01AE	FocalLength	0A92	0500	01000000	8E020000
	01BA	UserComments	8692	0700	2E000000	96020000
	01C6	SubSecTime	9092	0200	04000000	30303000
	01D2	SubSecTimeOriginal	9192	0200	04000000	"000"00
	01DE	SubSecTimeDigitized	9292	0200	04000000	"000"00
	01EA	FlashPixVersion	A000	0700	04000000	"0100"
	01F6	ColorSpace	A001	0300	01000000	01000000
	0202	Pixel X Dimension	A002	0400	01000000	6C020000
	020E	Pixel Y Dimension	A003	0400	01000000	DB010000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	021A	Next IFD Offset	00000000			
Value longer than 4 Bytes of Exif IFD	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			
	021E	ExposureTime Value	010000003C000000			
	0226	FNumber Value	0400000001000000			
	022E	DateTimeOriginal Value	"1997:09:01 12:00:00"00			
	0242	DateTimeDigitized Value	"1997:09:01 12:00:00"00			
	0256	CompressedBitsPerPixel Value	0200000001000000			
	025E	ShutterSpeedValue Value	0600000001000000			
	0266	ApertureValue Value	0400000001000000			
	026E	BrightnessValue Value	0000000001000000			
	0276	ExposureBiasValue Value	0000000001000000			
	027E	MaxApertureRatioValue Value	0100000001000000			
	0286	SubjectDistance Value	0F0000000A000000			
	028E	FocalLength Value	3200000001000000			
	0296	UserComment Value (46 Bytes)	4A49530000000000....			
1st IFD	**Offset (Hex)**	**Name**	**Interoperability Number (Hex)**			
	02C4	Number Of Interoperability	0F00			
	Offset (Hex)	**Name**	**Tag ID (Hex)**	**Type (Hex)**	**Count (Hex)**	**ValueOffset (Hex or "ASCII")**
	02C6	ImageWidth	0001	0400	01000000	50000000
	02D2	ImageLength	0101	0400	01000000	3C000000
	02DE	BitsPerSample	0201	0300	03000000	7E030000
	02EA	Compression	0301	0300	01000000	01000000
	02F6	PhotometricInterpretation	0601	0300	01000000	06000000
	0302	StripOffsets	1101	0400	01000000	94030000
	030E	SamplesPerPixel	1501	0300	01000000	03000000
	031A	RowsPerStrip	1601	0400	01000000	3C000000
	0326	StripByteCounts	1701	0400	01000000	201C0000
	0332	XResolution	1A01	0500	01000000	84030000
	033E	YResolution	1B01	0500	01000000	8C030000
	034A	PlanarConfiguration	1C01	0300	01000000	01000000
	0356	ResolutionUnit	2801	0300	01000000	02000000
	0362	YCbCrSubSampling	1202	0300	02000000	02000200
	036E	YCbCrPositioning	1302	0300	01000000	02000000
	Offset (Hex)	**Name**	**Offset (Hex)**			
	037A	Next IFD Offset	00000000			
Value longer than	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**			

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4byte of 1st IFD	037E	BitsPerSample Value	080008000800
	0384	XResolution Value	4800000001000000
	038C	YResolution Value	4800000001000000
Thumbnail Image Data	**Offset (Hex)**	**Name**	**Data (Hex or "ASCII")**
	0394	Thumbnail Image Data Strip	:

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Appendix B Audio File Description Examples

B.1 PCM Audio Data

Table 43 PCM Audio File Description Sample Contents

Audio Data	
Format Type	PCM Format
Channels	monaural
Sampling Frequency	22.05 kHz
Bits per Sample	8 Bits/Sample
Total Samples	27768 Samples
Attribute Information	
Audio Title	ExifPCMExampleZ
Audio Genre	None
Recording Date	1997-07-13
Recording Engineer	Taro Yamada
Copyright	Copyright Exif Corporation on 1997.
Exif-specific Information	
Exif Version	0200 (Version 2.0)
Related Exif Image File	DSC00001.JPGZ
Recording Start Time	10:15:30.130Z
Recording Equipment Manufacturer	DSC CorporationZ
Recording Equipment Model	DSC1000Z
Manufacturer Note	None
User Comment	None

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Table 44 PCM Audio File Description Example

	Offset (Hex)	Name	Comment	Data (Hex or "ASCII")
RIFF-ck	0000	ckID	RIFF	52494646
	0004	ckSize		766D0000
	0008	formType	WAVE	57415645
fmt-ck	000C	ckID	fmt_	666D7420
	0010	ckSize		10000000
	0014	wFormatTag	PCM Format	0100
	0016	nchannels	monaural	0100
	0018	nSamplesPerSec	22.05 kHz	22560000
	001C	nAvgBytesPerSec	22050 bytes/sec	22560000
	0020	nBlockAlign	1 byte/block	0100
	0022	wBitsPerSample	8 bits/sample	0800
INFO-LIST	0024	ckID	LIST	4C495354
	0028	ckSize		6E000000
	002C	listType	"INFO"	494E464F
INAM-ck	0030	ckID	INAM	494E414D
	0034	ckSize		0F000000
	0038	ckData	(audio title)	"ExifPCMExample"0000
ICRD-ck	0048	ckID	ICRD	49435244
	004C	ckSize		0B000000
	0050	ckData	(July 13, 1997)	"1997-07-13"0000
IART-ck	005C	ckID	IART	49415254
	0060	ckSize		0C000000
	0064	ckData	(creator)	"Taro Yamada"00
ICOP-ck	0070	ckID	ICOP	49434F50
	0074	ckSize		21000000
	0078	ckData	(copyright)	"Copyright Exif Corporation on 1997."0000
exif-LIST	009A	ckID	LIST	4C495354
	009E	ckSize		64000000
	00A2	listType	exif	65786966
ever-ck	00A6	ckID	ever	65766572
	00AA	ckSize		4000000
	00AE	ckData	Ver. 2.0	200
erel-ck	00B2	ckID	erel	6572656C
	00B6	ckSize		0D000000
	00BA	ckData	(relation to Exif image file)	"DSC00001.JPG"0000
etim-ck	00C8	ckID	etim	6574696D
	00CC	ckSize		0D000000
	00D0	ckData	(10:15:30.130)	"10:15:30.130"0000
ecor-ck	00DE	ckID	ecor	65636F72
	00E2	ckSize		10000000
	00E6	ckSize	(equipment manufacturer)	"DSC Corporation"00
emdl-ck	00F6	ckID	emdl	656D646C
	00FA	ckSize		8000000
	00FE	ckData	(equipment model)	"DSC1000"00
data-ck	0106	ckID	data	64617461
	010A	ckSize		706C0000
	010E	ckData	PCM Audio Data	00000000000.....

(Total samples = 27768)

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B.2 μ-Law Audio Data

Table 45 μ-Law Audio File Description Sample Contents

Audio Data	
Format Type	μ-LAW PCM
Channels	monaural
Sampling Frequency	8.000 kHz
Bits per Sample	8 bits
Total Samples	111912
Attribute Information	
Audio Title	μ-LAW PCM ExampleZ
Audio Genre	GreetingZ
Recording Date	1997-07-17
Recording Engineer	Interoperability Multimedia AssociationZ
Copyright	Copyright ABCZ
Exif-specific Information	
Exif Version	0200 (Version 2.0)
Related Exif Image File	DSC00001.JPGZ
Recording Start Time	10:20:30.130Z
Recording Equipment Manufacturer	ABCD CorporationZ
Recording Equipment Model	Camera XYZZ
Manufacturer Note	0000000000000000
User Comment	User Comment (ASCII)

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Table 46 μ-Law Audio File Description Sample

	Offset (Hex)	Name	Comment	Data (Hex or "ASCII")
RIFF-ck	0000	ckID	RIFF	52494646
	0004	ckSize		AAB60100
	0008	formType	WAVE	57415645
fmt-ck	000C	ckID	fmt_	666D7420
	0010	ckSize		12000000
	0014	wFormatTag	μ-Law Format	0700
	0016	nchannels	monaural	0100
	0018	nSamplesPerSec	8.00 kHz	401F0000
	001C	nAvgBytesPerSec	8.00Kbytes/sec	401F0000
	0020	nBlockAlign	1 byte/block	0100
	0022	wBitsPerSample	8 bits/sample	0800
	0024	cbSize	0	0000
fact-ck	0026	ckID	fact	66616374
	002A	ckSize		04000000
	002E	dwSampleLength		28B50100
INFO-LIST	0032	ckID	LIST	4C495354
	0036	ckSize		AC000000
	003A	listType	INFO	494E464F
INAM-ck	003E	ckID	INAM	494E414D
	0042	ckSize		12000000
	0046	ckData	(audio title)	"uLAW PCM Example"00
IGNR-ck	0058	ckID	IGNR	49474E52
	005C	ckSize		09000000
	0060	ckData	(recording genre)	"Greeting"Z
ICRD-ck	006A	ckID	ICRD	49435244
	006E	ckSize		0B000000
	0072	ckData	(July 17, 1997)	"1997-07-17"00
ICMT-ck	007E	ckID	ICMT	49434D54
	0082	ckSize		18000000
	0086	ckData	(This File μ-LAW Sample)	"This File uLAW Sample"000000
IART-ck	009E	ckID	IART	49415254
	00A2	ckSize		23000000
	00A6	ckData	(creator)	"Interoperability Multimedia Association"00
ICOP-ck	00CA	ckID	ICOP	49434F50
	00CE	ckSize		10000000
	00D2	ckData	(creator)	"ABCD Corporation"00
exif-LIST	00E2	ckID	LIST	4C495354
	00E6	ckSize		94000000
	00EA	listType	exif	65786966
ever-ck	00EE	ckID	ever	4C495354
	00F2	ckSize		94000000
	00F6	ckData	Ver. 2.0	65786966
erel-ck	00FA	ckID	erel	4C495354
	00FE	ckSize		94000000
	0102	ckData	(relation to Exif image file)	"DSC00001.JPG"00
etim-ck	0110	ckID	etim	4C495354
	0114	ckSize		94000000
	0118	ckData	(10:20:30.130)	"10:20:30.130"00
ecor-ck	0126	ckID	ecor	4C495354
	012A	ckSize		94000000

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		012E	ckSize	(equipment manufacturer)	"ABCD Corporation"00
	emdl-ck	0140	ckID	emdl	656D646C
		0144	ckSize		0A000000
		0148	ckData	(equipment model)	"Camera XY"0000
	emnt-ck	0152	ckID	emnt	656D6E74
		0156	ckSize		08000000
		015A	ckData	(manufacturer note)	0000000000000000
	eucm-ck	0162	ckID	eucm	6575636D
		0166	ckSize		14000000
		016A	ckData	(user comment)	4153434949000000557365722043 6F6D
data-ck		017E	ckID	data	64617461
		0182	ckSize		28B50100
		0186	ckData	µ-Law Audio Data	F2FE00007FFF0000E3.....

(Total samples = 111912)

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B.3 IMA-ADPCM Audio Data

Table 47 IMA-ADPCM Audio File Description Sample Contents

Audio Data	
Format Type	IMA-ADPCM Format
Channels	stereo
Sampling Frequency	8.000 kHz
Bytes per Block	8110 bytes/sec
Bits per Sample	4 bits/sample
Total Data Bytes	35840 bytes
Attribute Information	
Audio Title	IMA-ADPCM ExampleZ
Audio Genre	None
Recording Date	1997-08-11Z
Comment	None
Recording Engineer	Hanako YamadaZ
Copyright	Copyright XYZ on 1997.Z
Exif-specific Information	
Exif Version	0200 (Version 2.0)
Related Exif Image File	DSC00001.JPGZ
Recording Start Time	15:14:13.135Z
Recording Equipment Manufacturer	DSC Interoperability CorporationZ
Recording Equipment Model	DSC Camera-2Z
Manufacturer Note	None
User Comment	None

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Table 48 IMA-ADPCM Audio File Description Example

	Offset (Hex)	Name	Comment	Data (Hex or "ASCII")
RIFF-ck	0000	ckID	RIFF	52494646
	0004	ckSize		248D0000
	0008	formType	WAVE	57415645
fmt-ck	000C	ckID	"fmt_"	666D7420
	0010	ckSize	IMA-ADPCM Format	14000000
	0014	wFormatTag		1100
	0016	nchannels	stereo	0200
	0018	nSamplesPerSec	8.0kHz	401F0000
	001C	nAvgBytesPerSec	8110 bytes/sec	AE1F0000
	0020	nBlockAlign	512 bytes/block	0002
	0022	wBitsPerSample	4 bits/sample	0400
	0024	cbSize	Additional bytes = 2	0200
	0026	wSamplesPerBlock	505 bytes/block	F901
fact-ck	0028	ckID	fact	66616374
	002C	ckSize		04000000
	0030	dwSampleLength	35350 samples	168A0000
INFO-LIST	0034	ckID	LIST	4C495354
	0038	ckSize		68000000
	003C	listType	INFO	494E464F
INAM-ck	0040	ckID	INAM	494E414D
	0044	ckSize		12000000
	0048	ckData	(audio title)	"IMA-ADPCM Example"00
IGNR-ck	0058	ckID	IGNR	49474E52
	005C	ckSize		09000000
	0060	ckData	(recording genre)	"Greeting"Z
ICRD-ck	005A	ckID	ICRD	49435244
	005E	ckSize		0B000000
	0062	ckData	(August 11, 1997)	"1997-08-11"0000
IART-ck	006E	ckID	IART	49415254
	0072	ckSize		0E000000
	0076	ckData	(creator)	"Hanako Yamada"00
ICOP-ck	0084	ckID	ICOP	49434F50
	0088	ckSize		17000000
	008C	ckData	(copyright)	"Copyright XYZ on 1997."0000
exif-LIST	00E2	ckID	LIST	4C495354
	00E6	ckSize		94000000
	00EA	listType	exif	65786966
ever-ck	00A4	ckID	LIST	4C495354
	00A8	ckSize		78000000
	00AC	listType	exif	65786966
erel-ck	00BC	ckID	erel	6572656C
	00C0	ckSize		0D000000
	00C4	ckData	(relation to Exif image file)	"DSC00001.JPG"0000
etim-ck	00D2	ckID	etim	6574696D
	00D6	ckSize		0D000000
	00DA	ckData	(15:14:13.135)	"15:14:13.135"0000
ecor-ck	00E8	ckID	ecor	65636F72
	00EC	ckSize		1E000000
	00F0	ckSize	(equipment manufacturer)	"DSC Interoperability Corporation"00
emdl-ck	010E	ckID	emdl	656D646C

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	0112	ckSize		0D000000
	0116	ckData	(equipment model)	"DSC Camera-2"0000
data-ck				
	0124	ckID	data	64617461
	0128	ckSize		008C0000
	012C	ckData		.....

(Total bytes = 35840)

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Appendix C APEX Units

The camera information in this standard conforms to the APEX (Additive System of Photographic Exposure) unit system. APEX is a convenient unit for expressing exposure (Ev). The relation of APEX to other units is essentially as follows.

- ApertureValue (Av) = 2 $\log_2$ (F number)
- ShutterSpeedValue (Tv) = - $\log_2$ (exposure time)
- BrightnessValue (Bv) = $\log_2$ (B/NK) Note that: B:cd/cm^2, N,K: constant

Film sensitivity (not used in this standard) is expressed as follows.

- Film sensitivity (Sv) = $\log_2$ (ASA / 3.125)

Using these values, exposure (Ev) is calculated as follows.

- Ev = Av + Tv = Bv + Sv

The table below gives examples of values actually used as camera information.

Table 49 Typical APEX Values

ApertureValue (APEX)	F-Number
0	1
1	1.4
2	2
3	2.8
4	4
5	5.6
6	8
7	11
8	16
9	22
10	32

ShutterSpeed Value (APEX)	ExposureTime (second)
-5	30
-4	15
-3	8
-2	4
-1	2
0	1
1	1/2
2	1/4
3	1/8
4	1/15
5	1/30
6	1/60
7	1/125
8	1/250
9	1/500
10	1/1000
11	1/2000

BrightnessValue (APEX)	foot lambert
-2	1/4
-1	1/2
0	1
1	2
2	4
3	8
4	15
5	30

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Appendix D Recommended Implementation Examples

The purpose of this chapter is not to restrict Exif implementations, but to show examples of recommended practices that will increase the level of compatibility among DSC cameras and related systems using general-purpose removable media such as PC Card or Smart Media.

The practices illustrated below are recommended for DSC and other embedded systems when the processing capacity for handling the recording media is limited.

D.1 Recommended Directory Name Usage Examples

Writers

Create a subdirectory "IMxxxxxx" Interoperability the root directory, and record the Exif file there. The "xxxxxx" part of the name consists of no more than 6 alphanumerics and cannot contain special characters. "IM" are upper case. Hereafter this is called the Exif directory.

D.2 Recommended File Naming Usage Examples

Readers

An Exif reader plays the files in the Exif directory noted in D.1 above, treating those with the extension "JPG" as Exif compressed files, those with the extension "TIF" as Exif uncompressed files, and those with the extension "WAV" as audio files. On this basis it confirms the mandatory tags or chunk data in the file and plays it as appropriate. No specification is made regarding the handling of files with extensions other than the above.

D.3 Recommended File Operation Usage Examples

Exif compressed files, uncompressed files and audio files can be recorded in the same Exif directory. It is also possible to create two or more Exif directories Interoperability the root directory, so long as the stipulations for "IMxxxxxx" (in D.1 above) are observed. A specific usage case is given below.

Usage case

If the recording medium already has an Exif directory (e.g., IMXYZ) recorded by a different model, separate from the self-recorded Exif directory (e.g., IMFIDX10), then a self-recorded Exif directory (IMFIDX10) can be created

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Interoperability the root directory and used to record Exif files.

In this case the existing Exif directory (IMXYZ) continues to be preserved on the medium (see Fig. 50).

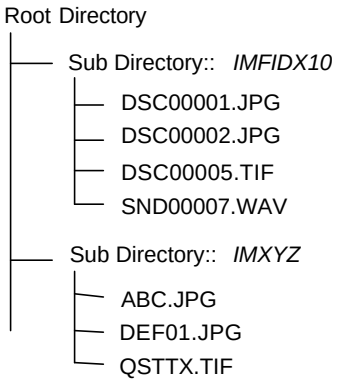


Fig. 50 Directory Structure and File Recording Example

Readers

The reader recognizes an Exif directory "IMxxxxxx" in the root directory (a subdirectory with "IM" as the first two letters of its name) and files in it that meet the naming conventions in section 2.8.3 and section 3.7.1, and plays the file if the contents of the mandatory tags or chunks match the equipment specifications.

When there are multiple Exif directories "IMxxxxxx" Interoperability the root directory, it must be possible to recognize the files recorded in those directories.

D.4 Interoperability "Recommended Exif Interoperability Rules" (ExifR98)

ExifR98 is established as detailed rules recommended by this specification to ensure the more playback Interoperability among the devices using this specification. In ExifR98 naming rules of directories and files to store images are defined more concretely in conformance with this specification and the thumbnail format and covering range of playback is defined according to the function of devices.

Separate Volume Recommended Exif Interoperability Rules Version 1.0

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Appendix E Color Space Guidelines

These guidelines are given with reference to sRGB[xviii], ITU-R BT.709[xix], and ITU-R BT.601[xx]. For details see the documents themselves.

E.1 sRGB

The sRGB standard gives strict color space definitions based on standard monitor characteristics and viewing conditions (details are Interoperability deliberation in IEC/TC 100 PT 61966). This standard takes the characteristics of typical commercially available displays as its median reference values.

ITU-R BT.709 is a standard specification for cameras, which specifies algorithms for photographing a scene and displaying it on a standard monitor. It does not, however, give a clear specification of the standard monitor characteristics. Accordingly, sRGB can be thought of as a standard that augments and is compatible with ITU-R BT.709.

In actual camera design, the ITU-R BT.709 characteristics can be used as the picture-taking algorithms, presupposing the standard monitor characteristics and viewing conditions given in sRGB, in order to generate images with a standard color space.

E.2 Tone Reproduction (Brightness and Contrast)

Scene reflectance can be nonlinearly converted based on ITU-R BT.709, and recorded using 8-bit quantization.

The ITU-R BT.709 transfer characteristics are as follows.

(1) When R, G, B equal or lager than 0.018

$R' = 1.099R^{0.45}-0.099$

$G' = 1.099G^{0.45}-0.099$

$B' = 1.099B^{0.45}-0.099$

(2) When R, G, B less than 0.018

$R' = 4.5R$

$G' = 4.5G$

$B' = 4.5B$

After this conversion takes place, the data are enlarged by a factor of 255 and recorded using 8-bit quantization.

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E.3 Luminance/Chrominance and RGB Transformation

Calculation of R, G, B from luminance Y and chrominance Cb and Cr takes place as follows based on ITU-R BT.601.

Y = 0.299R + 0.587G + 0.114B

Cb = (-0.299R - 0.587G + 0.886B) * 0.564 + offset

Cr = (0.701R - 0.587G - 0.114B) * 0.713 + offset

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Appendix F Notes on Conversion to FlashPix

The data recording method in this standard makes it possible to convert from Exif to FlashPix format with no loss of image quality, and retaining all attribute information. A file that is thus designed from the start for conversion to FlashPix is called a FlashPix-Ready (FPXR) file.

There are three main FlashPix-Ready functions:

- All Exif tag information is mapped to the FlashPix Image Info Property Set,
- APP2 extended data can be converted to FlashPix extensions,
- JPEG images can be converted to the FlashPix tile structure without image quality loss, making use of restart markers.

Fig. 51 illustrates the conversion process.

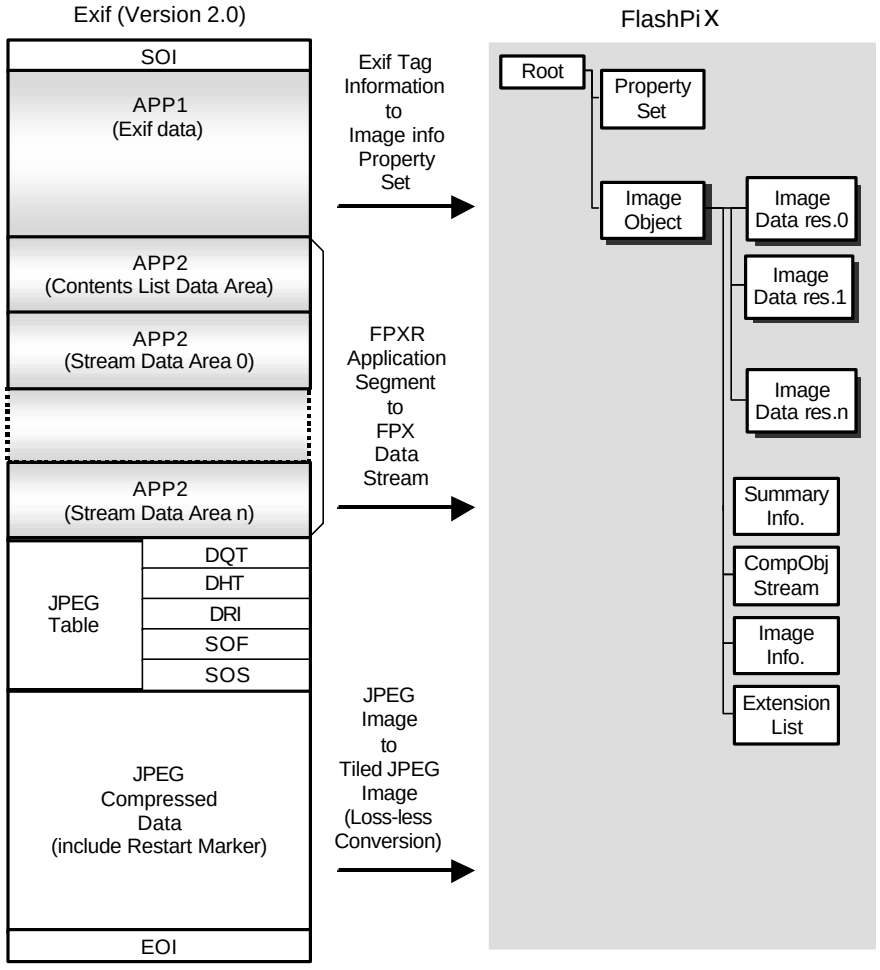


Fig. 51 Conversion from Exif to FlashPix

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F.1 Converting Image Data

FlashPix compressed image data consists of JPEG-compressed 64 x 64-pixel tiles. Converting JPEG images without restart markers to FlashPix images requires that the JPEG data be expanded and re-compressed, which can lead to image quality loss. By inserting restart markers at 64-pixel Interoperability, FlashPix images of the maximum resolution can be generated simply by rearranging the JPEG-compressed data.

Fig. 52 shows how compressed data is rearranged using restart markers.

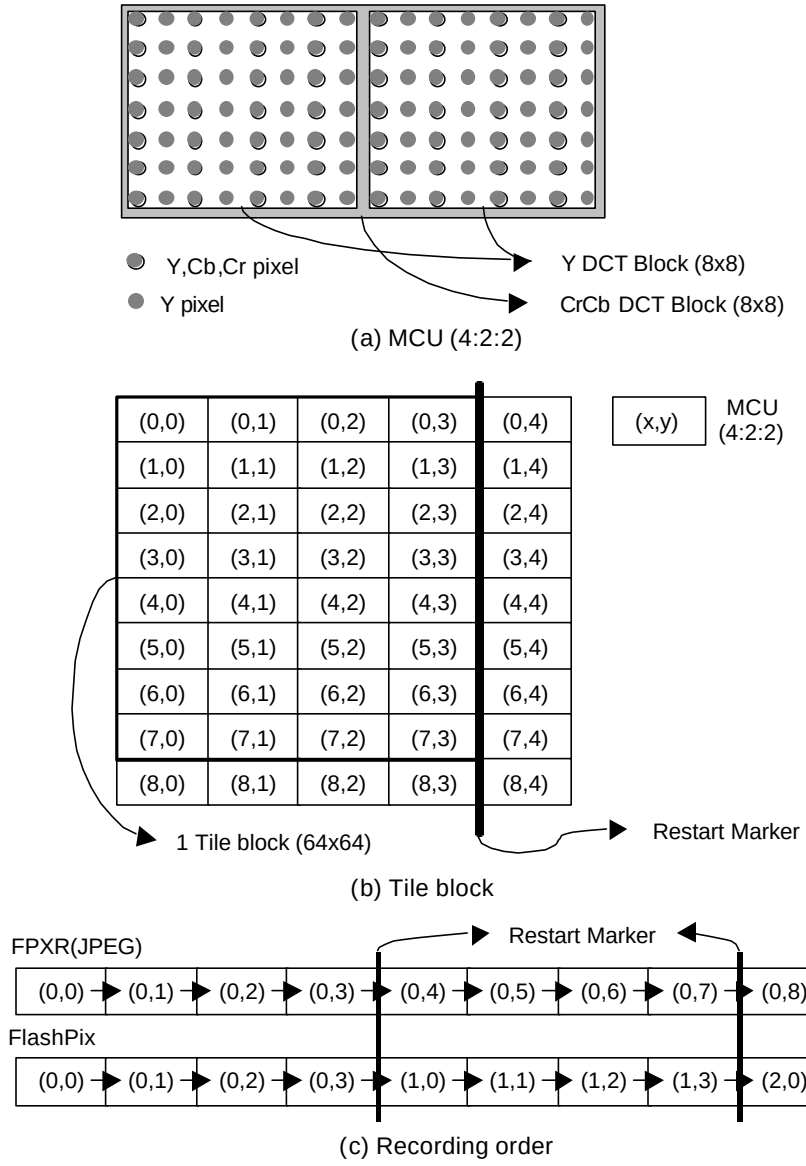


Fig. 52 Conversion to FlashPix Using Restart Markers

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Recording of restart markers is optional, and conversion to FlashPix is possible without them; but conversion without restart markers may result in some image quality loss and require a longer processing time.

In order for restart markers to be inserted at 64-pixel Interoperability, the image data width must be an exact multiple of 64. Therefore the valid image width is recorded as tag information (*PixelXDimension*), and the JPEG compressed data is recorded with the valid image padded to the right to make it an exact multiple of 64 (see section 2.8.1).

As in the FlashPix standard, padding is used where necessary to achieve exact multiples of 64; and when converting to FlashPix, the padding data on the right can be treated in the same way as valid image data.

If the image height is not an exact multiple of 64, Exif files are not padded; so when converting to FlashPix it is necessary to pad the bottom edge of the image.

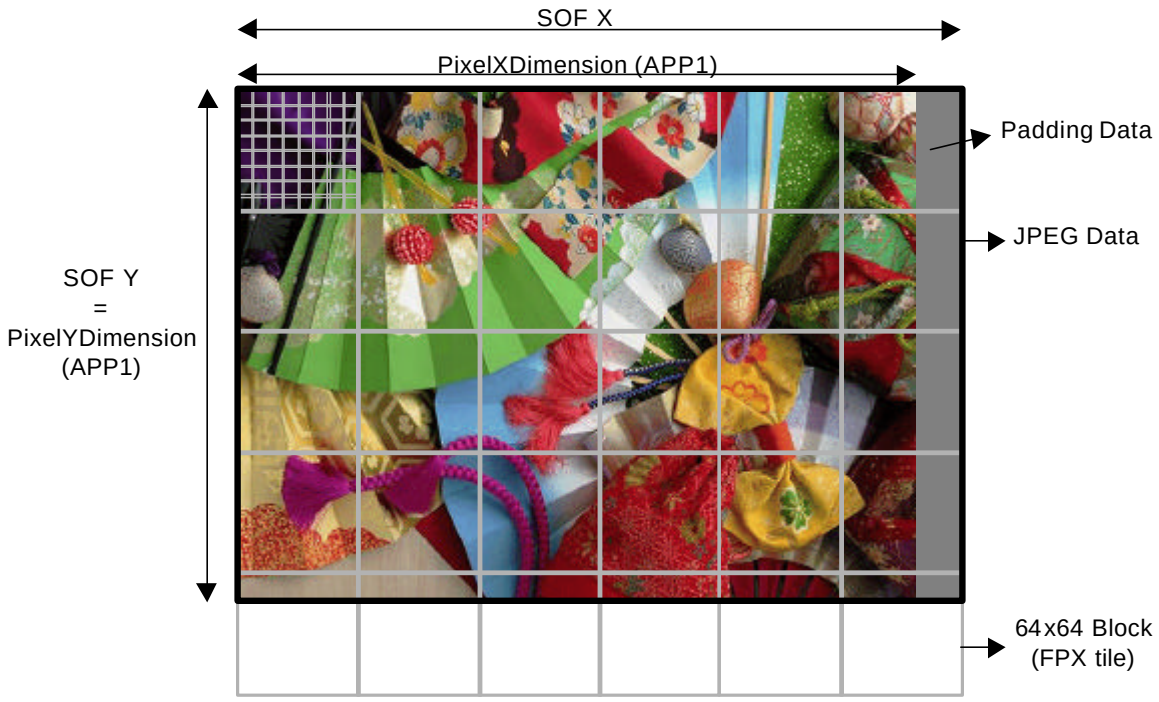


Fig. 53 Image Size Restrictions

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F.2 Converting Tag Data

When Exif attribute information is converted to FlashPix, a one-to-one conversion can be made to the Property Set used to record FlashPix attributes. The rules for converting from each kind of Exif tag to the FlashPix PropertySet are given in the tables below (conversion of GPS Info tags is to be determined later).

Table 50 Conversion between Exif Tags and FlashPix Property Set (1) (TIFF Tags)

Exif			FPX		
Field Name	Tag Code		Property Set	Group	Name
	Dec	Hex			
ImageWidth	256	100	-	-	-
ImageLength	257	101	-	-	-
BitsPerSample	258	102	-	-	-
Compression	259	103	-	-	-
PhotometricInterpretation	262	106	-	-	-
ImageDescription	270	10E	Image Info	Content Description	Caption text
Make	271	10F	Image Info	Camera Information	Camera manufacturer name
Model	272	110	Image Info	Camera Information	Camera model name
StripOffsets	273	111	-	-	-
Orientation	274	112	Transform	-	Spatial Orientation
SamplesPerPixel	277	115	-	-	-
RowsPerStrip	278	116	-	-	-
StripByteCounts	279	117	-	-	-
XResolution	282	11A	Image Contents	Primary description	Default display width
YResolution	283	11B	Image Contents	Primary description	Default display height
PlanarConfiguration	284	11C	-	-	-
ResolutionUnit	296	128	Image Contents	Primary description	Display height/width units
TransferFunction	301	12D	-	-	-
Software	305	131	Image Info	File source	Software Name
DateTime	306	132	Ignore	Ignore	Ignore
Artist	306	13B	Image Info	Intellectual Property	Authorship
WhitePoint	318	13E	-	-	-
PrimaryChromaticities	319	13F	-	-	-
YCbCrCoefficients	529	211	-	-	-
YCbCrSubSampling	530	212	-	-	-
YCbCrPositioning	531	213	Ignore	Ignore	Ignore
ReferenceBlackWhite	532	214	-	-	-
Copyright	33432	8298	Image Info	Intellectual Property	Copyright message
Exif IFD Pointer	34665	8769	-	-	-
GPS Info IFD Pointer	34853	8825	-	-	-

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Table 51 Conversion between Exif Tags and FlashPix Property Set (2) (Exif Private Tags)

Exif			FPX		
Field Name	Tag Code		Property Set	Group	Name
	Dec	Hex			
ExposureTime	33434	829A	Image Info	Per Picture Camera Setting	Exposure time
FNumber	33437	829D	Image Info	Per Picture Camera Setting	F-number
ExposureProgram	34850	8822	Image Info	Per Picture Camera Setting	Exposure program
SpectralSensitivity	34852	8824	Image Info	Digital Camera Characterization	Spectral sensitivity
ISOSpeedRatings	34855	8827	Image Info	Digital Camera Characterization	ISO speed ratings
OECF	34857	8829	Image Info	Digital Camera Characterization	OECF
ExifVersion	36864	9000	-	-	-
DateTimeOriginal	36867	9003	Image Info	Content Description	Date of the original image
			Image Info	Per Picture Camera Setting	Capture date
DateTimeDigitized	36868	9004	Summary Info	-	Create date/time
ComponentsConfiguration	37121	9101	Ignore	Ignore	Ignore
CompressedBitsPerPixel	37122	9102	Ignore	Ignore	Ignore
ShutterSpeedValue	37377	9201	Image Info	Per Picture Camera Setting	Exposure time
ApertureValue	37378	9202	Image Info	Per Picture Camera Setting	F-number
BrightnessValue	37379	9203	Image Info	Per Picture Camera Setting	Brightness value
ExposureBiasValue	37380	9204	Image Info	Per Picture Camera Setting	Exposure bias value
MaxApertureValue	37381	9205	Image Info	Per Picture Camera Setting	Maximum aperture value
SubjectDistance	37382	9206	Image Info	Per Picture Camera Setting	Subject distance
MeteringMode	37383	9207	Image Info	Per Picture Camera Setting	Metering mode
LightSource	37384	9208	Image Info	Per Picture Camera Setting	Scene illuminant
Flash	37385	9209	Image Info	Per Picture Camera Setting	Flash
			Image Info	Per Picture Camera Setting	Flash return
FocalLength	37386	920A	Image Info	Per Picture Camera Setting	Focal length
MakerNote	37500	927C	-	-	-
UserComment	37510	9286	Image Info	Content description	Content description note
SubSecTime	37520	9290	Ignore	Ignore	Ignore
SubSecTimeOriginal	37521	9291	Image Info	Content Description	Date of the original image
			Image Info	Per Picture Camera Setting	Capture date
SubSecTimeDigitized	37522	9292	Summary Info	-	Create date/time
FlashPixVersion	40960	A000	-	-	-
ColorSpace	40961	A001	Image Contents	resolution description	Subimage color
PixelXDimension	40962	A002	Image Contents	Primary description	Highest resolution width
PixelYDimension	40963	A003	Image Contents	Primary description	Highest resolution height
RelatedSoundFile	40964	A004	-	-	-
FlashEnergy	41483	A20B	Image Info	Per Picture Camera Setting	Flash Energy
SpatialFrequencyResponse	41484	A20C	Image Info	Digital Camera Characterization	Spatial frequency response
FocalplaneXResolution	41486	A20E	Image Info	Digital Camera Characterization	Focal plane X resolution
FocalplaneYResolution	41487	A20F	Image Info	Digital Camera Characterization	Focal plane Y resolution
FocalplaneResolutionUnit	41488	A210	Image Info	Digital Camera Characterization	Focal plane resolution unit
SubjectLocation	41492	A214	Image Info	Per Picture Camera Setting	Subject location
ExposureIndex	41493	A215	Image Info	Per Picture Camera Setting	Exposure index
SensingMethod	41495	A217	Image Info	Digital Camera Characterization	Sensing method
FileSource	41728	A300	Image Info	File Source	File source
SceneType	41729	A301	Image Info	File Source	Scene type
CFAPattern	41730	A302	Image Info	Digital Camera Characterization	CFA pattern

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Table 52 Conversion between Exif Tags and FlashPix Property Set (3) (GPS Info Tags)

Exif			FPX		
Field Name	Tag Code		Property Set	Group	Name
	Dec	Hex			
GPSVersionID	0	0	GPS Info extension	-	GPSVersionID
GPSLatitudeRef	1	1	GPS Info extension	-	GPSLatitudeRef
GPSLatitude	2	2	GPS Info extension	-	GPSLatitude
GPSLongitudeRef	3	3	GPS Info extension	-	GPSLongitudeRef
GPSLongitude	4	4	GPS Info extension	-	GPSLongitude
GPSAltitudeRef	5	5	GPS Info extension	-	GPSAltitudeRef
GPSAltitude	6	6	GPS Info extension	-	GPSAltitude
GPSTimeStamp	7	7	GPS Info extension	-	GPSTimeStamp
GPSSatellites	8	8	GPS Info extension	-	GPSSatellites
GPSStatus	9	9	GPS Info extension	-	GPSStatus
GPSMeasureMode	10	A	GPS Info extension	-	GPSMeasureMode
GPSDOP	11	B	GPS Info extension	-	GPSDOP
GPSSpeedRef	12	C	GPS Info extension	-	GPSSpeedRef
GPSSpeed	13	D	GPS Info extension	-	GPSSpeed
GPSTrackRef	14	E	GPS Info extension	-	GPSTrackRef
GPSTrack	15	F	GPS Info extension	-	GPSTrack
GPSImgDirectionRef	16	10	GPS Info extension	-	GPSImgDirectionRef
GPSImgDirection	17	11	GPS Info extension	-	GPSImgDirection
GPSMapDatum	18	12	GPS Info extension	-	GPSMapDatum
GPSDestLatitudeRef	19	13	GPS Info extension	-	GPSDestLatitudeRef
GPSDestLatitude	20	14	GPS Info extension	-	GPSDestLatitude
GPSDestLongitudeRef	21	15	GPS Info extension	-	GPSDestLongitudeRef
GPSDestLongitude	22	16	GPS Info extension	-	GPSDestLongitude
GPSDestBearingRef	23	17	GPS Info extension	-	GPSDestBearingRef
GPSDestBearing	24	18	GPS Info extension	-	GPSDestBearing
GPSDestDistanceRef	25	19	GPS Info extension	-	GPSDestDistanceRef
GPSDestDistance	26	1A	GPS Info extension	-	GPSDestDistance

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F.3 Converting to FlashPix Extensions (APP2)

The extended data recorded in APP2 marker segments can be converted readily to FlashPix extensions.

First of all, Fig. 54 shows the conversion process when APP2 is recorded as one Interoperability per stream of data.

An area with data size of 8000.H, Default value 00.H is allocated to the stream name "/¥005MyPropertySet" (¥005 means 005.H) in the FlashPix file Structured Storage structure, and the stream data recorded in APP2-2 is copied to offset 00000000.H, that is, the start of the allocated area.

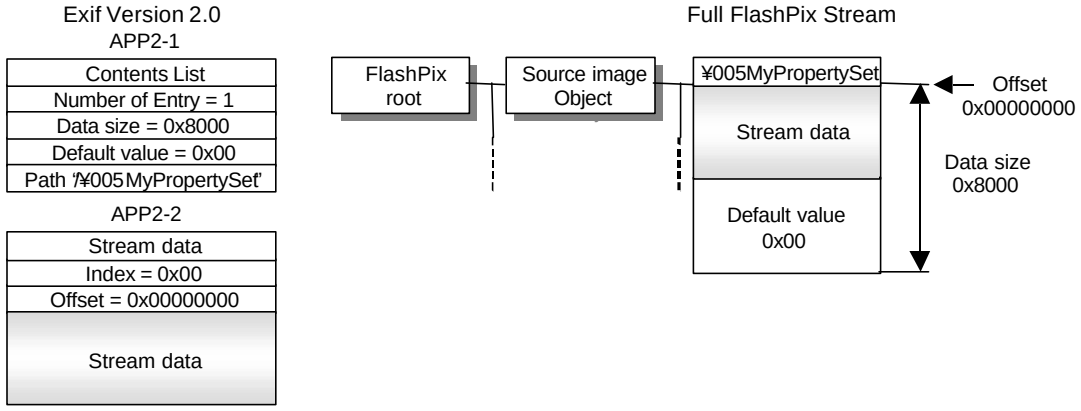


Fig. 54 Conversion to FlashPix Extensions (1)

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Next, Fig. 55 shows the conversion process when one Interoperability per two streams of data is recorded in APP2.

This time an area with data size of 10000.H, Default value 00.H is allocated to the stream name "/¥005MyPropertySet" in the FlashPix file Structured Storage structure, and the stream data recorded in APP2-2 is copied to offset 00000000.H, that is, the start of the allocated area, while the stream data recorded in APP2-3 is copied starting from offset 00008000.H.

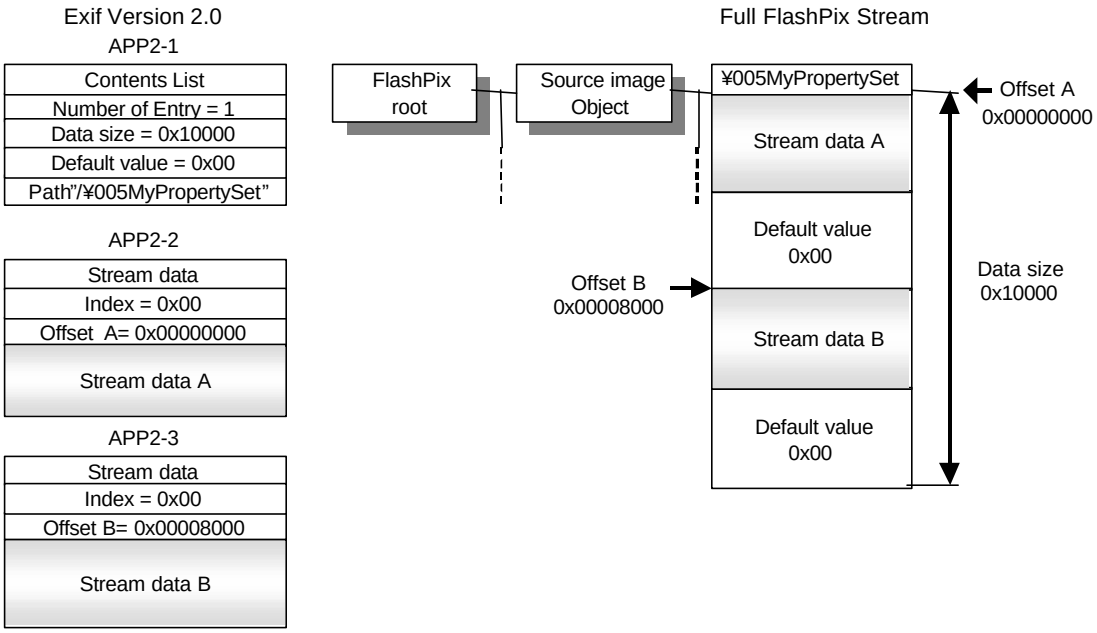


Fig. 55 Conversion to FlashPix Extensions (2)

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Finally, Fig. 56 shows an example of conversion when 2 Interoperability per stream of data are recorded in APP2.

Here a data size of 8000.H, Default value 00.H is allocated to the stream name "MyPropertySet" Interoperability the storage name "¥005MyStorage" in the FlashPix file Structured Storage structure, and the stream data recorded in APP2-2 is copied to offset 00000000.H, that is, the start of the allocated area.

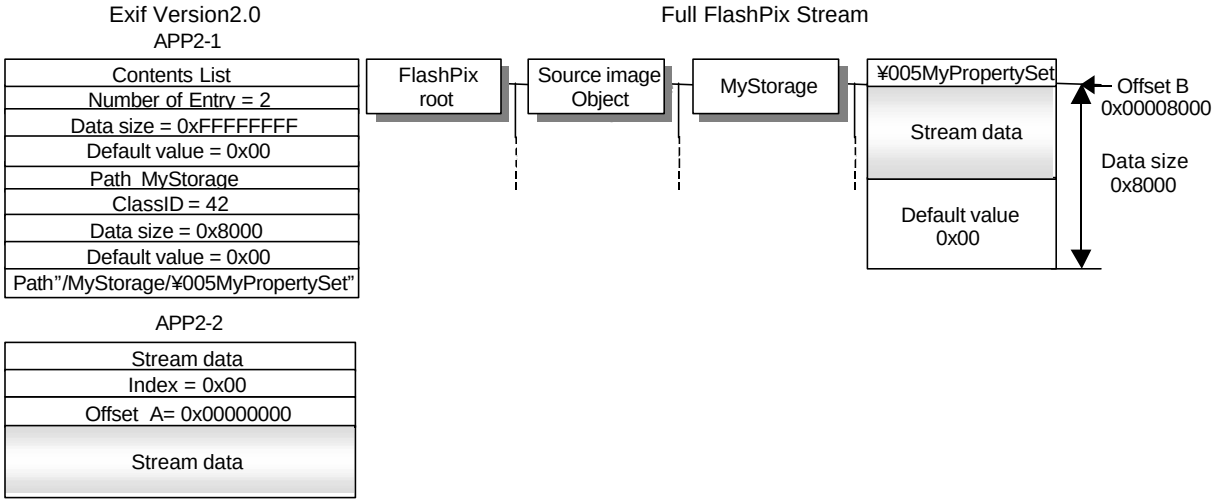


Fig. 56 Conversion to FlashPix Extensions (3)

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