

**UNITED STATES INTERNATIONAL TRADE COMMISSION
WASHINGTON, D.C.**

**Before the Honorable MaryJoan McNamara
Administrative Law Judge**

In the Matter of

**CERTAIN ELECTRONIC DEVICES,
INCLUDING SMARTPHONES,
COMPUTERS, TABLET COMPUTERS,
AND COMPONENTS THEREOF**

Investigation No. 337-TA-1373

COMPLAINANTS' INITIAL POST-HEARING BRIEF

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TABLE OF ABBREVIATIONS

Full Reference	Abbreviation
InterDigital, Inc., InterDigital VC Holdings, Inc., InterDigital Patent Holdings, Inc., and InterDigital Madison Patent Holdings SAS	InterDigital or Complainants
Lenovo PC HK Limited, Lenovo (United States) Inc., and Motorola Mobility LLC	Lenovo or Respondents
Counsel for Office of Unfair Import Investigations	Staff
U.S. Patent No. 10,250,877	'877 patent
U.S. Patent No. 8,674,859	'859 patent
U.S. Patent No. 9,674,556	'556 patent
'877, '859, and '556 patents	The Video Coding Patents
Complainants' Exhibit	CX-#
Respondents' Exhibit	RX-#
Joint Exhibit	JX-#
Complainants' Physical Exhibit	CPX-#
Respondents Physical Exhibit	RPX-#
Joint Physical Exhibit	JPX-#
Deposition Transcript	Dep. Tr.
Complainants' Demonstrative	CDX-#
Respondents' Demonstrative	RDX-#
Accused Products	The Accused Products
AOMedia Video 1	AV1
Apple DI Products	iPhone 15 Pro iPhone 15 Pro Max
Vizio DI Products	Vizio D-Series, V-Series, M-Series, P-Series and OLED Digital TVs ("DTVs")
Complainants' Pre-Hearing Brief	CPre
Respondents' Pre-Hearing Brief	RPre
Staff's Pre-Hearing Brief	SPre
Complainants' Initial Post-Hearing Brief	CIB
Respondents' Initial Post Hearing Brief	RIB
Staff's Post-Hearing Brief	SB

I. INTRODUCTION

InterDigital is one of the world’s largest research, innovation, and licensing companies. A leader in wireless, video, AI, and emerging technologies, InterDigital’s inventions enable and enhance our everyday devices and the connected industries of tomorrow. InterDigital’s world-class engineers address the industry’s most critical technical challenges. InterDigital has over 100 engineers (more than half with Ph.Ds.) dedicated to video compression technology and every one of those engineers is a named inventor on at least one patent. Each asserted patent in this Investigation is the result of the R&D efforts InterDigital made in video compression technology.

The Hearing in this Investigation left no doubt that Complainants InterDigital, Inc., InterDigital VC Holdings, Inc., InterDigital Patent Holdings, Inc., and InterDigital Madison Patent Holdings SAS (collectively, “InterDigital” or “Complainants”) proved a violation of Section 337 has occurred. InterDigital proved that Respondents infringe each asserted claim of U.S. Patent Nos. 9,674,556 (the ’556 patent), 10,250,877 (the ’877 patent), and 8,674,859 (the ’859 patent). InterDigital proved the existence of a domestic industry through its licensees’—Apple Inc. and Vizio, Inc.—products that practice the asserted patents and through its licensees’ substantial and significant U.S. investments. InterDigital’s economic prong of domestic industry evidence is un rebutted. As a result of Respondents infringement and to protect the domestic industry in the asserted patents, InterDigital requests issuance of an exclusion order and a cease and desist order.

The ’556 patent relates to a novel two-stage filtering process that successively uses a deblocking filter and an adaptive sparse de-noising filter in-loop to more effectively remove or reduce artifacts (i.e. noise) in decoded videos. The specific combination of filters claimed in the ’556 patent improves de-artifact filtering because the deblocking filter reduces blocking artifacts, changing the signal to make it a better fit for the adaptive sparse denoising filter to effectively reduce or remove remaining artifacts. Infringement of the ’556 patent is largely undisputed. The

[REDACTED]

only meaningful question remaining is whether the accused constrained direction enhancement filter (“CDEF”) in AV1 is a “sparse denoising filter.” InterDigital proved that it is. To avoid this inescapable conclusion on infringement, Respondents rely on arguments that directly conflict with the plain and ordinary meaning of the term “sparse denoising filter.” Indeed, Respondents noninfringement arguments are contradicted by the testimony of its own claim construction expert, Dr. Orchard, who noticeably was dismissed from this case once infringement became clear.

The ’877 patent relates to a novel, elegant, adaptive resolution technology that improves computer functionality through reduced memory requirements and processing time. The ’877 patent achieved this improved computer performance via the novel composition of resampling and motion compensation interpolation filters in the vertical and horizontal direction. While InterDigital’s engineers proposed incorporating their novel filters into the HEVC standard, it was rejected as being too complex. However, shortly thereafter, some of the same companies that rejected including the technology in HEVC chose to incorporate it into AV1 without InterDigital’s knowledge. At the Hearing, InterDigital proved that the block inter prediction process in AV1 infringes the asserted claims of the ’877 patent. Again, this is largely undisputed, and the disputes that do exist rely on arguments that directly conflict with the plain and ordinary meaning of the claim or on arguments regarding equality that InterDigital proved were factually erroneous.

The ’859 patent relates to a novel arithmetic decoder and decoding process that improved video decoding efficiency. InterDigital proved that the Accused Products’ implementation of arithmetic decoding in accordance with the AV1 specification infringes the asserted claims of the ’859 patent. Respondents’ noninfringement arguments are largely based on new claim construction arguments—including an order of steps argument—that were not raised during the claim construction process and, as a result, were waived. But, even if the Court finds these arguments

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were not waived, the arithmetic decoding process specified by AV1 infringes either literally or under the doctrine of equivalence.

A. Procedural History

InterDigital filed its complaint on September 1, 2023, alleging infringement of U.S. Patent Nos. 10,250,877, 8,674,859, 9,674,556, 8,737,933, and 9,173,054. On October 5, 2023, the Commission instituted the Investigation. (EDIS Doc. No. 805424).

On November 7, 2023, Respondents filed their response to the Complaint. (EDIS Doc. No. 807995). On December 12, 2023, Complainants and Respondents filed a joint motion to amend the complaint. (EDIS Doc. No. 801270). On December 18, 2023, the ALJ granted the parties' motion to amend the complaint. (EDIS Doc. No. 810505). On January 9, 2024, Complainants filed an Amended Complaint. (EDIS Doc. No. 811712). On February 5, 2024, Respondents filed a response to the Amended Complaint. (EDIS Doc. No. 813384).

The Parties submitted their *Markman* briefs on January 26 and 29, 2024. (EDIS Doc. Nos. 812712, 812735, and 812766). The ALJ held a claim construction hearing on February 12, 2024.

To narrow the Investigation, Complainants moved for partial termination on May 22, 2024 and July 25, 2024. (EDIS Doc. Nos. 822124, 827119). The following claims remain asserted in this Investigation: '877 patent, claims 1 and 7; '859 patent, claims 10 and 15; '556 patent, claims 1, 3, 5, and 7.

B. The Parties

1. Complainants

Complainant InterDigital, Inc. is a Pennsylvania corporation with its principal place of business at 200 Bellevue Parkway, Suite 300, Wilmington, DE 19809. Complainant InterDigital VC Holdings, Inc. is a Delaware corporation with its principal place of business at 200 Bellevue Parkway, Suite 300, Wilmington, DE 19809. InterDigital VC Holdings, Inc. owns, by assignment,

[REDACTED]

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all rights, title, and interest in and to the '556 patent. InterDigital VC Holdings, Inc. has been the sole owner of the '556 patent at all relevant times. Complainant InterDigital Madison Patent Holdings, SAS is a French corporation with its principal place of business at 3 Rue du Colonel Moll, Paris, France 75017. InterDigital Madison Patent Holdings SAS owns, by assignment, all rights, title, and interest in the '877 and '859 patents. InterDigital Madison Patent Holdings SAS has been the sole owner of the '877 and '859 patents at all relevant times. Complainant InterDigital Patent Holdings, Inc. is a Delaware corporation with its principal place of business at 200 Bellevue Parkway, Suite 300, Wilmington, DE 19809.

2. Respondents

Lenovo PC HK Limited is a corporation operating under the laws of Hong Kong with its principal place of business at 23rd Floor, Lincoln House, Taikoo Place, 979 King's Road, Quarry Bay, Hong Kong SAR. (Response to Complaint, (EDIS Doc. No. 807997 at ¶ 18). Lenovo PC HK Limited is the foreign entity that contracts with Lenovo's customers for global sales, procurement, and supplier agreements. Lenovo PC HK is a subsidiary of Lenovo Group Limited. (*Id.*).

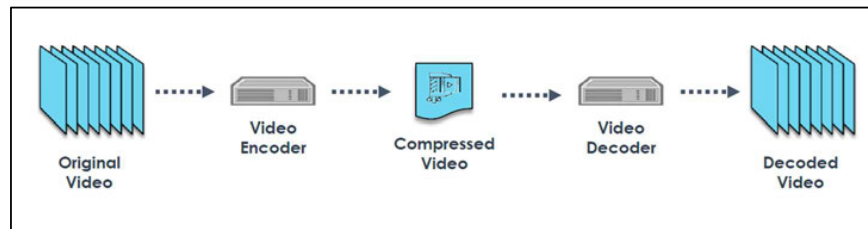
Lenovo (United States) Inc. is a Delaware corporation with principal place of business at 8001 Development Drive, Morrisville, North Carolina 27560. (*Id.* at ¶ 19). Lenovo (United States) is a subsidiary of Lenovo Group Limited. (*Id.*). Lenovo (United States) is engaged in the importation and sale after importation of the Accused computers and tablet computers. (*Id.*).

Motorola Mobility LLC is a Delaware limited-liability company with principal place of business at 222 W. Merchandise Mart Plaza, Suite 1800, Chicago, Illinois 60654. (*Id.* at ¶ 20). Motorola Mobility LLC is a subsidiary of Lenovo Group Limited. Motorola Mobility LLC is engaged in the design, importation, or sale after importation of the Accused smartphones. (*Id.*).

C. Overview of Video Codec Technology

Video compression coding, often abbreviated to video coding, is the process of

compressing (encoding) video prior to transmission or storage and decompressing (decoding) compressed video so that it can be displayed. (Tr. (Oisel) at 150:14-151:11). A video encoder converts digital video into a compressed form known as coded or compressed video, suitable for transmission or storage, and a video decoder converts coded or compressed video into uncompressed digital video. (*Id.* at 151:14-153:10). The pair of video encoder and video decoder is known as a video codec:



Video coding is important because uncompressed video takes up a significant amount of storage space and would require an impractical amount of bandwidth to transmit in real time. (Tr. (Oisel) at 151:14-153:10). For example, a 500 Gbyte hard disk can store around only 40 minutes of uncompressed HD video. The same hard disk can store around 600 hours of compressed HD video, depending on the video content and the compression format. As display resolutions get bigger and consumers expect better video quality and higher resolution images when viewing stored video or video streamed over the internet, efficient and effective video compression continues to be of vital importance. (*Id.*)

D. The Patents at Issue

1. U.S. Patent No. 10,250,877

The '877 patent is entitled “Method and Device For Coding an Image Block, Corresponding Decoding Method and Decoding Device” and issued on April 2, 2019. (JX-0004). The '877 patent is generally directed to novel adaptive resolution filters that jointly motion compensate and resample blocks of reference images of a different size from the current image to be reconstructed.

[REDACTED]

(See generally *id.* at Abstract). The named inventors are Philippe Bordes, Pierre Andrivon, and Philippe Salmon. (*Id.*). The '877 patent expires on May 22, 2035 and claims priority to FR1250334A, filed on January 13, 2012. (*Id.*).

2. U.S. Patent No. 8,674,859

The '859 patent is entitled “Method for Arithmetic Coding and Decoding and Corresponding Devices” and issued on March 18, 2014. (JX-0001). The '859 patent is directed to more efficient techniques for arithmetic decoding by providing a dynamically varying set of probability models. (See JX-0001 at 8:14-21). The named inventors are Philippe Bordes, Dominique Thoreau, Jerome Vieron, and Edouard Francois. (*Id.*). The '859 patent expires on June 22, 2030 and claims priority to FR0954483 filed on July 1, 2009. (*Id.*).

3. U.S. Patent No. 9,674,556

The '556 patent is entitled “Methods and Apparatus For In-Loop De-Artifact Filtering” and issued on June 6, 2017. (JX-0003). The '556 patent is generally directed to improving in-loop de-artifact filtering using a deblocking filter and an adaptive sparse de-noising filter, which are successively used in-loop to remove or reduce noise in video images. (JX-0003 at 10:6-53). The named inventors are Meng-Ping Kao, Peng Yin, and Divorra Escoda. (*Id.*). The '556 patent expires on October 25, 2027, and claims priority to U.S. Provisional Patent Application No. 60/864,917, filed on November 8, 2006. (*Id.*).

E. The Products at Issue

1. Video Coding Accused Products

The Alliance for Open Media (“AV1”) video coding protocol (“AV1 Specification”) “defines the bitstream formats and decoding process for the Alliance for Open Media AV1 video codec.” (CX-0247.0003). The AV1 Specification defines how devices supporting the AV1 Specification decompress video. More specifically, the AV1 Specification describes how devices

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supporting the Specification decode an AV1 encoded bitstream. A device that is capable of decoding AV1 video must be operable to decode video in accordance with the AV1 Specification. The AV1 Specification specifies that it is necessary for all complying implementations of AV1 to conform to the Specification. For example, Section A.2 states that “‘Main’ compliant decoders must be able to decode streams with seq_profile equal to 0.” (CX-00247.0651). The seq_profile field indicates the AV1 profile, and, for example, “Main compliant” decoders refers to decoders that are operable to decode AV1 Main Profile. The Video Decoding Accused Products comprise smartphones, computers (laptop and desktop), and tablet computers that are capable of decoding video according to the AV1 Specification. (See, e.g., CDX-0005C.0004-5).

2. Representative Products

A single product may be representative of multiple products when the “products operate similarly with respect to the claimed limitation.” *Spanston, Inc. v. Int’l Trade Comm’n*, 629 F.3d 1331, 1351-52 (Fed. Cir. 2010). As Dr. Richardson explained, the representative products all comply with the AV1 specification and operate similarly with respect to the claimed limitations of the asserted patents. (Tr. (Richardson) at 401:4-411:7, 818:1-824:10; CDX-0005C.17). Moreover, Lenovo stipulated that for purposes of this investigation, it does not contend that [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

(EDIS Doc. ID 830478 at 2).

(i) Representative Video Decoding Products

Each of the Video Decoding Accused Products decodes AV1 encoded bitstreams in materially the same way for purposes of infringement. (Tr. (Richardson) at 401:5-25; 402:24-403:3 (MediaTek), 403:25 (Intel), 404:1-406:2 (AMD), 406:25-407:8 (NVIDIA), 407:1-8 (Qualcomm), 407:9-20 (Google), 408:23-411:7 (DI Products); EDIS Doc. ID 830478 at 2). A device sold to a

[REDACTED]

consumer as having AV1 functionality must be able to decode AV1-compliant video bitstreams. (CX-00247.0651). The functionality is set forth in the AV1 Specification. (CX-0247.0003). Dr. Schonfeld admitted the Video Decoding Accused Products can decode AV1 encoded bitstreams. (Tr. (Schonfeld) at 1038:13-15). [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

The Lenovo Tab P11 Pro Gen 2 (TB132FU), Model No.: ZAB50101US (the “MediaTek Representative Product”) incorporating the MT8797 (MediaTek™ Kompanio 1300T) chip is representative of the Video Decoding Accused Products that incorporate a MediaTek Chip because each product decodes AV1 encoded bitstreams in materially the same way for purposes of infringement. (Tr. (Richardson) at 401:4-25, 402:1-403:2; Tr. (Xiong) at 186:20-187:14; CX-0514; CDX-0005C.7; CDX-0007C.22).

The ThinkPad X1 Carbon Gen 11 14” Touch-screen Laptop i7 with 16GB Memory- 512GB SSD (Model No. 21HM000JUS) (the “Intel Representative Product”) incorporating an Intel Core i7-1355U, 10C (2P + 8E) / 12I, P-core 1.7 / 5.0GHz, E-core 1.2 / 3.7GHz, 12MB CPU with Integrated Intel Iris Xe Graphics is representative of the Video Decoding Accused Products that incorporate an Intel Chip. Each product decodes AV1 encoded bitstreams in materially the same way for purposes of infringement. (Tr. (Richardson) at 401:4-25, 403:4-25; Tr. (Xiong) at 183:23-185:13; CDX-0005C.9; CDX-0007C.22).

The ThinkPad X13 Gen 4 (AMD) (Model No. 21J30008US) (the “AMD VCN 4.0 Representative Product”) incorporating the AMD Ryzen 7 PRO 6850U APU with integrated AMD Radeon 680M Graphics is representative of the Video Decoding Accused Products that incorporate

AMD Chips with VCN 4.0 Architecture because each product decodes AV1 encoded bitstreams in materially the same way for purposes of infringement. (Tr. (Richardson) at 401:4-25, 404:1-406:3; Tr. (Xiong) at 183:23-185:1; CX-1600C; CDX-0005C.10; CDX-0007C.22).

The ThinkPad T16 (16" AMD) Gen 1 Laptop (Model No. 21CH004BUS) (the "AMD VCN 3.0 Representative Product") incorporating the AMD Ryzen 7 PRO 6850U APU with integrated AMD Radeon 680M Graphics is representative of the Video Decoding Accused Products that incorporate AMD Chips with VCN 3.0 Architecture because each product decodes AV1 encoded bitstreams in materially the same way for purposes of infringement. (Tr. (Richardson) at 401:4-25, 404:1-406:3; Tr. (Xiong) at 183:23-185:13; CX-1600C; CDX-0005C.10; CDX-0007C.22).

The Motorola Edge+ | 2023 | Unlocked | Made for US 8/512 | 50 MPCamera | Interstellar Black, 161.16x74x8.59 (Model No.: PAWJ0004US) (the "Qualcomm Representative Product") with the Snapdragon® 8 Gen 2 Mobile Platform (SM8550, code name "Kailua") chip is representative of the Video Decoding Accused Products that incorporate the Kailua chips because each product decodes AV1 encoded bitstreams in the same way for purposes of infringement. (Tr. (Richardson) at 401:4-25, 406:4-19; Tr. (Xiong) at 187:17-189:6, 197:5-9, 203:10-204:8; CDX-0005C.11; CDX-0007C.22).

The Lenovo 16" IdeaPad Pro 5i Laptop (Arctic Gray) (Model No.: 83AQ004HUS) (the "NVIDIA Representative Product") incorporating the NVIDIA GeForce RTX 4050 6GB GDDR6 is representative of the Video Decoding Accused Products that incorporate NVIDIA GPUs because each product decodes AV1 encoded bitstreams in materially the same way for purposes of infringement. (Tr. (Richardson) at 401:4-25, 406:20-407:8; Tr. (Xiong) at 183:23-185:13; CDX-0005C.12; CDX-0007C.22).

Dr. Richardson further confirmed that all of the products that include the Google Chrome

browser—Tab P12 and the Moto G 5G— decode AV1 encoded bitstreams in materially the same way for purposes of infringement. (Tr. (Richardson) at 401:4-25, 407:9-408:14; Tr. (Xiong) at 189:7-192:7; CDX-0005C.12; CDX-0007C.22).

3. The Domestic Industry Products

The Apple DI Products include the iPhone 15 Pro and iPhone 15 Pro Max. (Tr. (Richardson) at 408:23-409:5; *See* CDX-0005C.4). The Apple DI Products include the new A17 chipset, which includes a dedicated AV1 video decoder and decodes AV1 video materially in the same way for purposes of this Investigation. (Tr. (Richardson) at 410:13-411:7; Tr. (Xiong) at 192:9-193:11; CDX-0005C.17; CDX-0007C.28). The Vizio DI Products include the Vizio D-Series, V-Series, M-Series, P-Series and OLED Digital TVs (“DTVs”). The Vizio M-Series, P-Series, D-Series, V-Series and OLED DTVs all use either the [REDACTED] chipset and decode AV1 encoded bitstreams in materially the same way. (Tr. (Richardson) at 409:9-410:12; Tr. (Xiong) at 193:13-194:20; MTK-CODE-0261-0349; MTK-CODE-0678; MTK-CODE-0261-0349; MTK-CODE-0678; CDX-0005C.16; CDX-0007C.28).

F. Level of Skill of a Person of Ordinary Skill in the Art

The Private Parties have agreed on the level of skill of the Person of Skill in the Art as of the priority dates of the Video Coding Patents. (CDX-0005C.3; RDX-0002.5).

II. JURISDICTION AND IMPORTATION

The Commission has jurisdiction over this Investigation and Respondents. Subject-matter jurisdiction exists because Complainants have alleged that each Respondent has engaged in unlawful and unfair acts in conjunction with its importation, sale for importation, and/or sale after importation of articles into the United States. *See Certain Ammonium Octamolybdate Isomers*, Inv. No. 337-TA-477, Comm’n Op. at 15-16 (Jan. 5, 2004). Respondents do not dispute the Commission’s jurisdiction over them or the Accused Products and have stipulated that the

importation requirement has been satisfied with respect to the Accused Products. (JX-0027C).

III. U.S. PATENT NO. 10,250,877

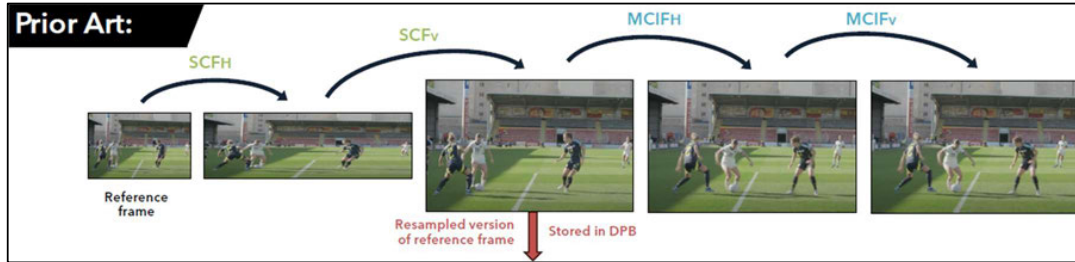
A. Claim Construction

The parties agreed “circuit configured to” (claim 7) has its plain and ordinary meaning (i.e., requires pre-existing programming of hardware and software to perform the cited functionality). (CX-0337). The parties did not identify additional terms, but Respondents have raised several noninfringement arguments that rely on new, not previously disclosed constructions, each of which has been waived. (*See infra* §§ III.B.3.b, d, e, f; G.R. 1.14.1).

B. Direct Infringement

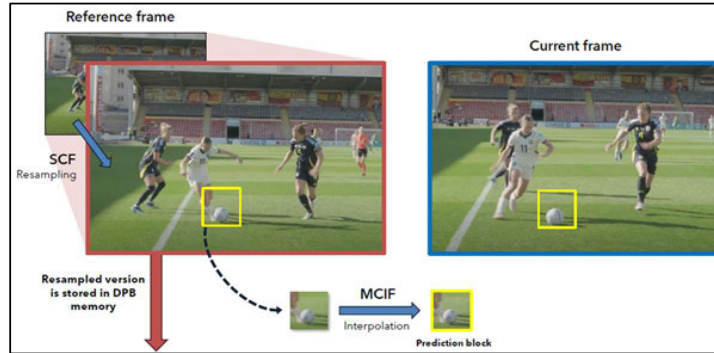
1. Overview of the '877 Patent

During times of reduced bandwidth, pictures may become blocky or pixelated as overall video quality declines. (Tr. (Richardson) at 503:5-23). Adaptive resolution coding seeks to remedy this reduced video quality by downsampling frames at the encoder side so that picture quality is maintained while the amount of data to be transmitted is decreased. (Tr. (Richardson) at 503:24-504:18; JX-0004 at 1:26-44, FIG. 3; CDX-0005C.61). Prior art decoding methods required reference images to first be resampled to match the size of the current image before performing motion compensation. This resulted in the need to store numerous resampled reference images of various sizes in the decoded picture buffer (DPB) memory. (Tr. (Richardson) at 505:10-508:3, 508:11-17; JX-0004 at 1:51-64). As a result, significant amounts of DPB memory were required to perform adaptive resolution in the prior art.



(CDX-0005C.103). For example, the adaptive resolution method of the AV1 Specification permits 16 different picture resolutions for each reference block. According to the prior art method of adaptive resolution, 16 differently sized versions of a reference frame would need to be stored in the DPB. (Tr. (Richardson) at 508:4-10, 513:13-18, 564:1-9).

Prior art adaptive resolution methods required two separate filtering steps in each of the horizontal and vertical directions to motion compensate a reference block. First, a resampling filter (SCF) was applied to *the entire previously decoded reference image* to generate a resampled version of the entire reconstructed reference frame that is the same size as the current frame. (Tr. (Richardson) at 509:4-17, 510:8-18; CDX-0005C.63). This resampled version of the reconstructed reference image was stored in the DPB and could then be motion compensated using motion vector information received from the encoder to “find” in the reference frame the closest visual match to the current block to be predicted. (*Id.*; see also Tr. (Schonfeld) at 867:15-25). When the motion information pointed to a subpixel location, a motion compensated interpolation filter (MCIF) would then have to be applied to the reference image to interpolate, or generate estimated pixel values, between existing pixels, to create a better-quality prediction. (Tr. (Richardson) at 510:8-18, 511:3-12; Tr. (Schonfeld) at 869:5-870:2; CDX-0005C.63).



The inventors of the '877 patent solved “several problems at once” with their “elegant” improved adaptive resolution filtering invention. (Tr. (Richardson) at 511:13-21). First, the novel filtering method avoids the intermediate step of resampling the reference image to match the size of the current image—thus eliminating the storage of numerous intermediate resampled reference pictures in the DPB. (Tr. (Richardson) at 512:15-513:2; Tr. (Schonfeld) at 873:5-13; RX-0358C (Bordes) at 72:13-21). Instead, according to the invention, the reference image is left “at its original decoded scale, and then one block at a time . . . a block of pixels in that reference image” is identified and jointly resampled and motion compensation interpolated “without generating or storing any intermediate resampled version of that reference frame.” (Tr. (Richardson) at 559:16-560:1). The resultant memory savings “i[s] a really big deal,” as “limited memory sizes is one of the big constraints of video codec design and chip design” for consumer devices. (Tr. (Richardson) at 513:3-8, 513:25-513:4; RX-1088.0001; JX-0004 at 2:8-13). Second, by combining MCIF and SCF filters into a single grouped filter (GF) in each direction, the invention “saves processing” time for the decoder. (Tr. (Richardson) at 512:13-15, 675:1-8; Tr. (Schonfeld) at 873:21-874:2). In other words, “the memory bandwidth,” or “the amount of access to [the] memory,” is reduced by avoiding an intermediate storage step. (Tr. (Richardson) at 675:1-8). When the inventors of the '877 patent proposed incorporating their novel filters into the HEVC standard then under development, they noted “encoding gains [] between 0.1% to 1.8% in Luma and up to 4.9% in

Chroma” due to enhanced processing efficiencies. (RX-1088.0001 (the “H0321-r1 proposal”); RX-0358C (Bordes) at 48:13-24, 58:20-59:6).

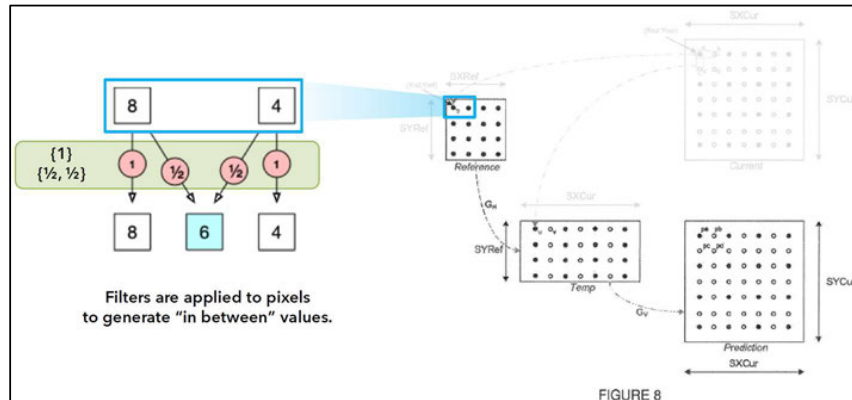
Although the invention of the ’877 patent was found to be too complex and ahead of its time for inclusion in the HEVC standard by its members, the AV1 Specification incorporated the claimed filtering invention into its block inter prediction process. (CX-0247.0274-79; Tr. (Schonfeld) at 878:11-24; CX-0247.0274-79; RX-0358C (Bordes) at 56:21-57:17, 189:3-189:16).

a. Separable Interpolation Filters

The novel filters of the ’877 patent are separable interpolation filters that “depend[] on . . . the size of the reference image and on the size of the current image.” (JX-0004 at 2:32-40). As the ’877 patent describes and depicts in Figure 8, “different filters are applied to the same pixels of the reference image” to generate pixel values in between existing pixels (or interpolated pixels). (JX-0004 at 6:33-40, FIG. 8). Specifically, when interpolating between existing pixels to generate a single in-between value as depicted in Figure 8 of the ’877 patent, two filters are applied to each pixel value. (Tr. (Richardson) at 517:18-518:14). Each number (coefficient) in the filter acts as a weighted multiplier for the pixel(s) on which it is applied, and multi-tap filters (i.e., those with multiple coefficients) weigh and then add together multiple neighboring pixel values. (See Tr. (Richardson) at 518:25-519:9; Tr. (Schonfeld) at 897:14-18). The ’877 patent provides several examples of its claimed filters. (JX-0004 at 7:1-24 (e.g., $GFv=\{0\ 0\ 64\ 0\ 0\}/64$)).

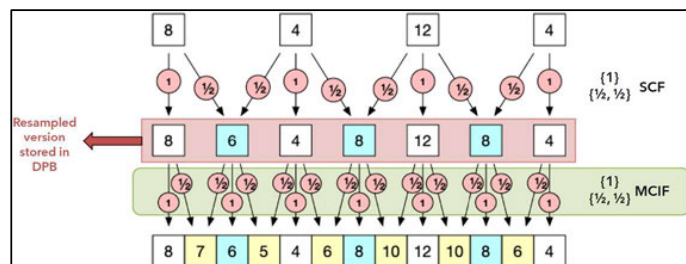
In the simplified example of horizontal filtering below, the set of bilinear filters $\{1\}$ and $\{\frac{1}{2}, \frac{1}{2}\}$ is applied to existing pixel values of 8 and 4 to generate the pixel value 8 and the interpolated pixel value of 6. (See generally Tr. (Richardson) at 517:18-520:4, 521:11-14). First, the filter $\{1\}$ is applied to the existing pixel value of 8 to yield a pixel in the temporary block with a value of 8. (*Id.* at 518:15-24). The filter $\{\frac{1}{2}, \frac{1}{2}\}$ is then applied to both existing pixels, which are each weighted by the coefficients and then summed to generate the in-between pixel value of 6,

i.e., $(1/2 * 8 + 1/2 * 4)$. (*Id.* at 518:25-519:12). If applied along the entire row of pixels for each of the four rows of existing pixels, this process generates a horizontally filtered array like the Temp array in Figure 8. (*Id.* at 519:16-520:4). Applying the same set of filters vertically to the Temp array results in the final prediction block labeled “Prediction” in Figure 8. (*Id.* at 517:18-518:2).



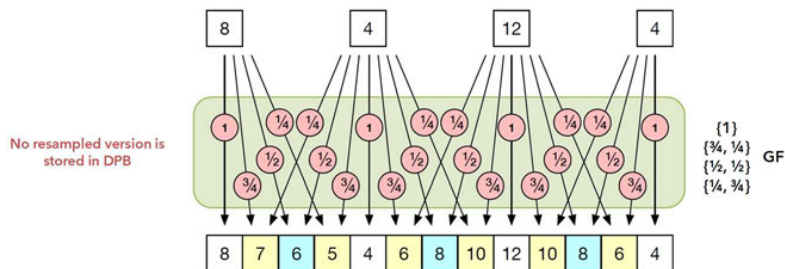
(CDX-0005C.66; JX-0004 at FIG. 8 (annotated)).

In prior art adaptive resolution methods, a predicted image could be generated using a motion compensated interpolation filter (MCIF) applied to the resampled reference image. (Tr. (Schonfeld) at 869:5-10, 869:15-870:2). As shown below, the same set of bilinear filters $\{1\}$ and $\{1/2, 1/2\}$ could be used to first upsample a row of pixels according to the prior art method. (Tr. (Richardson) at 521:15-523:13). The output of the resampling filter SCF could then be motion compensation interpolated using the same set of bilinear filters. (*Id.* at 523:14-524:17). A different set of filters could also be used. (*Id.*). Thus, a row of pixels that has been resampled and motion compensation interpolated can be created from two filters SCF and MCIF applied separately.



(CDX-0005C.69).

According to the invention of the '877 patent, the same resampling and motion compensated interpolation can be achieved with a single filtering step in each direction. (Tr. (Richardson) at 525:11-22). For example, a single set of bilinear filters $\{1\}$, $\{\frac{3}{4}, \frac{1}{4}\}$, $\{\frac{1}{2}, \frac{1}{2}\}$, and $\{\frac{1}{4}, \frac{3}{4}\}$ can be applied to the same pixel values as above (i.e., 8, 4, 12, 4) to generate three interpolated pixels in between each original pixel. (*Id.* at 525:23-526:13, 542:8-22). In this way, “what this filter has done in a single step is generate the same output values but without having to go through the intermediate step.” (*Id.* at 526:14-18). The output pixel value of 8 is produced by weighting the single input pixel by $\{1\}$. The output pixel value of 7 is produced by applying the filter $\{\frac{3}{4}, \frac{1}{4}\}$ to the original pixel values of 8 and 4, which are weighted by $\frac{3}{4}$ and $\frac{1}{4}$, respectively, and summed. The output pixel value of 6 is produced by applying the filter $\{\frac{1}{2}, \frac{1}{2}\}$, i.e., weighting 8 and 4 by $\frac{1}{2}$ and adding the results together. Finally, the output pixel value of 5 is obtained by applying the filter $\{\frac{1}{4}, \frac{3}{4}\}$, weighting the original values by the respective filter coefficients, and adding them. (*Id.* at 525:23-526:13). As shown below, the single filter “GF []” does the same job in a single stage as those two stages of filters in the previous” example. (*Id.* at 525:17-22).



(CDX-0005C.70). In other words, a single filter, GF, can be designed to perform the tasks of two filters, SCF and MCIF, and generate an identical output. (*See, e.g.*, Tr. (Richardson) at 527:14-17).

The filters of the AV1 Specification operate in the same manner, according to the claimed invention. The AV1 Specification contains a set of bilinear filters specified by the constant array

Subpel_Filters¹ (reproduced below). (*See Id.* at 542:8-22). The bilinear filter set, like all filter coefficient arrays specified by Subpel_Filters, contains 16 filters, a subset of which may be selected depending on filtering parameters. (*Id.* at 541:9-14; Tr. (Schonfeld) at 1072:21-1073:21). (CX-0247.0278; CDX-0005C.89). Although they contain larger coefficient values (by a factor of 128) and numerous zeros, the bilinear filters of the AV1 Specification are applied in the same way as the simplified example above to interpolate up to 15 additional pixels for each pixel in the reference block or temporary array. (Tr. (Richardson) at 542:8-22, 541:9-14). The zero coefficients in AV1's bilinear filters can be ignored, as they indicate that no weight is assigned to the neighboring pixel values. (*See id.* at 521:1-7).

2. Executive Summary

The block inter prediction process of the AV1 Specification practices each and every limitation of claims 1 and 7 of the '877 patent. During block inter prediction, the decoder accesses a reconstructed reference image specified by refIdx from FrameStore (i.e., the DPB), where previously decoded images used for prediction are stored. (Tr. (Richardson) at 529:4-530:6; CX-0247.0196, .0275). Because the reference image and current image can be different sizes, AV1's motion vector scaling process adjusts sampling locations "to compensate for any difference in the size of the reference frame compared to the current frame." (Tr. (Richardson) at 530:7-531:10, 532:6-20; CX-0247.0273). Then, as shown in the AV1 block inter prediction pseudocode, motion compensation is performed to generate "the 2D array named pred containing inter predicted samples." (Tr. (Richardson) at 532:16-533:4; CX-0247.0274, .258). Specifically, "a horizontal filter is used to build up a temporary array, and then this array is vertically filtered to obtain the final prediction." (CX-0247.0275-8; *see also* Tr. (Richardson) at 533:21-534:8). Finally, a decoded

¹ Each row of the array Subpel_Filters represents a single filter. (Tr. (Richardson) at 540:18-20).

residual is added to the prediction block to reconstruct a current block of the current image, which is stored in the DPB. (Tr. (Richardson) 531:11-532:3; CX-0247.0307).

The parties generally agree how AV1's block inter prediction functions to generate a prediction block. There is no dispute that AV1 describes reconstructing a current block from a reference image of a different size from the current image, as the '877 patent claims require. (Tr. (Richardson) at 529:4-530:6; CX-0247.0196, .0275; RDX-0002.63). The parties agree that Complainants identified a single vertical and horizontal filter used during block inter prediction that jointly motion compensation interpolates and resamples. (Tr. (Schonfeld) at 1061:17-1062:6; Tr. (Richardson) at 544:22-545:6). There is no dispute that the AV1 Specification describes reconstructing the current block from the sum of a decoded residue block and the prediction block. The only meaningful infringement dispute is whether AV1's block inter prediction process meets Respondents' manufactured claim requirements and unfounded assumptions.

First, Respondents contend that the expression $GF_v(s)=MCIF_v(SCF_v(s))$ in claim 1.3 (and the similar expression $GF_H(u)=MCIF_H(SCF_H(u))$ in claim 1.4) is a mathematical equation that requires Complainants to prove exact mathematical equality between the claimed GF_v and the composition of $MCIF_v$ and SCF_v . Complainants disagree. Complainants have shown (and Respondents agree) that the filters used in AV1's block inter prediction jointly resample and motion compensate. (Tr. (Schonfeld) at 1061:17-1062:6; Tr. (Richardson) at 544:22-545:6). That is all that is required to satisfy this claim limitation. Regardless, Complainants have shown that the output of the AV1 filter used to create a prediction array (i.e., GF_v) is equal to the composition of two hypothetical motion compensated interpolation and resampling filters.

Second, Round2 does not affect the equality analysis. Respondents' Round2 argument appears to rely on the assumption that the GF_v identified in the AV1 Specification (after Round2)

[REDACTED]

must be equal to the composition of a hypothetical SCFv (after Round2) and MCIFv (after Round2). (Tr. (Schonfeld) at 1080:16-1081:4). There is no basis for this apples-to-oranges comparison. As Dr. Schonfeld admitted, applying Round2 to two identical filter outputs results in identical values. (*Id.*). Thus, Complainants have shown the output of the composition of MCIFv and SCFv is equal to the output of GFv regardless of whether the Round2 function is applied.

Complainants have shown that AV1's block inter prediction process practices every limitation of claims 1 and 7 of the '877 patent. Thus, through decoding AV1-encoded bitstreams in compliance with the AV1 Specification, the Accused Products infringe the '877 patent.

3. Infringement of Claim 1 of the '877 Patent

Complainants have shown that the Accused Products decode video in accordance with the AV1 Specification. (Tr. (Richardson) at 398:1-9, 564:23-565:1, 527:22-528:10). Complainants also proved that compliance with the AV1 Specification infringes claim 1 of the '877 patent. (*Id.*). Testing, third party source code, and other documents confirm that claim 1 is infringed. (*Id.* at 398:1-401:1; CX-0514C; CX-0519; CX-1600C; CX-0514C; CX-0519; CX-1600C; CDX-0005C.5).

a. Claim 1.P ("A decoding method of a binary stream to reconstruct a current block of a current image from a reference block of a reference image reconstructed at a different size from the size of said current image, said reconstructed reference image being stored in a decoded picture buffer")

Complainants proved that each of the Accused Products infringe claim 1.P. The parties agree that the preamble of claim 1 is limiting. (Tr. (Schonfeld) at 1141:5-9). There is no dispute that the Accused Products infringe this limitation by practicing AV1's block inter prediction process. (Tr. (Richardson) 528:23-529:3; Tr. (Schonfeld) at 912:21-25; RDX-0002.63, .100-101). For example, the parties agree that reference frames used for AV1's inter prediction process are stored in FrameStore, i.e., the decoded picture buffer ("DPB"). (Tr. (Richardson) 529:4-530:9; Tr.

[REDACTED]

(Schonfeld) 884:7-11; CX-0247.0196, .0275; CDX-0005C.74). Dr. Schonfeld admitted that “FrameStore is sort of a virtual memory that [the] AV1 Specification describes is where you would want to store your frames so that you can use them for both reference frames and to show them on the display.” (Tr. (Schonfeld) 884:12-15; CX-0247.0275, .0087-91, .0194-96, .0666). AV1’s motion vector scaling process accounts for any size differences between a reference frame and a current frame to be reconstructed by adjusting sampling locations in the reference frame “to compensate for any difference in the size of the reference frame compared to the current frame.” (Tr. (Richardson) 530:7-531:10; CX-0247.0016, .0096-97, .0270-.0279; CDX-0005C.75). And the AV1 Specification describes that its reconstruction process outputs reconstructed samples in the current frame CurrFrame. (Tr. (Richardson) 531:11-532:3; Tr. (Schonfeld) 883:15-23; CX-0247.0307-0309, .0017, .0097-99; CDX-0005C.76). Thus, Complainants have shown that the Accused Products infringe this claim limitation. (Tr. (Richardson) 532:4-10).

b. Claim 1.1 (“motion compensating said reference block of said reconstructed reference image by applying a single horizontal filter GFH and a single vertical filter GFv successively on the lines and on the columns of pixels of said reference block”)

Complainants proved that each of the Accused Products motion infringe claim 1.1. Complainants have shown that AV1’s block inter prediction process practices this limitation. (*See generally* Tr. (Richardson) at 532:11-538:7; CDX-0005C.78-83).

The ’877 patent specification clearly describes what it means to apply the claimed GFv and GFH “successively on the lines and on the columns of pixels of said reference block.” For example, it is undisputed that Figure 8 of the ’877 patent depicts separable filters such as the claimed GFv and GFH being applied to pixels according to the ’877 patent and according to how a POSITA would understand separable filters typically function. (Tr. (Richardson) at 514:18-515:25, 556:11-13; Tr. (Schonfeld) 871:18-872:9). There is no dispute that the filters used in AV1’s block inter

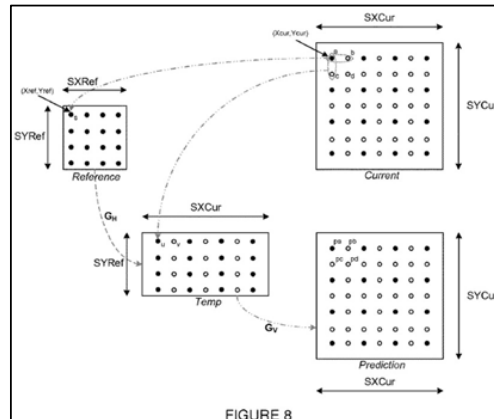
[REDACTED]

[REDACTED]

prediction process are applied in this typical fashion. (Tr. (Richardson) at 533:21-534:15; Tr. (Schonfeld) at 895:21-896:4. 1060:2-9). The sole dispute manufactured by Respondents regarding this limitation is whether the '877 patent embodiments and the filtering of AV1's accused block inter prediction process fall into the ambit of Respondents' erroneous "literal meaning of the claim." (Tr. (Schonfeld) at 1058:9-17). Respondents' interpretation of the claims is wrong. Respondents improperly construe the claims in a vacuum, ignoring the intrinsic evidence in its entirety. *See Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (en banc) (internal citation omitted). "The claims, of course, do not stand alone. Rather, they are part of 'a fully integrated written instrument,' consisting principally of a specification that concludes with the claims." *Id.* at 1315 (internal citation omitted).

Complainants have shown that, under the correct construction, the Accused Products, practicing the AV1 Specification, infringe claim 1.1. The '877 patent describes that resampling and motion compensated interpolation "are performed jointly by applying a separable interpolation filter successively on the lines and on the columns of pixels of the reference block." (JX-0004 at 6:8-15). Figure 8 of the '877 patent and the accompanying text, as Dr. Richardson testified, depicts the grouped filters being applied successively to a reference block to generate a prediction block according to the invention. (Tr. (Richardson) 514:18-517:10; JX-0004 at FIG. 8); *Phillips*, 415 F.3d at 1315, (claims "must be read in view of the specification, of which they are a part") (quoting *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 979 (Fed. Cir. 1995) (en banc), *aff'd*, 517 U.S. 370 (1996)). In particular, Figure 8 shows that horizontal filters are first applied to the rows of pixels of a reference block to interpolate additional pixels horizontally. (Tr. (Richardson) 516:1-13; JX-0004 at FIG. 8; CDX-0005C.65). Then vertical filters are applied to the columns of pixels of the intermediate or temporary block ("Temp") to interpolate additional pixels vertically and

generate the upsampled prediction block. (Tr. (Richardson) 516:14-23, 517:11-17; JX-0004 at FIG. 8; CDX-0005C.65). As the specification states, “[t]he filters GF_H and GF_V are [] successively applied *as shown in FIG. 8* to determine the prediction block Bp.” (JX-0004 at 6:35-36 (emphasis added); CDX-0005C.65).

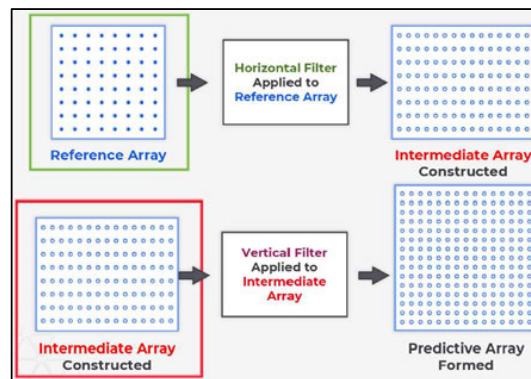


(JX-0004 at FIG. 8). Figure 8 depicts “what it means in the context of the patent to successively apply horizontal and vertical filters.” (Tr. (Richardson) at 516:24-517:10); *Phillips*, 415 F.3d at 1315 (“the specification ‘is always highly relevant to the claim construction analysis. Usually, it is dispositive; it is the single best guide to the meaning of a disputed term’”) (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)).

The parties agree that the block inter prediction process of AV1 generates a prediction block that has been motion compensated and resampled by first applying a horizontal filter to generate a temporary array and then a second vertical filter to the temporary array to generate a prediction block. (Tr. (Richardson) at 533:2-5; Tr. (Schonfeld) at 1060:2-9, 1061:1-1062:6). The AV1 Specification describes that during block inter prediction, “[f]irst a horizontal filter is used to build up a temporary array, and then this array is vertically filtered to obtain the final prediction.” (CX-0247.0278, .275; *see also* Tr. (Richardson) at 533:21-534:8; CDX-0005C.81).

AV1’s block inter prediction pseudocode confirms that these filters perform motion

compensated interpolation and resample the reference block. (Tr. (Richardson) at 551:5-14). For example, the pseudocode specifying the array intermediate shows that during the horizontal filtering process, a single filter is applied to the reference block “ref” to generate an intermediate (or temporary) array. (Tr. (Schonfeld) at 878:25-879:12; RX-0584.0275-76; RDX-0002.47). The single horizontal filter is selected from the arrays specified by Subpel_Filters. (Tr. (Richardson) at 534:9-19). Each line of the Subpel_Filters array is a filtering operation. (*Id.* at 534:13-15). The AV1 block inter prediction pseudocode specifying the array pred shows that a single filter is then applied during the vertical filtering process to the intermediate array to generate the final prediction array. (Tr. (Schonfeld) at 879:13-21; Tr. (Richardson) at 532:16-533:5; RX-0584.0275-76; RDX-0002.47). As Dr. Schonfeld testified, “the output of the previous filter is now the input of the current filter . . . and the vertical filter is no longer applied to the reference array, but, rather, to the intermediate array . . . and its output is the predictive array, which was the pred array.” (Tr. (Schonfeld) at 879:25-880:22, 903:6-15; RDX-0002.48-49, .86).



(RDX-0002.86).

In other words, AV1’s block inter prediction filters operate exactly how the claimed filters are depicted in Figure 8 of the ’877 patent. (Tr. (Schonfeld) at 1060:2-9; Tr. (Richardson) at 534:9-535:2). And AV1’s block inter prediction filters and the claimed filters of Figure 8 are both applied consistently with how a POSITA understands separable filters would work. As Dr. Schonfeld

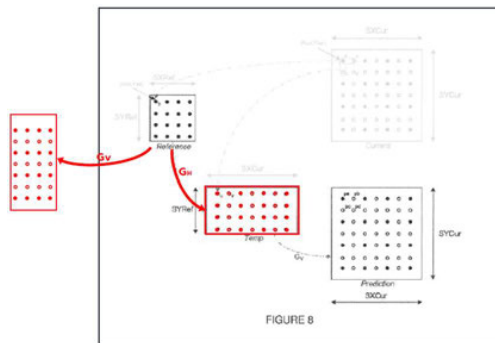
testified, “Fig. 8 shows the way we use separable filters normally”: first, “a series of one-dimensional filters” is applied to each row of pixels to yield an intermediate image. (Tr. (Schonfeld) at 871:18-872:5, 876:7-13). Then, “a series of vertical filters” is applied “to the result of the first filter” to yield the final prediction block. (Tr. (Schonfeld) at 872:3-6, 876:7-13; *see also* Tr. (Richardson) at 515:12-25 (“[I]ts job is to process a block in two dimensions, horizontally and vertically, and with the right choice of filter you can split those tasks up into a horizontal filtering step and a vertical filtering step.”)). The filtering applied during block inter prediction to generate a temporary and then prediction array is thus “consistent with a traditional way of requiring separable filters.” (Tr. (Schonfeld) at 878:16-24). Indeed, Dr. Schonfeld testified:

if you want to do separable in the traditional way, you have to take the input ref and produce an output intermediate, and then the output intermediate has to be the input of the next filter, the vertical filter, to produce the final output pred, and *that’s exactly what this filter does in the block inter prediction filters.*

(Tr. (Schonfeld) at 895:21-896:4) (emphasis added). Under a reading of the claim language properly informed by the specification and embodiments of the ’877 patent, Complainants showed that the Accused Products, practicing AV1, infringe claim 1.1.

Respondents advance an erroneous construction based on a mischaracterization of the claim language. The Federal Circuit “normally do[es] not construe claims in a manner that would exclude the preferred embodiment, especially where it is the only disclosed embodiment.” *GE Lighting Solutions, LLC v. AgiLight, Inc.*, 750 F.3d 1304, 1311 (Fed. Cir. 2014) (citation omitted). “[W]here claims can reasonably [be] interpreted to include a specific embodiment, it is incorrect to construe the claims to exclude that embodiment, absent probative evidence on the contrary.” *Id.* (citation omitted). Respondents’ construction eliminates *every* embodiment of the ’877 patent invention, and Respondents provide no reason for doing so. Instead, Respondents ignore the practical impossibility of their construction and contend the claim is “defective.”

In particular, Respondents contend that the claim requires a single horizontal filter applied to “said reference block,” followed by “a single vertical filter [applied] to the same said reference block.” (Tr. (Schonfeld) at 895:10-15, 876:18-877). As Dr. Schonfeld admits, “[i]f you do that, you get something different from the traditional separable filter argument.” (Tr. (Schonfeld) at 895:16-20). According to Respondents, “the literal words” of the claim language “is not what’s depicted in the embodiment of Fig. 8.” (Tr. (Schonfeld) at 876:18-877:2, 1057:13-1058:21). Instead, under Respondents’ interpretation, two separate outputs would be generated. (Tr. (Schonfeld) at 876:18-25; CDX-0005C.83; RDX-0002.41). Dr. Richardson confirmed that Respondents’ interpretation would “generate a horizontally filtered block” and “a separate vertically filtered block,” as depicted below. (Tr. (Richardson) at 536:12-23; CDX-0005C.83).



(CDX-0005C.83).

Respondents’ erroneous interpretation should be rejected. Not only do Respondents contend that the “literal meaning of the claim limitation does not map to Fig. 8,” but Dr. Schonfeld admits there is not a single depiction of Respondents’ proposed construction anywhere in the ’877 patent. (Tr. (Schonfeld) at 1058:9-17). As the Federal Circuit has repeatedly explained, “‘highly persuasive’ evidence is required to read claims as excluding a preferred embodiment of the invention” and “a claim interpretation that excludes a preferred embodiment from the scope of the claim is rarely, if ever, correct.” *CUPP Computing AS v. Trend Micro Inc.*, 53 F.4th 1376, 1381

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(Fed. Cir. 2022) (quotation marks and citations omitted). “The only meaning that matters in claim construction is the meaning in the context of the patent.” *Trustees of Columbia Univ. v. Symantec Corp.*, 811 F.3d 1359, 1363 (Fed. Cir. 2016). Indeed, the claim would, in fact, be “defective” under Respondents’ strained construction. (Tr. (Schonfeld) at 1058:18-21).

Complainants’ interpretation of the claim language is the correct one. As Dr. Richardson testified, “[t]he figure and the text state that what the patent means by successively applying these two filters is as shown in Fig. 8,” which depicts the application of a first filter to a reference block to create a temporary array, to which the second filter is applied to generate a prediction block. (Tr. (Richardson) at 535:16-536:11, 537:9-19). In other words, “[t]he specification says exactly what . . . the inventors meant by ‘successively applied’ in this instance.” (Tr. (Richardson) at 536:911). Dr. Schonfeld agreed—the block inter prediction filters of “AV1 operate[] consistently with Fig. 8 for the purposes of just looking at successively applying filters.” (Tr. (Schonfeld) at 1060:2-9). Thus, under the proper interpretation of the claim, the Accused Products’ practice of the AV1 Specification infringes claim 1.1.

Lastly, Respondents introduced a new noninfringement theory at the Hearing. Specifically, Respondents contend that if the Round2 function is not part of the single filters and is instead an operation applied to the output of the filters (as Complainants allege), then claim 1.1 cannot be practiced “because you have an extra step of Round2 in between.” (Tr. (Schonfeld) at 1155:5-18, 898:17-899:9). Respondents’ theory would require that no intervening rounding functions occur between the application of the claimed single vertical and horizontal filters. Respondents are wrong. Round2, regardless of when it is applied, has no impact on whether motion compensation occurs or whether filters are applied successively on the lines and on the columns of pixels of the reference block. Indeed, as Respondents acknowledged, prior art filtering method required that

rounding occur after each separate filter in order for it to “be realizable on an integer machine.” (*Id.* at 1080:1-9). That Round2 is specified in the AV1 block inter prediction pseudocode does not change the fact that the single filters are applied one after another (i.e., successively without intervening filters) to create a prediction block (i.e., motion compensation). Complainants have shown that the Accused Products practice this claim limitation. (Tr. (Richardson) at 538:2-7).

c. Claim 1.2 (“decoding, for the current block, a residue block, and reconstructing the current block from said residue block and from said motion compensated reference block”)

Complainants proved that each of the Accused Products infringe claim 1.2. There is no dispute that Complainants have shown that AV1’s block inter prediction process infringes this claim limitation. (Tr. (Richardson) at 538:8-539:16; Tr. (Schonfeld) at 883:15-23, 912:21-25; RDX-0002.63, .101). Drs. Richardson and Schonfeld agree that the AV1 Specification describes reconstruction as the process of “[o]btaining the addition of the decoded residual and the corresponding prediction values.” (Tr. (Richardson) at 538:11-17; Tr. (Schonfeld) at 883:15-23CX-0247.0017, .0307, .0309; RX-0584.0017; CDX-0005C.87; RDX-0002.53). Specifically, the AV1 Specification describes that a decoded block of CurrFrame is created by adding a residual block Residual[i][j] to a prediction block CurrFrame[plane][y+yy][x+xx]. (Tr. (Richardson) at 538:18-539:14; CX-0247.0307, .0309; CDX-0005C.86; *see also* Tr. (Schonfeld) at 884:1-11). Thus, Complainants have shown that the Accused Products’ practice of the AV1 Specification infringes this claim limitation.

d. Claim 1.3 (“said single vertical filter GFv applied on a pixel s is such that $GFv(s)=MCIFv(SCFv(s))$, where MCIFv is a vertical motion compensation interpolation filter and SCFv is a vertical resampling filter, MCIFv and SCFv being applied jointly”)

Complainants proved that each of the Accused Products infringe claim 1.3. Complainants have shown that the filters used in the AV1 block inter prediction process practice this claim

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limitation. (Tr. (Richardson) at 557:20-23). There is no dispute that the filtering of AV1's block inter prediction process uses single horizontal and vertical filters to generate a prediction block by jointly resampling and motion compensation interpolating a block of a reference frame of a different size from the current frame. (Tr. (Schonfeld) at 1060:2-9, 1061:17-1062:6; Tr. (Richardson) at 544:22-545:6). The developers of the AV1 Specification themselves described that "it would be more compute efficient to combine such rescaling with subpel interpolation for motion compensation, and that is what AV1 does." (*Id.* at 555:13-557:19; CX-2112.0002).

Respondents' two noninfringement arguments rest on the assumption that the expression $GF_v(s) = MCIF_v(SCF_v(s))$ requires Complainants to show exact mathematical equality between AV1's implementation of GF and the composition of two hypothetical MCIF and SCF filters not contemplated in the AV1 Specification itself. **First**, Respondents allege that to satisfy this claim limitation, Complainants must "find a filter, a single joint filter, whose output is equal to the composition of the two filters." (Tr. (Schonfeld) at 889:18-21). While Complainants disagree with this purported equality requirement, Complainants did in fact demonstrate that there exist (at least) two hypothetical MCIF and SCF filters that, when composed, equal the single filter Complainants identified in the AV1 Specification. (*See, e.g.*, Tr. (Richardson) at 546:22-547:10, 550:2-9, 688:2-20; CDX-0005C.69-70). **Second**, Respondents assume that Complainants must demonstrate equality between (1) the implementation of the claimed single filter GF_v as specified by the AV1 block inter prediction pseudocode, and (2) two hypothetical filters ***implemented such that rounding occurs after each separate filter***. (Tr. (Schonfeld) at 893:11-16). In other words, Respondents argue that Complainants must not only identify two hypothetical filters, but that the Court must also assume that there is hypothetical rounding (according to the AV1 Specification) that occurs after each of those hypothetical filters. Respondents' assumption is unfounded.

Moreover, Complainants have shown regardless of whether it is part of the filtering operation itself or is applied to the filter outputs, AV1's Round2 function does not prevent equality.

(i) The AV1 Block Inter Prediction Process Specifies a Single Vertical Filter for Joint Motion Compensated Interpolation and Resampling

Throughout the course of this Investigation, Complainants have consistently maintained that the filtering employed in AV1's block inter prediction process performs both motion compensated interpolation and resampling. The claimed joint motion compensated interpolation and resampling is achieved by filtering the intermediate array samples using the filter coefficient array Subpel_Filters and the step size yStep, which takes into account yScale. (*See, e.g.*, CPre at 18-19 ("The vertical filter, which utilizes yStep and a filter coefficient array specified by Subpel_Filters, is applied to the intermediate array to create a prediction array.")). In other words, the variable yScale is used in conjunction with the filter array Subpel_Filters in the block inter prediction process to carry out both claimed operations. (CPre at 19 ("Each row in the array is a filter, and yStep [] indicates how many of these filters are applied to the samples.")). Dr. Richardson's testimony at the evidentiary Hearing proves that the block inter prediction filtering of AV1 infringes this claim limitation. (Tr. (Richardson) at 695:8-13).

The parties agree that the decoders in the Accused Products implement the AV1 block inter prediction pseudocode (reproduced below) from the AV1 Specification to create a prediction array. The pseudocode specifies the application of a single vertical filter that jointly resamples and performs motion compensated interpolation to the intermediate array. (Tr. (Richardson) at 544:22-545:6; Tr. (Schonfeld) at 890:6-11). The pseudocode "describe[es] the logical steps that a decoder should take" and shows that the temporary array resulting from the horizontal filtering of the block inter prediction process is "vertically filtered to obtain the final prediction." (Tr. (Richardson) at 542:23-543:6, 540:15-18; CX-0247.0275-76). The most constrained "for loop" (i.e., from "for (t

= 0; t < 8; t++)” to “intermediate[(p >> 10) + t][c]”) (identified with a red box below) describes the vertical filtering operation. (Tr. (Richardson) at 549:4-21; Tr. (Schonfeld) at 1083:5-1084:9).

• The array pred is specified as follows:

```
interpFilter = InterpFilters[ candRow ][ candCol ][ 0 ]
if ( h <= 4 ) {
    if ( interpFilter == EIGHTTAP || interpFilter == EIGHTTAP_SHARP ) {
        interpFilter = 4
    } else if ( interpFilter == EIGHTTAP_SMOOTH ) {
        interpFilter = 5
    }
}
for ( r = 0; r < h; r++ ) {
    for ( c = 0; c < w; c++ ) {
        s = 0
        p = (y & 1023) + yStep + r
        for ( t = 0; t < 8; t++ )
            s += Subpel_Filters[ interpFilter ][ (p >> 6) & SUBPEL_MASK ][ t ] *
                intermediate[ (p >> 10) + t ][ c ]
        pred[ r ][ c ] = Round2(s, InterRound1)
    }
}
```

(CX-0247.0274-76 (annotated); CDX-0005C.90; RDX-0002.69).

Within the most constrained “for loop” is the constant array Subpel_Filters. (Tr. (Schonfeld) at 1083:3-9). Dr. Richardson testified that each line in the filter coefficient arrays of Subpel_Filters is a filtering operation that can be selected and applied vertically “depending on the pixel position that’s being generated.” (Tr. (Richardson) at 540:1-20). While there are six filter arrays specified by Subpel_Filters, one particular set of filters (the bilinear filter) is reproduced below. (CX-0247.0278; Tr. (Richardson) at 542:4-7; CX-0247.0278; CDX-0005C.89). This set of filters is “used for bilinear filtering” and can be selected for use by the AV1 encoder. (Tr. (Richardson) at 540:15-16). “Bilinear filtering is an option that is transmitted in the AV1 bitstream, it’s one of the filter types,” and “[t]he AV1 encoder can choose one of these filter types.” (*Id.* at 541:15-19). The single vertical filter GFv is embedded in the bilinear filter because when the set of bilinear filters is used, “the decoder for each pixel position uses one of these filters, one of these lines to filter pixels . . . to produce upsampled [and] motion compensated interpolated [pixels] of the prediction block.” (*Id.* at 541:3-542:3).

```

Subpel_Filters[ 6 ][ 16 ][ 8 ] = {
{
  { 0, 0, 0, 128, 0, 0, 0, 0 },
  { 0, 0, 0, 120, 8, 0, 0, 0 },
  { 0, 0, 0, 112, 16, 0, 0, 0 },
  { 0, 0, 0, 104, 24, 0, 0, 0 },
  { 0, 0, 0, 96, 32, 0, 0, 0 },
  { 0, 0, 0, 88, 40, 0, 0, 0 },
  { 0, 0, 0, 80, 48, 0, 0, 0 },
  { 0, 0, 0, 72, 56, 0, 0, 0 },
  { 0, 0, 0, 64, 64, 0, 0, 0 },
  { 0, 0, 0, 56, 72, 0, 0, 0 },
  { 0, 0, 0, 48, 80, 0, 0, 0 },
  { 0, 0, 0, 40, 88, 0, 0, 0 },
  { 0, 0, 0, 32, 96, 0, 0, 0 },
  { 0, 0, 0, 24, 104, 0, 0, 0 },
  { 0, 0, 0, 16, 112, 0, 0, 0 },
  { 0, 0, 0, 8, 120, 0, 0, 0 }
}

```

GFv is embedded in the bilinear filter

(CDX-0005C.89; CX-0247.0278).

In addition to containing the variable Subpel_Filters in the most constrained “for loop,” (Tr. (Schonfeld) at 898:6-9), the AV1 block inter prediction pseudocode contains variables such as yStep, which identifies the “single pixel position that we want to create in the upsampled motion compensated prediction block.” (Tr. (Richardson) at 543:7-21; CX-0247.273 (yStep “giv[es] the step size in units of 1/1024th of a sample”). yStep in turn depends on the variable yScale, which, along with xScale, “specify the size of the reference frame relative to the current frame.” (CX-0247.0274; Tr. (Richardson) at 543:21-24). yStep is then used in conjunction with Subpel_Filters (specifically, the bilinear filters) “to create for that pixel an upsampled motion compensated prediction sample.” (Tr. (Richardson) at 544:4-8).

Respondents’ effort to mischaracterize Dr. Richardson’s hearing testimony as presenting a “new” infringement theory lacks credibility. (Tr. (Schonfeld) 905:3-10, 887:24-889:2). Respondents contend Complainants originally identified the entirety of the AV1 block inter prediction pseudocode used to generate the pred array and intermediate array as the claimed GFv and GFH, respectively. (*Id.* at 888:1-10). This is demonstrably wrong. Complainants have consistently maintained that “[i]t’s the filter in AV1 . . . that is used to construct the array with the variable name pred” that is the claimed GFv. (Tr. (Richardson) at 695:8-13, 699:4-9). As shown

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in CDX-0005C.89, the GFv filter in AV1 is embedded in the six filter arrays specified by Subpel_Filters, including the bilinear filter. (CX-0247.0278; Tr. (Richardson) at 542:4-7; CX-0247.0278; CDX-0005C.89). At no time during this Investigation did Dr. Richardson or Complainants identify the entire block inter prediction pseudocode for generating the prediction array as being the claimed GFv. (Tr. (Richardson) at 697:10-13).

To the contrary, Complainants and Dr. Richardson have repeatedly stated that “[a]n example of a filter coefficient array specified by the AV1 Specification’s Subpel_Filters is shown at CX-0247.0277-79.” (CPre at 19). And that “[e]ach row in the array is a filter, and yStep (and xStep) indicates how many of these filters are applied to the samples.” (*Id.*). Even Dr. Schonfeld recognizes that Complainants did not identify the entirety of the AV1 block inter prediction pseudocode to be the claimed filter. He explained that parameters such as stepX (or xStep) appearing in the pseudocode “themselves are not filters, they are just numbers, to know how that single joint filter should operate.” (Tr. (Schonfeld) at 888:14-889:10). Dr. Richardson also testified that “a person of ordinary skill in the art reading this snippet of pseudocode would understand that the array intermediate² is the third last line [in the pseudocode], intermediate[r] and so on.” (Tr. (Richardson) at 697:10-19). “What is in array intermediate [and pred] is effectively specified by this pseudocode,” but “the entire section of pseudocode mention[s] a number of variables,” of which intermediate (and pred) is one. (*Id.* at 697:20-24). Thus, the entirety of the AV1 block inter prediction pseudocode cannot be (and was never identified as) the claimed GFv.

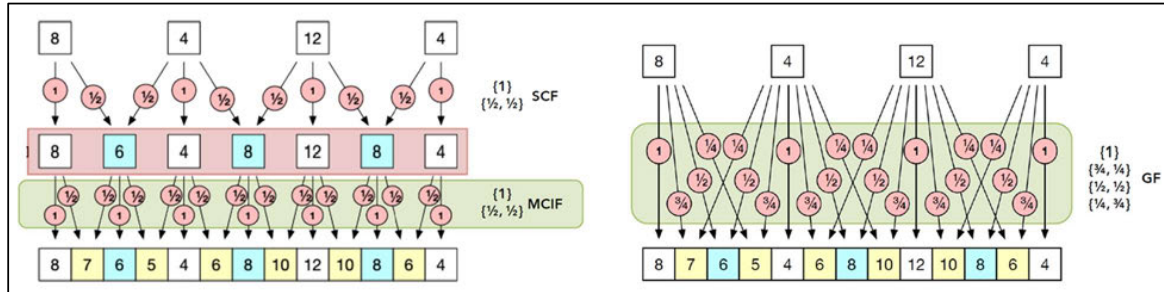
(ii) Complainants Demonstrated that GFv Is a Composition of a Hypothetical MCIFv and SCFv

The parties dispute whether the expression $GFv(s)=MCIFv(SCFv(s))$ requires exact

² Although Dr. Richardson was questioned about the intermediate array pseudocode here, the same analysis applies to the pseudocode for the pred array generated by the vertical filter GFv.

mathematical equality between the claimed GFv and the hypothetical MCIFv and SCFv from which GFv is composed. Read in light of the specification, the claim language does not require proof of exact mathematical equality. The '877 patent merely claims a single filter GFv (and GFH) that can jointly motion compensation interpolate and resample a reference block. The MCIF and SCF themselves are not claimed (nor could they be, as they are replaced by the inventive GFv). Dr. Richardson explained that the expression simply “means that GFv carries out the functions of two filters: SCFv and MCIFv.” (Tr. (Richardson) at 546:20-21). The filters used by the block inter prediction of AV1 do just that. (CX-2112.0002; Tr. (Richardson) at 555:13-557:19; CX-2112.0002). Respondents do not contest this. (Tr. (Schonfeld) at 1061:17-1062:6). Respondents, however, would require that Complainants “do the mathematics” and “do a composition of the two” hypothetical SCF and MCIF filters. (Tr. (Schonfeld) at 889:22-890:5).

Even under Respondents’ tortured “construction,” Complainants have still demonstrated infringement. Complainants showed that two hypothetical filters MCIFv and SCFv can be composed to form GFv, i.e., the filters specified by AV1’s Subpel_Filters. Complainants have “f[ou]nd a filter, a single joint filter, whose output is equal to the composition of the two filters,” as Respondents argue is required. (Tr. (Schonfeld) at 889:18-21, 890:24-891:1). Comparing prior art filtering to the claimed single filtering operation (depicted in the figures below), Dr. Richardson explained that it is possible to achieve in one filtering step (in each direction) what was previously accomplished using two successively applied filters (in each direction). (*See supra* § III.B.1.a). For example, the successive application of the SCF $\{1\}$, $\{\frac{1}{2}, \frac{1}{2}\}$ and MCIF $\{1\}$, $\{\frac{1}{2}, \frac{1}{2}\}$ generates an output equal to the application of a single filter GF $\{1\}$, $\{\frac{3}{4}, \frac{1}{4}\}$, $\{\frac{1}{2}, \frac{1}{2}\}$, $\{\frac{1}{4}, \frac{3}{4}\}$.



(CDX-0005C.69-70) (annotated). At the Hearing, Dr. Richardson showed an “example [illustrated above] where [he] walked through an SCF filter, a simple bilinear filter, followed by an MCIF filter, another bilinear filter . . . and then showed [] another slide where . . . a single filter that in a single step carries out the job of both of those filters, that is entirely consistent in [his] view with th[e] expression” $GFv(s)=MCIFv(SCFv(s))$. (Tr. (Richardson) at 546:22-547:10; Tr. (Schonfeld) at 1070:21-1071:1; *see also* Tr. (Richardson) at 550:2-9 (“I showed you that there was a . . . filter that combined the operations of both of those filters and produced exactly the same result.”)).

Although Dr. Richardson’s examples used simplified bilinear filters, the same compositional relationship can be established using larger filter coefficients. For example, the output of a hypothetical SCF {8}, {4, 4}—which is the {1}, {1/2, 1/2} filter set multiplied by 8—composed with a hypothetical MCIF {16}, {8, 8}—which is the {1}, {1/2, 1/2} filter set multiplied by 16—is equal to the output of the original, simplified MCIF(SCF) example multiplied by 128 (i.e., $8 \times 16 = 128$). (See Tr. (Schonfeld) at 1065:18-23). And the output of a hypothetical GF of {128}, {96, 32}, {64, 64}, {32, 96} is the output of the simplified GF example—the {1}, {3/4, 1/4}, {1/2, 1/2}, {1/4, 3/4} filter—multiplied by 128. (Tr. (Schonfeld) at 1071:2-22).

In AV1’s implementation of the grouped filters, the xStep and yStep parameters of the block inter prediction pseudocode specify how many of the 16 rows of filters are used to motion compensate a reference block and sets of various numbers of filters could be selected. (Tr. (Schonfeld) at 1072:21-1073:21, 888:12-23). For example, a set containing every fourth filter of

the bilinear filters of Subpel_Filters could be selected, i.e., {0, 0, 0, 128, 0, 0, 0, 0}, {0, 0, 0, 96, 32, 0, 0, 0}, {0, 0, 0, 64, 64, 0, 0, 0}, {0, 0, 0, 32, 96, 0, 0, 0}. (*See id.*). The hypothetical GF of {128}, {96, 32}, {64, 64}, {32, 96} is identical to this set of filters specified by Subpel_Filters reproduced below because the zero coefficients in AV1's bilinear filters can be ignored, as they merely indicate that no weight is assigned to the neighboring pixel values. (*See* Tr. (Richardson) at 521:1-7). And the hypothetical SCF of {8}, {4, 4} and hypothetical MCIF of {16}, {8, 8} could also be represented as {0, 0, 0, 8, 0, 0, 0, 0}, {0, 0, 0, 4, 4, 0, 0, 0} and {0, 0, 0, 16, 0, 0, 0, 0}, {0, 0, 0, 8, 8, 0, 0, 0}, respectively. (*See id.* at 521:1-7). Thus, Complainants have shown that a GFv of {0, 0, 0, 128, 0, 0, 0, 0}, {0, 0, 0, 96, 32, 0, 0, 0}, {0, 0, 0, 64, 64, 0, 0, 0}, {0, 0, 0, 32, 96, 0, 0, 0} selected from Subpel_Filters of the AV1 Specification is equal to the composition of a hypothetical SCF of {0, 0, 0, 8, 0, 0, 0, 0}, {0, 0, 0, 4, 4, 0, 0, 0} and MCIF of {0, 0, 0, 16, 0, 0, 0, 0}, {0, 0, 0, 8, 8, 0, 0, 0}. (Tr. (Richardson) at 542:8-22 (the AV1 filters “are filters of the same form as the ones I described earlier, but the numbers are larger”)).

$$\begin{Bmatrix} 0, 0, 0, 8, 0, 0, 0, 0 \\ 0, 0, 0, 4, 4, 0, 0, 0 \end{Bmatrix} \circ \begin{Bmatrix} 0, 0, 0, 16, 0, 0, 0, 0 \\ 0, 0, 0, 8, 8, 0, 0, 0 \end{Bmatrix} = \begin{Bmatrix} 0, 0, 0, 128, 0, 0, 0, 0 \\ 0, 0, 0, 120, 8, 0, 0, 0 \\ 0, 0, 0, 112, 16, 0, 0, 0 \\ 0, 0, 0, 104, 24, 0, 0, 0 \\ 0, 0, 0, 96, 32, 0, 0, 0 \\ 0, 0, 0, 88, 40, 0, 0, 0 \\ 0, 0, 0, 80, 48, 0, 0, 0 \\ 0, 0, 0, 72, 56, 0, 0, 0 \\ 0, 0, 0, 64, 64, 0, 0, 0 \\ 0, 0, 0, 56, 72, 0, 0, 0 \\ 0, 0, 0, 48, 80, 0, 0, 0 \\ 0, 0, 0, 40, 88, 0, 0, 0 \\ 0, 0, 0, 32, 96, 0, 0, 0 \\ 0, 0, 0, 24, 104, 0, 0, 0 \\ 0, 0, 0, 16, 112, 0, 0, 0 \\ 0, 0, 0, 8, 120, 0, 0, 0 \end{Bmatrix},$$

(CX-0247.0278 (annotated); CDX-0005C.89).

As another example, the entirety of the bilinear filter of AV1's Subpel_Filters can also be decomposed into a hypothetical SCF and a hypothetical MCIF.

$$\begin{array}{l}
 \{0, 0, 0, 8, 0, 0, 0, 0\} \\
 \{0, 0, 0, 4, 4, 0, 0, 0\}
 \end{array}
 \circ
 \begin{array}{l}
 \{0, 0, 0, 16, 0, 0, 0, 0\} \\
 \{0, 0, 0, 14, 2, 0, 0, 0\} \\
 \{0, 0, 0, 12, 4, 0, 0, 0\} \\
 \{0, 0, 0, 10, 6, 0, 0, 0\} \\
 \{0, 0, 0, 8, 8, 0, 0, 0\} \\
 \{0, 0, 0, 6, 10, 0, 0, 0\} \\
 \{0, 0, 0, 4, 12, 0, 0, 0\} \\
 \{0, 0, 0, 2, 14, 0, 0, 0\}
 \end{array}
 =
 \begin{array}{l}
 \{0, 0, 0, 128, 0, 0, 0, 0\}, \\
 \{0, 0, 0, 120, 8, 0, 0, 0\}, \\
 \{0, 0, 0, 112, 16, 0, 0, 0\}, \\
 \{0, 0, 0, 104, 24, 0, 0, 0\}, \\
 \{0, 0, 0, 96, 32, 0, 0, 0\}, \\
 \{0, 0, 0, 88, 40, 0, 0, 0\}, \\
 \{0, 0, 0, 80, 48, 0, 0, 0\}, \\
 \{0, 0, 0, 72, 56, 0, 0, 0\}, \\
 \{0, 0, 0, 64, 64, 0, 0, 0\}, \\
 \{0, 0, 0, 56, 72, 0, 0, 0\}, \\
 \{0, 0, 0, 48, 80, 0, 0, 0\}, \\
 \{0, 0, 0, 40, 88, 0, 0, 0\}, \\
 \{0, 0, 0, 32, 96, 0, 0, 0\}, \\
 \{0, 0, 0, 24, 104, 0, 0, 0\}, \\
 \{0, 0, 0, 16, 112, 0, 0, 0\}, \\
 \{0, 0, 0, 8, 120, 0, 0, 0\}
 \end{array}$$

(CX-0247.0278).

(iii) **Round2 Does Not Prevent Equality Between the Claimed GFv and the Composition of the Hypothetical MCIFv and SCFv**

The parties do not dispute how the AV1 Specification carries out the Round2 function as part of the block inter prediction process. Dr. Richardson interprets the innermost loop of the AV1 block inter prediction pseudocode as depicting “the s+ line [] carried out 8 times and [] each time the variable s is having a pixel value multiplied by a weight from Subpel_Filters and added to the total s.” (Tr. (Richardson) at 548:22-549:21). Then, “[o]nce all of that is done and [] the total of s is complete,” the Round2 function is applied, which “changes the magnitude of the input and it rounds the result” to an integer number.” (*Id.*). Similarly, Dr. Schonfeld agrees that “only after that ‘for loop’ completes its work are we going to encounter the Round2 function.” (Tr. (Schonfeld) at 1083:15-1084:2). In other words, Round2 “is applied to each and every pixel of the output before it is recorded in the intermediate array and then in the prediction array.” (Tr. (Schonfeld) at 881:2-9). The parties agree that the Round2 function of AV1 ensures that the calculated output of the filters is an integer and remains within the maximum values allowed by computer hardware. (Tr. (Richardson) at 550:20-551:4, 549:16-21; Tr. (Schonfeld) at 892:10-893:10).

The parties dispute, however, whether the Round2 function is a part of the claimed filter itself or is merely a function applied to the filter outputs. (*Compare* Tr. (Richardson) at 548:22-

549:21 *with* Tr. (Schonfeld) at 880:23-881:9). It does not matter. In neither scenario is the compositional relationship between GFv and MCIFv(SCFv) affected. (Tr. (Richardson) at 551:5-14). Complainants showed above that the bilinear filter described in AV1's Subpel_Filters (i.e., GFv) can be decomposed into two hypothetical filters MCIFv and SCFv. (*See, e.g.*, Tr. (Richardson) at 546:22-547:10, 542:4-22). Complainants showed that the output of GFv is equal to the output of the composition of the hypothetical MCIFv and SCFv. *See supra* § III.B.3.d(ii). And applying the Round2 function to those identical filter outputs yields identical results. (Tr. (Schonfeld) at 1079:20-1080:15). Dr. Schonfeld agrees. (*See id.*).

Respondents contend that because Round2 is “part of the AV1 Specification, once you have Round2 operation, you cannot get exact equality when you decompose.” (Tr. (Schonfeld) at 893:4-10). Respondents' argument is based on an untenable assumption: that the accused GFv (with Round2) must produce an output equal to the composition of SCFv (with Round2) and MCIF (with Round2). In other words, Respondents seek to require equality between the output of a single stage of rounding and the output of two stages of rounding. (*See id.* at 1080:20-1081:1). That is not what the '877 patent claims require.

Respondents' rounding argument is based on a prior art HEVC proposal that is unrelated to the infringing inter prediction process of AV1. According to the proposed adaptive resolution method in HEVC, a clipping or rounding function similar to Round 2 was applied after the operation of a separate resampling filter and motion compensated interpolation filter in each direction (horizontal and vertical). (RX-1088.0003 at FIG. 4). In the HEVC proposal, this separate rounding function was necessary because a resampled version of the reconstructed reference frame was required to be stored in the DPB prior to motion compensated interpolation. (Tr. (Richardson) at 550:20-551:4, 549:16-21, 511:13-512:17; Tr. (Schonfeld) at 893:17-894:5; RX-1088.0007;

[REDACTED]

[REDACTED]

RDX-0002.79). The single filters of the '877 patent, on the other hand, only permit the final prediction block to be saved to the DPB and eliminate the intermediate saving step. Thus, according to the invention of the '877 Patent, only a single rounding function for each grouped filter would be required for an actual implementation, resulting in a “computational saving.” (Tr. (Richardson) at 527:14-21).

Respondents argue that because in the prior art method “SCFv would not be realizable on an integer machine” without a rounding operation, Round2 must be applied after the hypothetical SCFv *and* after the hypothetical MCIFv in any hypothetical composition (and after the hypothetical SCFH and MCIFH). (Tr. (Schonfeld) at 1080:1-9; *see also id.* at 1079:11-19). In other words, according to Respondents, “you need Round2 in the middle” of the filtering operations “if it’s going to be a realizable machine on a hardware processor.” (Tr. (Schonfeld) at 1080:20-25). Respondents cite nothing in the '877 patent to support this argument. Rather, Respondents invoke the deposition testimony of '877 patent inventor Philippe Bordes, who explained that the output of his proposed single filters GH and Gv were not “identical” to the successive application of separate filters SCH, SCv, MCIH, and MCIV. (Tr. (Schonfeld) at 1081:20-1081:1, 894:8-18; RX-0358C (Bordes) at 104:14-106:3; RX-1088; RDX-0002.80). Dr. Bordes described in his H0321-r1 proposal that the proposed grouped filter’s “gains may be explained because with the proposed method, only one rounding stage is made, while with previous method two rounding stages are performed.” (Tr. (Schonfeld) at 893:17-894:5; RX-1088.0007; RDX-0002.79).

Respondents’ reliance on Dr. Bordes’ testimony and H0321-r1 proposal is misplaced. As an initial matter, the equality that the expression $GFv(s)=MCIFv(SCFv(s))$ purportedly requires in the claims of the '877 Patent (according to Respondents) is between the single filter GFv and the composition of MCIFv and SCFv. (*See generally* JX-0004 at cl. 1). Dr. Bordes testified that the

[REDACTED]

result of “using a single horizontal filter and a single vertical filter” in his H0321-r1 proposal was not identical to “using the four filters separately shown in figure 4a” of the proposal. (RX-0358C (Bordes) at 104:14-105:15, 88:1-89:2, 89:21-90:10). But the ’877 patent claims contain no such requirement that the convolution of GFv and GFH must be equal to the convolution of SCFv, SCFH, MCIFv, and MCIFH. Thus, Dr. Bordes’ testimony did not address the “equality” urged by Respondents and does not support Respondents’ argument. Dr. Schonfeld admitted as much, stating that Dr. Bordes’ deposition testimony and proposal pertained to implementation of resampling and motion compensated interpolation filters *as they then existed in the HEVC standard*, which required a clipping operation (not Round2) between each filtering step in order to save the output of those filters in hardware. (Tr. (Schonfeld) at 1081:10-1082:13, 1082:14-18; *see also* RX-0358C (Bordes) at 81:3-23). To the extent Dr. Bordes’ H0321-r1 proposal is relevant, it demonstrates that equality is not required to practice the claims of the ’877 patent and, in particular, the expression $GFv(s)=MCIFv(SCFv(s))$.

Respondents’ Round2 argument hinges on the flawed assumption that the expression $GFv(s)=MCIFv(SCFv(s))$ requires equality between GFv (after applying Round2) and the composition of a hypothetical SCFv (after applying Round2) and a hypothetical MCIFv (after applying Round2). (Tr. (Schonfeld) at 1078:24-1079:19, 1080:20-1081:1). Nowhere in the claims is this type of equality required. Dr. Schonfeld contended Complainants must “find a filter, a single joint filter, whose output is equal to the composition of the two filters.” (Tr. (Schonfeld) at 889:18-25). That is precisely what Complainants have done. (Tr. (Richardson) at 545:22-546:10; Tr. (Schonfeld) at 1070:21-1071:1; *see also* Tr. (Richardson) at 549:2-9). Dr. Schonfeld ultimately admitted that the hypothetical filters “don’t have to be in the accused products.” (*Id.* at 889:24-25). Nor could they be, because the AV1 Specification does not specify motion compensated

[REDACTED]

interpolation and resampling filters separate and apart from the Subpel_Filters that perform these operations jointly. Dr. Schonfeld also could not explain why the hypothetical filters SCFv and MCIFv must be subject to Round2 at all—these filters are not part of the AV1 Specification and do not actually exist. And, as Dr. Schonfeld admitted, rounding “is not a necessary reality in software” because software does not require integer precision. (Tr. (Schonfeld) at 892:23-893:3). Thus, in software, “[y]ou could have done it without Round2.” (*See id.* at 893:1-10). In software, no intermediate rounding step would be required.

When Respondents’ baseless requirement of two rounding steps is removed, it becomes clear that Round2 has no bearing on the equality of GFv and MCIFv(SCFv). Indeed, Dr. Schonfeld agreed that if Round2 were applied only to the output of the composition of MCIFv and SCFv without an intermediate rounding step, “you would get the same value” as if Round2 were applied to GFv. (Tr. (Schonfeld) 1081:2-4; *see also id.* at 1080:1-15). Accordingly, regardless of whether equality is required by the claims, Complainants have shown that the Accused Products’ implementation of the AV1 Specification infringes this claim limitation.

- e. **Claim 1.4 (“said single horizontal filter GFH applied on a pixel u is such that $GFH(u)=MCIF(SCFH(u))$, where MCIFH is a horizontal motion compensation interpolation filter and SCFH is a horizontal resampling filter, MCIFH and SCFH being applied jointly”)**

Complainants proved that each of the Accused Products infringe claim 1.4. Complainants have shown that the Accused Products infringe claim 1.4 for the same reasons as claim 1.3. (Tr. (Richardson) at 558:3-559:8). The block inter prediction pseudocode specifying the pred array demonstrates that AV1 practices this limitation by horizontally applying a filter from the Subpel_Filters to the reference block to generate an intermediate array. (Tr. (Richardson) at 544:9-21, 558:3-559:4, 550:2-9; CX-0247.0274-76, .0278). Specifically, the same set of bilinear filters as described above in Section III.B.3.d(ii) specified by Subpel_Filters can be selected for use in

block inter prediction. (See Tr. (Richardson) at 541:3-542:22). As Dr. Richardson testified, “the horizontal filtering pseudocode looks very similar” to the vertical filtering pseudocode used to generate the pred array, but “everything is aligned in the horizontal direction to filter across a line of pixels rather than to filter up and down a vertical column of pixels.” (Tr. (Richardson) at 544:16-21). The composition of a hypothetical SCFH with a hypothetical MCIFH would likewise “get to the same result” as shown in the vertical direction. (*Id.* at 550:2-14). Thus, Complainants have shown that the Accused Products’ practice of the AV1 Specification infringes this claim limitation.

• The array intermediate is specified as follows:

```

interpFilter = InterpFilters[ candRow ][ candCol ][ 1 ]
if ( w <= 4 ) {
    if ( interpFilter == EIGHTTAP || interpFilter == EIGHTTAP_SHARP ) {
        interpFilter = 4
    } else if ( interpFilter == EIGHTTAP_SMOOTH ) {
        interpFilter = 5
    }
}
for ( r = 0; r < intermediateHeight; r++ ) {
    for ( c = 0; c < w; c++ ) {
        s = 0
        p = x + xStep * c
        for ( t = 0; t < 8; t++ )
            s += Subpel_Filters[ interpFilter ][ (p >> 6) & SUBPEL_MASK ][ t ] *
                ref[ plane ][ Clip3( 0, lastY, (y >> 10) + r - 3 ) ]
                [ Clip3( 0, lastX, (p >> 10) + t - 3 ) ]
        intermediate[ r ][ c ] = Round2(s, InterRound0)
    }
}

```

(CX-0247.0275-76) (annotated).

f. Claim 1.5 (“no resampled version of said reconstructed reference image is stored in the decoded picture buffer”)

Complainants proved each of the Accused Products infringe claim 1.5. (Tr. (Richardson) at 559:9-564:22). The parties do not dispute *how* the AV1 Specification dictates storing reconstructed blocks (and images), but rather only *whether* the final reconstructed image saved in the DPB is a prohibited “resampled version.” Under the correct reading of the claim informed by the specification, Complainants proved that the reconstructed samples saved to the DPB at the final step of the decoding process are not “resampled versions” that cannot be stored. Because (as the parties agree) no intermediate resampled version of the reconstructed reference image is stored

[REDACTED]

during the block inter prediction process, the Accused Products’ practice of the AV1 Specification infringes this limitation. (Tr. (Richardson) at 559:16-560:1; Tr. (Schonfeld) at 1087:3-10).

At the end of the decoding process, after being motion compensated, reconstructed block by block, and then modified by a series of in-loop, loop restoration and CDEF filters, the decoded samples denoted by LrFrame (i.e., reconstructed reference frame) are saved to FrameStore (i.e., the DPB). (Tr. (Richardson) at 559:16-561:3; Tr. (Schonfeld) at 883:24-884:15, 907:4-12; CX-0247.0362-63). Indeed, the only data the AV1 Specification permits to be written into FrameStore are the reconstructed reference images in the form of LrFrame samples. (Tr. (Richardson) at 564:10-22). The newly reconstructed reference frames can then be displayed or used as a reference frame for future block inter predictions. (*Id.* at 560:561:4-8; Tr. (Schonfeld) at 884:18-885:2). Respondents do not dispute that, unlike prior art adaptive resolution methods, AV1’s block inter prediction process avoids storing an intermediate resampled version of the reconstructed reference image. (Tr. (Richardson) at 562:13-563:25, 559:16-560:1; Tr. (Schonfeld) at 1087:3-10; JX-0004 at 5:44-52, 7:65-8:2, FIG. 3).

The language of the claims dictates that a version of the reconstructed reference image used for prediction that has only been resampled cannot be stored in the DPB. (Tr. (Richardson) at 563:14-25; JX-0004 at 6:1-7, 5:44-52). In other words, a reference image that has been merely resampled (i.e., a “resampled version”) is not stored in the DPB. (Tr. (Richardson) at 563:14-25; JX-0004 at 6:1-7, 5:44-52). However, the ’877 patent specification expressly contemplates that a reconstructed reference image (i.e., one that has been resampled, motion compensated, and to which a residual has been added) is stored in the DPB. (Tr. (Richardson) at 563:14-25; JX-0004 at 6:1-7, 5:44-52). Specifically, the ’877 patent explains that “no resampled reference image, i.e. over- or subsampled, is stored in the DPB memory *in addition to the reconstructed reference*

[REDACTED]

image.” (JX-0004 at 6:1-7 (emphasis added); *see also* EDIS Doc. ID 830531 at 3 (“[T]he fact that the reconstructed reference image may have been (and likely was) resampled does not mean that it cannot meet this limitation.”)). Thus, the claims and specification make crystal clear that the reconstructed reference image that results from the claimed decoding method is not itself a “resampled version of said reconstructed reference image.”

Respondents interpret the claim as “say[ing] that you cannot store any version of the reconstructed frame, which means that the reconstructed frame itself cannot be stored.” (Tr. (Schonfeld) at 906:5-907:24, 908:2-12). Respondents’ interpretation relies on a single passage of the ’877 patent specification describing that while reconstructed reference images are stored in the DPB, “no *other* upsampled or subsampled version is stored.” (Tr. (Schonfeld) at 906:14-907:1, 908:2-12; JX-0004 at 5:44-52 (emphasis added), FIG. 3; RDX-0002.90). From this, Respondents conclude that “the reconstructed reference image is, therefore, a version of said reconstructed image.” (Tr. (Schonfeld) at 908:2-12; RDX-0002.92). Respondents’ overexpansive interpretation is wrong and prevents the claim from *ever* being practiced. (Tr. (Schonfeld) at 1140:10-22).

A decoded image stored in the DPB is made up of numerous prediction blocks. (Tr. (Richardson) at 561:23-562:8). Each block can be predicted from a different previously decoded reference frame. (*Id.* at 507:13-21). While the blocks of a decoded reconstructed reference image have indeed been resampled, they have also been motion compensation interpolated, added to a decoded residual, and further modified by additional filters. (*Id.* at 559:16-560:1, 560:9-19, 562:9-12; Tr. (Schonfeld) at 907:2-12). And as Dr. Richardson testified, the stored LrFrame “doesn’t come from one reference picture” because it is made up of a patchwork quilt of prediction blocks, each of which “is predicted potentially in a different way from a different reference picture.” (Tr. (Richardson) at 561:23-562:12). In other words, the LrFrame cannot be a “resampled version of

[REDACTED]

said reconstructed reference image” (i.e., a single reference image) because the blocks that it is made up of are predicted from different reference images. Additionally, Dr. Schonfeld agrees that the decoded image LrFrame stored in FrameStore is a different image that is separated in time from the reference frame used for prediction. (Tr. (Schonfeld) at 1084:22-1087:10; Tr. (Richardson) at 509:22-510:4; RDX-0001C.31). For all these reasons, Complainants have shown that its interpretation is the correct one, and Respondents’ interpretation is wrong.

Respondents’ additional theory—that AV1’s super-resolution process stores a resampled version of the reconstructed reference image—is also incorrect. (*See generally* Tr. (Schonfeld) at 908:13-911:11; RDX-0002.93-98). Super-resolution “allows an encoder to code any frame at a horizontally reduced spatial resolution.” (CDX-2112.0001). After reconstruction at the decoder side, super-resolution “converts the reconstructed frame to the original dimension” as “part of the output or in-loop processing that is done.” (RX-0232.0021; *see also* Tr. (Schonfeld) at 885:3-11). In other words, super-resolution is applied to a frame *that has already been decoded or reconstructed*. (*See* RX-0232.0021 (“The upsampling stage is applied to the reconstructed pixels.”)). The limiting preamble of claim 1, however, requires that the decoding method “reconstruct a current block of a current image from a reference block of a reference image reconstructed at a different size from the size of said current image.” (JX-0004 at cl. 1; Tr. (Schonfeld) at 1141:5-24). A reconstructed frame prior to the upsampling of super-resolution is not a different size from the size of the reference image; it is only after horizontally upsampling the reconstructed frame that the frame is a different size in the horizontal direction. (*See* Tr. (Schonfeld) at 909:23-910:20).

Dr. Schonfeld admitted that super resolution is an unaccused, optional feature of AV1 that is “completely different from the block inter prediction process.” (Tr. (Schonfeld) at 885:5-11,

909:7-19, 1144:8-17, 1144:23-25; RX-0584.0338; RDX-0002.93). Indeed, because super resolution only upsamples a reference frame horizontally, “it wouldn’t meet the claim limitations” even if it were accused of infringement (it is not). (Tr. (Schonfeld) 910:21-911:11, 1143:24-1144:2; RDX-0002.96-98). However, Respondents contend that no process in the entire AV1 Specification could ever store a “resampled version” of a reconstructed reference image in order to infringe, whether it meets the other limitations or not. This requirement is overbroad and must be rejected. *See, e.g., Gillette Co. v. Energizer Holdings, Inc.*, 405 F.3d 1367, 1372 (Fed. Cir. 2005) (“The addition of elements not recited in the claim cannot defeat infringement.”). Dr. Schonfeld admitted that super-resolution “has its own filtering” separate from the grouped filters used in block inter prediction. (Tr. (Schonfeld) at 1145:1-4; *see also* CX-0247.0339-340). Super-resolution filtering is not used for motion compensation as claimed, but rather for “upsampl[ing] the reconstructed frame to the original dimension.” (RDX-0002.93). Thus, super-resolution does not prevent the accused block inter prediction process from practicing this claim limitation.

4. Infringement of Claim 7 of the ’877 Patent

Claim 7 is an apparatus claim directed to a circuit configured to decode video in the same manner as claim 1. The parties agree that there are no differences between claims 1 and 7 that materially affect the infringement analysis. (Tr. (Richardson) at 527:22-528:22, 677:2-16; Tr. (Schonfeld) at 875:13-20). Thus, for the same reasons as stated above, the Accused Products infringe Claim 7 of the ’877 Patent. (Tr. (Richardson) at 432:24-433:7, 401:4-408:9; CDX-0005C.6-14; CPX-0001-3, 0006-9, 0014).

C. Indirect Infringement

Respondents induce infringement of the claims when they sell and advertise the Accused Products to their customers for use to decode video according to the AV1 Specification, with knowledge of or willful blindness to their infringement and with intent to induce infringement.

[REDACTED]

(Tr. (Richardson) at 643:17-644:15; CX-0158C (Pitarra Dep. Tr.) at 67:14-19, 67:5-11, 67:20-68:10, 78:14-93:6; SPre at 27-28, 58, 85-86).

Respondents also contribute to infringement by its customers to use the Accused Products. (Tr. (Richardson) at 644:20-645:10). The AV1 decoders of the Accused Products constitute a material part of the invention of the patent. *Id.* For example, with respect to the '877 Patent, the AV1 decoders are material to reconstructing a current block of a current image from a block of a reconstructed reference image a different size from the size of the current image without storing a resampled version of the reconstructed reference image in the DPB according to the AV1 Specification's block inter prediction process. (*Id.* at 505:13-514:4, 527:14-22, 560:2-564:22). The AV1 decoders also have no substantial non-infringing uses because they are specially designed and/or programmed to infringe the asserted patents, and specifically, with respect to the '877 patent, the block inter prediction and reconstruction processes cannot be used to decode video encoded in a non-AV1 format. (*Id.*; *see also id.* at 645:6-10; SPre at 27-28, 58, 85-86).

D. Domestic Industry – Technical Prong

The DI Products satisfy the claim limitations for the same reasons that the Accused Products infringe the Asserted Claims. The evidence, including testing conducted by Dr. Richardson, shows that the DI Products are operable to decode AV1 video and that each DI Product decodes AV1 bitstreams according to the AV1 Specification. (Tr. (Richardson) at 408:15-411:7, 417:20-25, 428:22-429:9). Dr. Schonfeld agreed that the analysis between the Domestic Industry and Accused Products is the same. (Tr. (Schonfeld) at 1011:10-13). Moreover, Apple's corporate representative confirmed that Apple produced testing documents that "confirm Apple's support for AV1 functionality in the A17 chip for the iPhone 15 Pro." (CX-0129C.0003). Dr. Richardson testified that the Vizio DI Products use MediaTek chips and that all MediaTek chips (used in Accused Products and Vizio DI Products) decode AV1 video in materially the same way. (Tr.

[REDACTED]

(Richardson) at 402:9-403:3, 409:9-410:12; *see also* CX-0514C.0003). Complainants have proved the DI Products practice claims 1 and 7 of the '877 patent for the same reasons the Accused Products infringe. Complainants accordingly incorporate their above analysis regarding infringement of the '877 patent into this section.

IV. U.S. PATENT NO. 8,674,859

A. Claim Construction

During *Markman*, Respondents argued that each of the claimed means-plus-function terms of claim 15 were indefinite for lack of corresponding structure, even though the '859 patent clearly describes that the functions are performed by an arithmetic decoder. Respondents argued there were too many kinds of arithmetic decoders such that a POSITA would not recognize any corresponding structure at all. (EDIS Doc. ID 812735 at 52). However, at the Hearing, Respondents' technical expert, Dr. Schonfeld, presented evidence supporting Complainants' position that a POSITA would understand the disclosed "arithmetic decoder" as structure that performs each of the five functions. Dr. Schonfeld testified that the prior art contained "standard" arithmetic decoders that a POSITA would recognize as the '859 patent's arithmetic decoder of Figure 13: "So the first proposed set of structures relates to an arithmetic decoder for all structures that's shown in the upper right-hand corner in *Fig. 13 of the patent*. And that *is consistent with the standard arithmetic decoder* that is disclosed by Mitchell." (Tr. (Schonfeld) at 972:14-20; 971:14-19). Dr. Schonfeld's opinion supports Complainants' position that a POSITA would recognize and understand the '859 patent's corresponding structure of an arithmetic decoder, thus providing additional evidence that compels the conclusion that claim 15 is not indefinite.

B. Direct Infringement

1. Executive Summary of the AV1 Arithmetic Decoding Process and Infringement Disputes

[REDACTED]

The Accused Products perform each of the five claimed steps/functions of claims 10 and 15 through compliance with the AV1 Specification. At the beginning of decoding each frame in AV1,³ the probability model identifier (syntax element `primary_ref_frame`) is decoded at a point in the stream in the frame header and initiates the process of changing the probability model in use. (*see infra* claim 15.1). Next, after `primary_ref_frame` is decoded, the function `load_cdfs` is called, and all the probability models (in AV1, called “CDF arrays”) for the frame are loaded from memory and changed (the selected CDF array becoming the current CDF array) (*see infra* claims 15.2-15.3). Each arithmetically encoded current symbol is then decoded using a CDF array from the current frame context (*see infra* claim 15.4) and each current CDF array is updated after being used to decode a symbol (*see infra* claim 15.5). At the end of a frame, the current CDF array is added to the subset of available CDF arrays for use in decoding symbols and is available for selection in subsequent frames (*see infra* claim 15.3).

As explained below, at the Hearing, Respondents presented three noninfringement arguments, each of which fails to rebut the evidence that the Accused Products infringe by complying with AV1. First, Respondents argue the claims require “adding” to occur in the order listed in the claim (i.e., as the third step, whereas in AV1 “adding” is performed last (with `save_cdfs`). Respondents waived this argument by failing to present it during claim construction. Additionally, no order is required because antecedent basis is preserved even when adding occurs last (in particular, both terms “said current probability model” and “said subset” preserve antecedent basis). Finally, even if an order were required, the Accused Products still infringe under the doctrine of equivalents. As Dr. Richardson explained and Respondents’ expert Dr. Schonfeld

³ Dr. Richardson summarized the AV1 decoding process. (*See* Tr. (Richardson) at 589:13-591:15; CDX-0005C.113; and in more detail at Tr. (Richardson) 590:16-600:8; CDX-5C.114-120).

[REDACTED]

conceded, the Accused Products perform the same function in the same way (adding or saving into an indexed set) to get the same result (the latest probability model is preserved for subsequent access, adding an additional available model, and the same probability models are available).

Second, Respondents' argument that the probability model identifier (`primary_ref_frame`) is "parsed" and not decoded reconstrues "decoding" to have an unsupported special definition. "Parsing," also called "fixed-length decoding," falls within the plain and ordinary meaning of "decoding" as Dr. Schonfeld conceded. Respondents failed to raise, and thus waived, their newly proposed special meaning for "decoding" during claim construction. The evidence also demonstrates that `primary_ref_frame` in AV1 is not only decoded as a fixed-length code (parsed) from the bitstream, but that this is decoded in the very way the patent teaches. While the claims require (and the specification teaches) non-fixed length decoding (decompression) for *other* claim elements, *decompression is not required* for decoding the probability model identifier.

Finally, Respondents' argue that Complainants failed to prove there is a "switching point" in AV1, alleging that Complainants identified only a "range" of points. But Respondents' argument applies to a theory Complainants did not present: that every syntax element within a location of the bitstream called the "frame boundary" is a switching point. Complainants' argument is not that the entire frame boundary is the switching point. Rather, Complainants presented un rebutted evidence at the Hearing that the "switching point" is the location *within* the frame boundary *where primary_ref_frame is decoded*.

2. Infringement of Claim 10 of the '859 Patent

In claim 10, each of the five claimed steps are required to be "applied at switching points," whereas in claim 15 only decoding the probability model identifier happens "at switching points." (Tr. (Richardson) at 641:4-642:21). Beyond that difference, the elements of method claim 10 and apparatus claim 15 are largely congruent.

[REDACTED]

[REDACTED]

In AV1, the decoding process begins with decoding the probability model (i.e., syntax element `primary_ref_frame`) at a point in each frame boundary distributed in the stream. The stream or bitstream is the entire encoded data of syntax elements (made of 1s and 0s) that is the decoder receives and decodes to generate a video. (Tr. (Richardson) at 411:14-412:18; 601:21-24, 581:7-11). The bitstream includes the data for each image or “frame” that constitutes a video. (Tr. (Richardson) at 445:2-6). The frame boundary is the part of the bitstream that wraps-up the decoding of the previous frame and sets up the decoding of the next frame. (Tr. (Richardson) at 591:25-592:4 (header at start of frame), 626:14-627:4 (wrapup at end of frame); 773:13-20 (frame boundary is location between data)). The point where `primary_ref_frame` is decoded in the frame boundary is the kick-off point for the Accused Products to perform each of the five claimed steps.⁴ (Tr. (Richardson) at 6:17-10-618:9). As Dr. Richardson explained, each step is “applied at switching points” because the first step (i.e., decoding `primary_ref_frame`) initiates the process “of selecting, adding, decoding, updating,” and that first step occurs at a switching point. (Tr. (Richardson) at 641:4-642:21). In other words, because each of the claimed steps is initiated by decoding the probability model identifier at a switching point, the steps of claim 10 are applied at switching points—points where the probability model used to code the current symbol can be modified (or selected). The steps of claim 10 are otherwise met by the Accused Products’ implementation of the AV1 Specification for the same reasons each corresponding function of claim 15 is met, as discussed below, which is incorporated by reference. (*Id.*; *see infra* § IV.B.3).

⁴ Complainants’ and Staffs’ construction for “switching points” is the same definition provided by the patent (“a point in the stream at the level of which the probability model used to code the current symbol can be modified”). Respondents’ construction is the same but adds an additional phrase at the end “—i.e., a probability model can be selected.” Because AV1 also selects the CDF array for the frame upon decoding `primary_ref_frame` (*see infra* Claim 15.2), Respondents’ construction for switching point is also met.

3. Infringement of Claim 15 of the '859 Patent

a. Claim 15.P (“Arithmetic decoder for decoding symbols coded in the form of a stream, comprising:”)

Claim 15.P is a non-limiting preamble and not in dispute. Nonetheless, Complainants proved the Accused Products infringe claim 15.P. The Accused Products comprise arithmetic decoders for decoding symbols from an AV1 encoded bitstream according to AV1’s arithmetic decoding process. (Tr. (Richardson) at 600:18-22; *see also* Tr. (Richardson) at 589:13-591:15; 579:20-583:12; *infra*, § IV.B.3 (elements 15.1 through 15.5)). As Dr. Richardson testified, each of the Accused Products complies with the AV1 Specification (Tr. (Richardson) at 401:16-25) and therefore includes arithmetic entropy decoders (*Id.* at 613:18-614:10) and includes processors and/or software operable to decode video according to the AV1 Specification. (*Id.* at 402:24-403:3) (MediaTek); (*id.* at 403:16-25 (Intel), 404:10-405:9, 405:24-406:3 (AMD), 406:4-19 (Qualcomm), 406:20-407:8 (NVIDIA), 407:9-20 (Google)). These processors and/or software execute all the AV1 functions (*Id.* at 419:1-417:6). The AV1 arithmetic decoding process is mapped to each claim element in detail below. (*Id.* at 589:13-591:15 (brief description); CDX-0005C.113). For each claim element, Complainants’ or Staff’s alternative proposed structures are arithmetic decoders (and/or entropy decoding modules) operable to perform the claimed functions, which include the steps of Figures 10 and/or 11 (and accompanying description, equivalents). (EDIS Doc. ID 814712). Because Figures 10 and/or 11 each include steps corresponding to the claim language (*see, e.g.*, Tr. (Richardson) at 762:8-765:15), Staff’s and Complainants’ alternative proposed structure are met for the same reasons described below for Staff’s and Complainants’ primary constructions. (*Id.*; *see also* Tr. (Richardson) at 589:13-590:15 (summarizing AV1 arithmetic decoding process that occurs for each AV1 frame), 613:8-614:8 (all video decoders begin with an entropy decoding module, including AV1); Tr. (Schonfeld) at 973:21-974:19

(alternative constructions met for same reasons as primary constructions)). Each of the proposed constructions are met by the arithmetic decoders of the Accused Products performing the functionality set forth below, the only additional algorithmic requirement being for claim 15.5, which (per Respondents) requires the increase of an occurrence number by 1 (which is satisfied as explained below). (EDIS Doc. ID 814712 at 6-10); Tr. (Richardson) 641:15-19; Tr. (Schonfeld) at 973:21-974:19).

b. Claim 15.1 (“means for decoding from the stream, at switching points distributed in said stream to decode a current symbol, for said current symbol, a probability model identifier”)

Complainants proved the Accused Products infringe claim 15.1.⁵ As Dr. Richardson explained, the Accused Products initiate the infringing AV1 arithmetic decoding process by decoding a syntax element called “primary_ref_frame” from an AV1 encoded bitstream. (Tr. (Richardson) at 590:16-592:29; 600:23-602:20); CX-0247.0052, 0165; *see also* Tr. (Richardson) at 619:22-24).

(i) “means for decoding from the stream . . . to decode a current symbol, for said current symbol, a probability model identifier”

The arithmetic decoders of the Accused Products decode “primary_ref_frame” from the stream. (Tr. (Richardson) at 601:11-602:19; CX-0247.0165). Primary_ref_frame is a probability model identifier, and it is used to select the probability model used for decoding each symbol in the current encoded frame. (*Id.*). In AV1, the probability models are called CDF arrays. (*Id.*; *see also* Tr. (Richardson) at 592:21-593:5). The primary_ref_frame identifies the probability models (i.e., the CDF arrays) for each current frame, which are used to decode the “current symbol,” i.e., each arithmetically encoded symbols in the current frame. (Tr. (Richardson) at 601:11-602:19);

⁵ Analysis of the function of claim 15.1 applies to claim 10.1.

[REDACTED]

CX-0247.0165). Dr. Richardson explained the syntax structure of where in the bitstream primary_ref_frame was decoded and specifically that it was decoded at a point “*within*” the frame boundary. (Tr. (Richardson) at 601:25-602:4; 600:23-602:19; 591:20-592:4; CDX-0005C.123). Respondents and Staff do not dispute that primary_ref_frame identifies the probability model used to decode the symbols in a frame.

Dr. Richardson explained the probability model identifier is like a pointer to a book on a shelf, where each book is analogous to a different probability model and the collection of books are the set of probability models. (Tr. (Richardson) at 592:5-20; CDX-0005C.122, .115). In AV1, the set of available probability models includes an available default probability model (i.e., a CDF array) (*id.* at 622:19-23; 624:17-625:2), the current or most recently updated probability model (*id.* at 624:9–20), and those probability models that are added to the available probability models. (*Id.* at 624:9–20). The default CDF array and any one or more added through save_cdfs() are part of the subset. (*Id.* at 622:19-23; 624:9-625:2).

a) “Decoding” Includes Parsing

Respondents and Staff argue that “decoding” (as recited in claim 15) excludes “parsing,” also referred to as fixed length decoding. (RPre at 48; SPre at 51-52). But what “decoding” means in the context of the claim is a claim construction issue. Respondents (and Staff) never raised this issue during claim construction and, therefore, waived the right to raise the issue now. *See In re Certain Semiconductor Devices & Consumer Audiovisual Prods. Containing*, Inv. No. 337-TA-1047, Final Determination, 2019 ITC LEXIS 1082 at *43 (Sep. 10, 2019). In *In re Certain Semiconductors*, the Commission refused to allow Complainant Broadcom to argue the “decoding process” should be construed to exclude parsing. (*Id.*). “If Broadcom believed that the claim limitation ‘a decoding process’ required a special definition based on the specification, Broadcom should have sought to construe the term during claim construction.” (*Id.*).

[REDACTED]

Testimony at the Hearing demonstrated Respondents and Staff are relying on a special meaning for “decoding.” Dr. Schonfeld admitted that the plain and ordinary meaning of “decoding” includes parsing (Tr. (Schonfeld) at 1128:3-7, 1127:5-1128:2) but argues that the patent has a special meaning for “decoding” that excludes parsing. (Tr. (Schonfeld) at 955:21-24 (“And even if you want to talk about parsing as decoding in some context, we are talking about an entropy coding patent, where everything is about compression. ***Decoding in the claim language should mean decompress.***”). The patent, however, never uses the word “compression” (or decompression) let alone describes any instance where the probability model identifier is compressed (or decompressed). (JX-0001 at 2:28, 3:46, 5:35-36, 6:34-35, 8:4-5, 10:1-2, 11:12-13). Because Dr. Schonfeld’s opinion relies on a special definition of “decoding” that was not presented in claim construction, the argument has been waived. *Semiconductor Devices*, 2019 ITC LEXIS 1082 at *43. In fact, given the parties’ proposed constructions for “means for decoding . . . a probability model identifier” and “means for decoding said current symbol,” Respondents and Staff could have proposed a construction for decoding that excluded parsing or required compression for decoding the probability model identifier. Neither did. (EDIS Doc. ID 814712).

Even if the Court were to construe “decoding” now, the term should be given its plain and ordinary meaning. As the evidence at the evidentiary Hearing demonstrated, a POSITA would understand that “decoding” in the context of the intrinsic evidence includes parsing (i.e., fixed length decoding), as well as other types of decoding (e.g., variable length decoding). (Tr. (Richardson) at 612:23-614:15; 620:14-6; Tr. (Schonfeld) at 1127:5-1128:2).

All technical experts testified that “decoding” as claimed includes parsing (i.e., fixed-length decoding). Complainants’ infringement expert, Dr. Richardson, explained that fixed length decoding involves reading the encoded codewords from the bitstream and determining the

corresponding value, which is quintessential “decoding.” For example, with respect to demonstrative CDX-0005C.107, Dr. Richardson testified:

And we could code a symbol with four values using fixed-length binary codes, and if it’s only got four possible values, then we could use a 2-bit code, and, as I’ve shown here, we could use 00 to represent A, 01 to represent B, 10 represents C, 11 represents D. So using fixed-length coding, a decoder can recognize or pick out one of these code words, which is the 2-bit code word I’ve shown here, and decode that code word, and if it’s 00, it decodes an A, if it’s 11, it decodes a D, and so on.

(Tr. (Richardson) at 580:22-581:6).

Fixed Length Coding		Variable Length Coding		
Symbol (Sc) value	Bits	Symbol (Sc) value	Bits	Probability
A (blue)	00	A (blue)	1	.90
B (green)	01	B (green)	01	.05
C (white)	10	C (white)	001	.03
D (gray)	11	D (gray)	0001	.02
Blue blue, green = 00 00 01		Blue, blue, green = 1 1 01		

(CDX-0005C.107 (excerpts)). Dr. Richardson explained that excluding fixed length decoding from the scope of the claim would be inconsistent with his 30-year career in video coding:

Symbols such as primary_ref_frame is a fixed-length code word of length 3. To decode that, *the decoder has to map the values of the bits that come in, whether it’s 111 or 001, it has to do a lookup and work out what those values represent.* And in this case they represent a choice of value between 0 and 7, because that’s all of the – 0 is 000, 7 is 111. So that process of extracting bits from the bitstream, decoding them, and identifying the value that they represent, *all throughout my 30-year career I have described that as decoding, and I think my colleagues in the field would do the same.* So that’s why I have no hesitancy.

(Tr. (Richardson) at 614:4-15; *see also id.* at 612:23-614:15).

Dr. Xiong also testified that fixed length decoding constitutes decoding. Dr. Xiong described the “whole process” of decoding a bitstream to reconstruct a color video, and that “within this decoding process there are multiple steps.” (Tr. (Xiong) at 213:13-18). Specifically, he explained that “the bitstream can generally be divided into three high-level categories: overhead,

motion bits, and then we call it texture bits or DCP bits.” (*Id.* at 213: 17-22). As Dr. Xiong explained, “[p]arsing is the first part of the decoding process that **decodes** the overhead.” (*Id.* at 214:3-4; *id.* at 214:18 (“so parsing is absolutely decoding, number one”). In the context of a syntax element, “parsing is definitely decoding.” (*Id.* at 215:11-13). And fixed length decoding or parsing “is decoding definitely. You can ask anyone. You can Google [it] for yourself.” (*Id.* at 215:4-6). Dr. Xiong explained decoding an entire video sequence requires more than parsing. It requires each of the three steps Dr. Xiong described. (*Id.* at 213:18-22). Thus, decoding a syntax element does not require more than parsing, but decoding an entire video sequence does. (*Id.*) Even Dr. Schonfeld conceded the plain and ordinary meaning of “decoding” includes parsing. (Tr. (Schonfeld) at 1128:3-6. (Q. “You agree that some people do talk about or refer to parsing as decoding. You agree with that, right?” A. “In general outside of the claim, yes.”)).

i) The Difference Between Variable-Length Decoding and Fixed-Length Decoding is Use of a Probability Model

Respondents argue fixed-length decoding is not “decoding,” but variable length decoding is “decoding.” (Tr. (Schonfeld) at 955:24-956:3; 962:10-963:15. As explained at the Hearing, Respondents are wrong because **the only difference** between the two is that variable length coding **uses a probability model** for decompression, while fixed length coding does not. (Tr. (Richardson) at 579:22-584:11, 612:23-614:15). Indeed, fixed length decoding is not only within the scope of the claims but is the ’859 patent’s preferred way of decoding the probability model identifier.

As can be observed in the demonstrative above (CDX-0005C.107), and as Dr. Richardson explained, comparing fixed-length decoding and variable-length decoding, **tracking the probabilities** permits fewer bits to be assigned to more frequently appearing symbols. (Tr. (Richardson) at 582:3-583:2; (CDX-0005C.107) (excerpts)). Fixed-length coding does not use a probability model to compress the number of bits and instead uses a fixed number of bits to

represent a symbol value, while variable-length coding uses a probability model to assign a variable-length number of bits to each symbol. (Tr. (Richardson) at 579:22-583:12). For instance, while green is assigned “01” in both the fixed-length coding and variable-length coding example above, “blue, blue, green” is 00 00 01 with fixed length coding, while “blue, blue, green” is two bits less (1 1 01) in variable length coding. (*Id.* at 582:3-583:2). Variable-length coding achieves this bit reduction by assigning the more frequently appearing values fewer bits. (*Id.* at 581:20-23). But the same **decoding** process, converting codewords to values, occurs in both fixed-length and variable-length decoding. Thus, while both fixed-length decoding and variable-length decoding decode a codeword, only variable-length decoding uses a probability model to do so.

- ii) The Claims Do Not Require Variable-Length Decoding (Use of a Probability Model) for the Probability Model Identifier

As claimed, the probability model identifier is not required to be decoded with a probability model. In each of the asserted claims, there are two things that are decoded: (1) the probability model identifier, and (2) the current symbol. (*See* JX-0001 at claims 10, 15). However, ***only the current symbol is required to be decoded with a probability model.*** (*Id.*). In other words, only the symbols are compressed with entropy coding and require variable length decoding. The probability model identifier is and can be decoded using fixed-length decoding.

15. Arithmetic decoder for decoding symbols coded in the form of a stream, comprising:
 means for decoding from the stream, at switching points distributed in said stream to decode a current symbol, for said current symbol, a probability model identifier, means for selecting using said probability model identifier a probability model in a set comprising a current probability model defined from symbols coded previous to the current symbol and a subset of probability models wherein subset comprises at least one probability model defined by default, means for adding in said subset said current probability model, the selected probability model becoming the current probability model, means for decoding said current symbol with said current probability model, and means for updating said current probability model according to the decoding of said current symbol.

(JX-0001 at claim 15 (annotations added)). Respondents attempt to rewrite the claims to require a probability model for decoding both the probability model identifier and the current symbol. The claim, however, is fully consistent with the patent specification, which always describes that a probability model is used to decode *the current symbol* but never discloses using a probability model to decode *the probability model identifier*. (JX-0001 at 2:28, 3:46, 5:35-36, 6:34-35, 8:4-5, 10:1-2, 11:12-13). In fact, the patent never uses the word “compression,” let alone describes any instance where the probability model identifier is compressed. (*Id.*).

b) Primary_ref_frame is “Decoded”

Respondents and Staff argue that primary_ref_frame is parsed, not “decoded.” (RPre at 48; SPre at 51-52). For the reasons above, Respondents and Staff improperly limit the plain meaning of “decoding.” As properly construed, there is no dispute that the Accused Products *decode* primary_ref_frame as a fixed-length code word from an AV1 bitstream. (Tr. (Richardson) at 612:23-614:15, 620:14-6; Tr. (Schonfeld) at 1127:5-1129:6). In fact, the AV1 Specification itself explains that primary_ref_frame is “coded” in the stream. (Tr. (Richardson) at 602:20-603:20; CX-0247.0165; *see also* CDX-0005C.123). The AV1 Specification also states that the uncompressed header, of which primary_ref_frame is a part, is coded:

Uncompressed header

High level description of the frame to be decoded that is encoded without the use of arithmetic encoding.

(CX-0247.0019). Because it is coded, the header, including `primary_ref_frame`, must be decoded before it can point to the appropriate probability model. (Tr. (Schonfeld) at 1040:25-1041:14).

Dr. Xiong explained how `primary_ref_frame` is decoded and that it is a three-bit syntax element, and “if the three bits is 000, the output of X is zero. If it’s 111, the output is 7. So we have what are called fixed-length code.” (*Id.* at 215:7-10; CX-0247.052, 366). So “that *parsing* of `primary_ref_[frame]` *corresponds to* fixed length *decoding* of the three bits.” (*Id.* at 215:11-12; CX-0247.052, 366) (emphasis added). While decoding an entire video frame requires more than parsing, parsing `primary_ref_frame` unquestionably decodes the syntax element. (*Id.* at 215:4-13).

Dr. Schonfeld also agreed *every* bit in the bitstream is encoded by the encoder, and that every bit in the bitstream is decoded by the decoder. (Tr. (Schonfeld) at 1040:25-1041:14). There is no dispute that `primary_ref_frame` (the probability model identifier in AV1) is three of those encoded and decoded bits. (*Id.* at 935:34-936:12). Dr. Schonfeld further confirmed that `primary_ref_frame` is coded. (*Id.* at 954:24-25 (“parsing of a syntax element with n-bits means that the next n-bits are read from the bitstream, and it has a code”). Dr. Schonfeld confirmed that the “code” is used to “read each syntax element” such as `primary_ref_frame`. (*Id.* at 954:25-955:1). Finally, Dr. Schonfeld admitted that, according to the AV1 Specification, “encoding” does not require arithmetic coding. (*Id.* at 1129:3-6). Importantly, Dr. Schonfeld was forced to admit the header in AV1 is decoded. (*Id.* at 1127:5-1128:2).⁶

⁶ To support the argument that the header in an AV1 encoded frame is not decoded, Dr. Schonfeld misinterprets the AV1 Specification, claiming the definition of uncompressed header refers to the *entire frame* as being “encoded without arithmetic coding.” (Tr. (Schonfeld) at 955:17-20 (“this is talking about the frame as a whole, and it’s talking specifically about the fact that arithmetic coding is not used. . . ”)). Dr. Schonfeld is wrong. The definition of *uncompressed header* states

[REDACTED]

For the foregoing reasons, Complainants proved that the Accused Products decode the probability model identifier for infringement of claim 15 of the '859 patent.

c) Decoding from the Header is “Decoding”

During his testimony, Dr. Schonfeld suggested that the '859 patent excludes decoding the probability model identifier from the header at the start of the frame because that is allegedly the “old way” of identifying probability models. (Tr. (Schonfeld) at 949:20-24). But that interpretation is inconsistent with the specification of the '859 patent. As Dr. Richardson testified, the '859 patent shows that the switching point—the point at which the probability model identifier is decoded—is located at the “beginning of the frame” where the header files are located. (Tr. (Richardson) at 618:20-619:21; JX-0001 at FIG. 4). There is no limitation that would preclude switching points being in the frame header. In fact, Dr. Schonfeld admitted the switching point can be anywhere. (Tr. (Schonfeld) at 1131:19-23).

In sum, the term “decoding” should be given its plain and ordinary meaning which includes both fixed length and variable length decoding. Nothing in the patent, specification, prosecution history excludes fixed length decoding or parsing. In fact, that is inconsistent with the testimony of all three technical experts, and the AV1 specification.

(ii) “at switching points”

The arithmetic decoders of the Accused Products decode primary_ref_frame “at switching points” under all parties’ proposed constructions for “switching point.”⁷ (Tr. (Richardson) at 616:1-15, 642:2-8). Under all proposed constructions, the “switching points” are a point at which

that it is a “[h]igh-level description of the frame” and that it—the uncompressed header—“is **encoded** without arithmetic coding.” (CX-0247.0019) (emphasis added).

⁷ Complainants’ and Staffs’ construction for “switching points” is the same definition provided by the patent (“a point in the stream at the level of which the probability model used to code the current symbol can be modified”). Respondents’ construction is the same but adds an additional phrase at the end “—i.e., a probability model can be selected.”

[REDACTED]

the infringing arithmetic decoding process begins. (Tr. (Richardson) at 642:2-8); JX-0001 at 4:60-5:7; 10:1-11:11; 11:12-60-64). As supported by the '859 patent and the testimony of Dr. Richardson, the switching point, the point where the probability model is modified, is a trigger for a multi-step process. (Tr. (Richardson) at 641:20-642:8; 600:23-602:19; 616:7-618:9; 786:4-20; JX-0001 at 10:1-11:11, 11:12-60-64). According to the '859 patent, once the location of a switching point is reached, the frame decoding process begins. (Tr. (Richardson) at 642:2-8); JX-0001 at 10:64-65 (“during a step 200, it is verified if the location is on a switching point SP.”).

The switching point in AV1 is the location of the syntax element where `primary_ref_frame` (the probability model identifier) is decoded. (Tr. (Richardson) at 616:7-619:21, 642:2-8; JX-0001 at 4:60-5:7; 10:1-11:11; 11:12-60-64). The switching point in AV1 is located at a point within the frame boundary. (*Id.*). The frame boundary includes the portion of the stream between the tile data of two frames, after the blocks of data of the previous frame, but before the blocks of data of the next. (Tr. (Richardson) at 591:25-592:4 (header at start of frame), 626:14-627:4 (wrapup at end of frame); 773:13-20 (frame boundary is location between data)). The frame boundary comprises header information for the upcoming frame (e.g., instructions to load data that will then be used). (*Id.*). `Primary_ref_frame` is a single syntax element and only three bits within the frame boundary. (Tr. (Richardson) at 602:20-603:8)).

The point *within* the frame header where `primary_ref_frame` is decoded is the switching point. (Tr. (Richardson) at 616:7-619:21, 641:20-642:8)). As Dr. Richardson explained, this provides a point that begins the process where the current probability model can be modified/selected. (*Id.* at 616:7-619:21, 642:2-8). Neither Respondents nor Staff dispute that `primary_ref_frame` is decoded at a point or that this is the first step in the AV1 arithmetic decoding process in a given frame. (Tr. (Schonfeld) at 1131:11-23; 953:22-954:1). Moreover, neither

Respondents nor Staff dispute that, in AV1, the probability model is modified from one frame to the next in a process that begins with decoding primary_ref_frame. (*See generally*, RPre, SPre). As Dr. Richardson testified, “[t]here’s a process in AV1 called load_cdfs(), and that process uses the primary_ref_frame value to select a probability model.” (Tr. (Richardson) at 593:6-23). The probability model selection process, step 2 of the claim, happens after decoding “primary_ref_frame.” (*Id.* at 619:25-622:18). “So this is a reminder that step 2, in my view, occurs at the beginning of decoding in AV1 frame, again, at the frame boundary, and, as my book analogy illustrates, it’s the step of selecting a probability model or a set of CDF arrays, in AV1 terminology, that going to be used for decoding the current frame.” (*Id.* at 620:7-12). The AV1 switching points provide a location at which the CDF array is modified to decode each current symbol at the frame level, because the process is initiated for every coded frame. (*Id.* at 642:2-8, 617:10-618:1). Accordingly, Complainants have proved that primary_ref_frame is decoded “at a point in the stream, the level of which the probability model used to code the current symbol can be modified” under Complainant’s and Staff’s construction (or additionally where a probability model “can be selected” as required by Respondents’ proposed construction). (*Id.* at 616:7-619:21, 642:2-8).

a) Respondents’ and Staff’s Arguments Regarding the “Switching Point” in AV1 Being a “Range” Are Wrong

The switching point is *the point within* the frame boundary where primary_ref_frame is decoded as the first step in AV1’s arithmetic decoding process. (*Id.* at 616:7-619:21, 642:2-8). While the frame boundary includes many other syntax elements, Complainants have identified the point where primary_ref_frame is decoded, specifically, as the switching point. (*Id.* at 641:24-642:8, 786:4-12). Primary_ref_frame is a single three-bit syntax element (*Id.* at (602:20-603:8) located within the uncompressed header in the frame boundary. (*Id.* at 591:5-592:4; 602:20-603). Respondents, however, mischaracterize Dr. Richardson’s opinion and argue that the switching

point identified by Dr. Richardson is the entire frame boundary and every single syntax element within it. (Tr. (Schonfeld) at 952:12-19). This argument fails to address, let alone rebut, the evidence and Complainants' argument that the switching point is the point where syntax element `primary_ref_frame` is decoded. (CPre. 43-44; Tr. (Richardson) at 616:7-619:21, 642:2-8).

In Complainants' Pre-Hearing Brief, with numerous cites to the record, Complainants explained that "[u]nder all parties' proposed constructions of 'switching point,' the switching points in an AV1 bitstream begin the infringing process at *a point in the frame boundary*." (CPre at 43). Complainants also explained that "the switching point in AV1 is *the location of the syntax element in the first infringing step* of the process, for example *the location where the primary_ref_frame (the probability model identifier) is decoded*." (*Id.* at 44; *see also id.* at 40 ("The boundaries between each image provide switching points where the infringing process begins for each image, for example, *the point where the probability model identifier is decoded. Such a point is in the frame boundary and is a switching point.*") (emphasis added). Staff agreed with Complainants and agreed the evidence would show the *location* where `primary_ref_frame` is decoded, specifically, is a switching point. (SPre at 50).

At the Hearing, Dr. Richardson testified that the switching point is a *trigger* that initiates the process, where "*if* the decoder is at a switching point . . . *then* a number of steps happen." (Tr. (Richardson) at 617:10-18). When asked whether the steps listed in claim 10 are applied at switching points in AV1, Dr. Richardson testified:

In my opinion they are. And in my opinion, *what AV1 does, when it decodes a probability model identifier*, at the beginning of the process, that I've described at some length, that that *is initiating this process* of selecting, adding, decoding, updating. So all of these things are, in my view, *initiated by that first step, which happens at a switching point*.

(*Id.* at 641:24-642:8) (emphasis added). Dr. Richardson further testified that the first step in AV1's

arithmetic decoding process (*id.* at 590:7-8) is the decoding of the three-bit syntax element `primary_ref_frame` (*id.* at 591:16-19). Thus, Dr. Richardson’s testimony is clear: ***the location of the first step***, the point in the stream where `primary_ref_frame` is decoded, is the switching point because it initiates the arithmetic decoding process in AV1. (*Id.* at 617:10-18, 641:24-642:8). Dr. Richardson unequivocally testified that “***the point when it decodes that primary – that PMI [probability model identifier], that would correspond, in my view, to step 1.***” (*Id.* at 786:4-12 (emphasis added)). Dr. Schonfeld himself testified that `primary_ref_frame` is decoded at a point in the stream. (Tr. (Schonfeld) at 1131:11-23; 953:22-954:1). Dr. Schonfeld also testified that step 1 of the infringing AV1 arithmetic decoding process, where `primary_ref_frame` is decoded, is a point within the frame boundary (and is not the entire frame boundary). (*Id.* at 1131:11-23, 938:16-939:6; 953:22-955:1; RDX-0002.172).

The “switching point” is a “point, the location of which the current probability model can be modified” (or under Respondents’ construction, where a probability model “can be selected”). Because `primary_ref_frame` is located at a point (Tr. (Richardson) at 786:4-12; Tr. (Schonfeld) at 1131:11-23, 953:22-954:1) that triggers the five-step AV1 arithmetic decoding process (Tr. (Richardson) at 641:24–642:8), which modifies the current probability model used to decode the current symbol (*id.* at 619:25-622:6), Complainants proved that the location of `primary_ref_frame` is a switching point. The only dispute Dr. Schonfeld identified regarding whether the location of `primary_ref_frame` is a switching point is whether the location at which `primary_ref_frame` was decoded is used to decode the current symbol. (Tr. (Schonfeld) at 1131:11-23). However, as Dr. Richardson testified, the switching point is the location where the arithmetic decoding process—which is used to decode each current symbol of the entire frame—is initiated. (Tr. (Richardson) at 618:2-9, 642:2-8). In short, there is no real dispute that the location of `primary_ref_frame` is a point

[REDACTED]

or that it is the point where the AV1 arithmetic decoding process begins.

In Staff's Post-Hearing Notice, Staff alleged that Dr. Richardson did not testify that the switching point was where the first step was performed or where `primary_ref_frame` was decoded. (EDIS Doc. ID 830531 at 5 ("None of this testimony identifies `primary_ref_frame` as the switching point"; "Complainants did not present evidence that the switching point in AV1 is `primary_ref_frame`"). As explained above, Staff's modified position is wrong. Dr. Richardson explained in detail where `primary_ref_frame` is located (Tr. (Richardson) at 591:5-592:4) and why that location is the switching point in AV1 that initiates the infringing process. (*Id.* at 641:24-642:8; 616:1-9; 617:10-618:1; 786:4-12). Under all parties' proposed constructions, decoding of "`primary_ref_frame`" is decoded at a location in the frame that permits AV1 to modify/select a probability model. (*Id.* at 593:6-23, 641:24-642:8; 766:2-7).

Complainants expect that Respondents will point to a single paragraph in Dr. Richardson's expert report in which he stated a switching point is a frame boundary. (Tr. (Richardson) at 772:24-773:11). However, Dr. Richardson clarified that that paragraph was part of a report with thousands of paragraphs and that it is his opinion "*that switching points occur at the frame boundary*" rather than being the frame boundary. (*Id.* at 772:24-773:2; 806:14-21; 808:21-809:1). Indeed, in Dr. Richardson's opinion, "*what AV1 does, when it decodes a probability model identifier*, at the beginning of the process, that I've described at some length, that that *is initiating this process* of selecting, adding, decoding, updating. So all of these things are, in my view, *initiated by that first step, which happens at a switching point.*" (*Id.* at 641:24-642:8) (emphasis added).

b) Respondents' Arguments Regarding Multiple "Switching Points" Should Be Rejected

For the same reasons above, Respondents' argument that the infringing steps occur across multiple switching points is also not supported. Dr. Richardson testified that the switching point

[REDACTED]

[REDACTED]

is the point where primary_ref_frame is decoded. (Tr. (Richardson) at 786:4-12, 641:24-642:8). It is undisputed that primary_ref_frame is only decoded at a single point for each frame. (Tr. (Schonfeld) at 1131:11-23). That begins the infringing AV1 arithmetic decoding process. (Tr. (Richardson) at 786:4-12, 641:24-642:8). The final step of the infringing AV1 arithmetic decoding process occurs with save_cdfs at the end of the frame, before the next primary_ref_frame is decoded. (*Id.* at 597:24-25; *see also id.* at 597:17-598:20). Therefore, the infringing steps occur upon reaching a single switching point for each frame. (*Id.* at 618:2-9, 766:2-77). Respondents' arguments hinge on the theory that the *entire* frame boundary is the switching point, because one frame boundary would encompass some steps at the frame beginning while the other would include adding at the end. But Complainants did not argue the entire frame boundary is the switching point. Therefore, Respondents' arguments about the steps being at "multiple" switching points are moot.

(iii) "distributed in said stream"

In AV1, primary_ref_frame is "distributed in said stream" for each coded frame. (Tr. (Richardson) at 642:9-21). That is not in dispute. Therefore, the switching points of AV1 (the location of primary_ref_frame) are also distributed in said stream. (*Id.* at 641:9-642:21).

(iv) Other Noninfringement Arguments

Respondents raised other arguments in their Pre-Hearing Brief that Respondents did not present at the Hearing. Respondents argued in their Pre-Hearing Brief that the steps/functions in AV1 are not "to code a current symbol" (as per the parties' proposed constructions for "switching points"). (RPre at 47-48). In AV1, upon selecting a CDF array, multiple symbols are decoded. (Tr. (Richardson) at 618:2-9). Respondents argue that AV1 is non-infringing because all steps/functions (according to Respondents) are required to be performed before the decoding of any other symbol, regardless of whether the steps occur and are used to decode a particular symbol. (RPre at 47-48). There is no requirement in the claim that the steps/functions be performed

immediately after the switching point, only that the probability model identifier (in claim 15) is at the switching point. (JX-0001 at claim 10, 15). Respondents improperly ascribe some specific meaning to “current symbol,” which is merely a given symbol currently being decoded, arguing that it *alone* is a symbol for which the claimed limitations are performed. (RPre at 47-48). But any symbol is a “current symbol” once it is being decoded. (Tr. (Richardson) at 618:2-9; 638:25-639:34). It does not matter whether steps are performed for *other symbols* in addition to the current symbol, because the claim only requires performing the steps to decode at least a single “current symbol.” (JX-0001, claim 10, claim 15). Therefore, this claim limitation is met.

Respondents also argue that the steps are not applied at switching points because there is allegedly no application of steps “at the level of which” the probability model used to code the current symbol can be modified or selected (RPre at 46-47). Each step/function is not required to be at the same level; under each construction, the *probability model* must be modified (or selected) at some level. (EDIS Doc. ID 814712 at 4-5). In AV1, the probability model is modified and selected *at the frame level*. (Tr. (Richardson) at 641:20-642:21 (process initiated at primary_ref_frame), 601:25-602:4 (primary_ref_frame is decoded in the uncompressed header), 766:2-7 (uncompressed header decoded for each frame); CX-0247.0165, 0050-0052). Therefore, this claim limitation is met.

The Accused Products comprise an arithmetic decoder that performs all the infringing functions or algorithms, including claim 15.1. (*Supra* Claim 15.P). The parties do not dispute the Accused Products comprise the structure that performs the function of claim 15.1. (*Id.*)

- c. **Claim 15.2 (“means for selecting using said probability model identifier a probability model in a set comprising a current probability model defined from symbols coded previous to the current symbol and a subset of probability models wherein [said] subset comprises at least one probability model defined by default”)**

[REDACTED]

[REDACTED]

Complainants proved the Accused Products literally infringe claim 15.2.⁸ (Tr. (Richardson) at 619:25-625:23; CDX-0005C.127). Dr. Richardson explained the step of “selecting using said probability model identifier a probability model in a set” is like pulling a specific book off the shelf. (*Id.* at 619:25-620:13;). The Accused Products select a CDF array (i.e. a probability model), based on the syntax element “primary_ref_frame,” from a set. (*Id.* at 620:14-622:6; CX-0247.0172 (load_cdfs), 0054 (load_cdfs using primary_ref_frame)). As Dr. Richardson explained, “load_cdfs is a process or function where the decoder uses an index . . . which is based on primary_ref_frame, and uses that to identify and load a set of CDF tables.” (*Id.*). The CDF array selected using the syntax element “primary_ref_frame,” is “loaded from an area of memory indexed by ctx,” a frame context index. (*Id.*). “The memory contents of these frame contexts have been initialized by previous calls to save_cdfs.” (*Id.*; CX-0247.0172). Dr. Richardson explained the syntax structure used in each AV1 frame to process load_cdfs from the uncompressed header. (Tr. (Richardson) at 620:14-621:2; CX-0247.0054, .172; CDX-0005C.128).

The current CDF array used to decode a current symbol is defined from symbols coded before the current symbol. (Tr. (Richardson) at 625:9-16; CX-0247.0172). After the first frame, the set of available CDF arrays includes those CDF arrays defined, updated, and added in previous frames. (*Id.*; *see infra* claim 15.3, claim 15.5). Therefore, the Accused Products *select[] using said probability model identifier a probability model in a set comprising a current probability model defined from symbols coded previous to the current symbol.*

Furthermore, the subset of probability models includes at least one probability model defined by default. There’s an “array . . . titled ‘default_is_inter_cdf,’ . . . [that] define[s] default probabilities for that syntax element.” (Tr. (Richardson) at 623:7-624:2). In other words, “[t]hat is

⁸ Analysis of the function of claim 15.2 applies to claim 10.2.

[REDACTED]

the CDF array for the syntax element is `_inter`, and it's the array that's defined by default.” (*Id.* at 624:3-10). The default array for each syntax element is “literally written into the AV1 Specification.” (*Id.*). In some cases, `primary_ref_frame` is equal to `PRIMARY_REF_NONE`, and the CDF arrays are set to default values. (Tr. (Richardson) at 623:7-624:2); CX-0247.0165, 0428-0521, 0054). “[I]t is allowed for `primary_ref_frame` to be coded as `PRIMARY_REF_NONE`, this will cause default values to be used for the CDF values and other state.” (CX-0247.0165; Tr. (Richardson) at 623:7-624:2). Accordingly, the subset from which the Accused Products select a probability model comprises at least one probability model defined by default.

In AV1, the set of available probability models comprises a default available probability model (CDF array), the current or most recently updated, and those that are added over time through the `save_cdfs()` function. (Tr. (Richardson) at 622:19-626:2). Dr. Richardson testified there are eight available probability models in AV1, including the default. (*Id.* at 614:4-10; 622:19-23). The default CDF array and any one or more added through `save_cdfs()` are therefore a subset of the entire set. (*Id.* at 625:3-25; 622:19-623:6; 614:4-10).

In their Pre-Hearing Brief, but not at the Hearing,⁹ Respondents argued that the probability model identifier does not “*select[] . . . a probability model in a set comprising . . . at least one probability model defined by default*” because other syntax elements are used to change the value of the probability model identifier when a default is selected. (RPre at 49). The claims, however, do not require the default probability model to be selected with the probability model identifier. (JX-0001 at claim 15.2). All the claims require is that the probability model identifier be used to select a probability model from the set, and the set must include a default probability model. (*Id.*

⁹ Complainants raised this theory in their opening statement, but Dr. Schonfeld presented no testimony about it.

[REDACTED]

at claim 10, 15). AV1 meets this limitation. Additionally, the primary_ref_frame can be coded as PRIMARY_REF_NONE such that the decoded value is used to select the default model. (Tr. (Richardson) at 602:20-603:20; CX-0247.165). Thus, even under Respondents’ interpretation, Complainants proved the Accused Products infringe.

In their Pre-Hearing Brief, but not at the Hearing, Respondents also argued there is no “current probability model” to be selected in AV1 because, for each frame, AV1 selects from an indexed set saved in memory. (Tr. (Richardson) at 627:5-627:25). Respondents are incorrect because the “current probability model” is the latest model used, with the latest update, not necessarily an un-stored version. Dr. Richardson explained this in his testimony and in reference to CDX-0005C.129. (*Id.* at 625:9-20; 622:7-18, 637:7-15; CX-0247.0372-73).

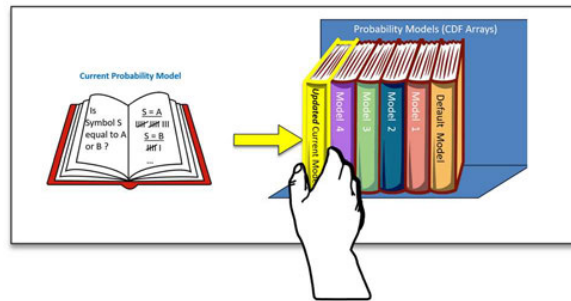
The Accused Products comprise an arithmetic decoder that performs all the infringing functions or algorithms, including claim 15.2. (*Supra* Claim 15.P). The parties do not dispute the Accused Products comprise the structure that performs the function of claim 15.2. (*Id.*). In sum, Complainants proved that claim 15.2 is met by the Accused Products, and Respondents have failed to rebut the evidence.

d. Claim 15.3 (“means for adding in said subset said current probability model, the selected probability model becoming the current probability model”)

Complainants proved the Accused Products infringe claim 15.3¹⁰ either literally or under the doctrine of equivalents. According to the AV1 Specification, CDF arrays are added to a subset at the end of a frame by calling “save_cdfs(ctx)[,]” a function call that indicates that all the CDF arrays are saved into frame context number ctx in the range 0 to (NUM_REF_FRAMES – 1).” (Tr. (Richardson) at 597:17-600:8, 625:24-629:16; CX-0247.0363-64). Dr. Richardson explained

¹⁰ Analysis of the function of claim 15.3 applies to claim 10.3.

that adding a probability model is like adding a book to a bookshelf, increasing the number of books. (Tr. (Richardson) at 598:6-599:12; CDX-0005C.131).



Dr. Richardson explained that at the end of each frame, as part of the decode frame wrap-up process, `save_cdfs` is processed. (Tr. (Richardson) at 626:14-627:25; 597:17-20). He also described the syntax structure that results in `save_cdfs` being called at the end of each frame. (*Id.* at 626:14-627:25 at 597:17-20; CDX-0005C.132). The subset includes the default probability models and any of the previously saved (and updated) CDF arrays. (Tr. (Richardson) at 625:3-23; 622:19-623:6; 614:4-10). In AV1, the set of available probability models includes a default probability model (CDF array) (*id.* at 622:19-625:2), the current or most recently updated model (*id.* at 625:9-23), and those that have been added. (*Id.* at 625:24-626:13, 629:8-13).

The AV1 Specification further specifies that the selected CDF becomes the current CDF via “`load_cdfs(ctx)`.” (*Id.* at 637:20-638:24; CX-0247.0172. Dr. Richardson testified that the `save_cdfs` function of AV1 adds more probability models to the subset of available probability models. (*Id.* at 599:6-13, 599:14-600:8). In other words, `save_cdfs` increases the number of probability models in the subset of available probability models. (*Id.* at 598:6-599:12). Dr. Schonfeld agreed with Dr. Richardson that AV1 increases the number of probability models in the subset. (Tr. (Schonfeld) at 1102:23-1103:14).

(i) Respondents and Staff Incorrectly Argue that “Adding” Must Occur in the Exact Order it Appears in the Claim

Respondents and Staff do not dispute that “`save_cdfs`” in AV1 adds a current probability

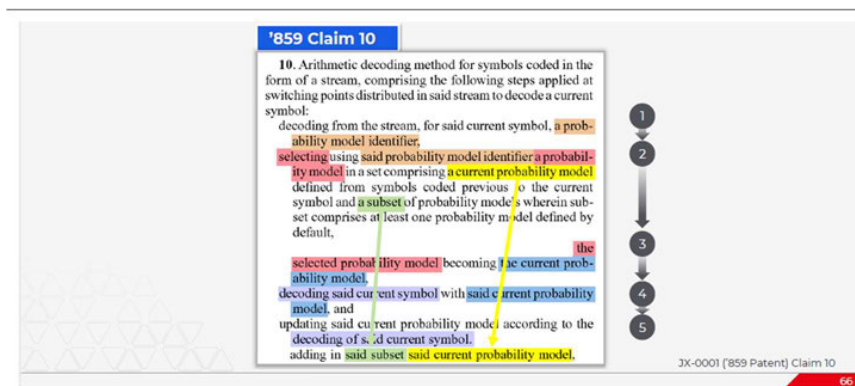
model when called. The parties dispute only whether the claim limitation “adding in said subset said current probability model” is met in the Accused Products’ implementation of AV1 based on the order of steps in claim 15. In claim 15, “adding in said subset” is the third recited means plus function element (and the third recited step in claim 10), but in AV1’s arithmetic decoding process, adding the probability model to the subset occurs last, i.e. at the end of the frame.

“The question of whether patent claims require a particular order is typically viewed as an issue of claim construction.” *Applications Int’l Corp. v. United States*, 169 Fed. Cl. 643, 698 (2024) (internal citation omitted). It is a well-settled principle that no order of steps is required for a method claim. As a general rule, “[u]nless the steps of a method claim actually recite an order, the steps are not ordinarily construed to require one.” *Altiris, Inc. v. Symantec Corp.*, 318 F.3d 1363, 1369 (Fed. Cir. 2003). Order is only required when the claim language requires it “as a matter of logic or grammar,” or “the specification directly or implicitly requires such a narrow construction.” *Id.* at 1369-70 (citations omitted). Claim 15 is an apparatus claim and it would be improper to “import a sequential limitation into an apparatus claim.” *Creative Internet Advert. Corp. v. Yahoo! Inc.*, No. 07-cv-00354, 2008 WL 5061625, at *16 (E.D. Tex. Nov. 24, 2008).

Respondents have waived their argument that an order is required. The Commission has routinely rejected untimely attempts to raise claim construction arguments. *See, e.g., In re Certain Semiconductor Devices & Consumer Audiovisual Prods. Containing*, Inv. No. 337-TA-1047, Final Determination, 2019 ITC LEXIS 1082 at *43 (Sep. 10, 2019); *Certain Electronic Devices, Including Wireless Communication Devices, Portable Music and Data Processing Devices, and Tablet Computers*, Inv. No. 337-TA-794, Initial Determination, 2012 ITC LEXIS 2296 at *197-98 (Sep. 14, 2012). Additionally, Ground Rule 10 specifies “[t]he parties will be bound by their claim construction positions.” (Order No. 2). Respondents (and Staff) failed to raise the issue of

order during claim construction. For claim 15 specifically, the parties already proposed constructions for *every claim limitation* (EDIS Doc. ID 814712), but no order was discussed. Respondents have waived their argument that the claims require an order. *Certain Electronic Devices*, Final Determination, 2019 ITC LEXIS 1082 at *43.

But even if not waived, Respondents and Staff failed to rebut the presumption that no order is required “as a matter of logic or grammar.” *Altiris*, 318 F.3d at 1369-70. Dr. Schonfeld testified that if the adding step occurred out of order, it would violate the antecedent basis of claim 15, but that theory does not withstand scrutiny. (Tr. (Schonfeld) at 1087:18-1088:1). In the claim, “adding in said subset said current probability model” last does not violate any antecedent basis. Both “said subset” and “said current probability model” recited in the third means-plus-function limitation of claim 15 have an antecedent basis to terms that appear earlier in the claim, “a current probability model” and “a subset.” (JX-0001 at claims 10, 15). Adding last, as in AV1, does not move the definite article (see yellow and green “said,” below) before the indefinite article (see yellow and green “a,” below). (*Id.* at claims 10, 15; RDX-0001C.66). The terms maintain antecedent basis regardless of whether adding occurs in the recited order or at the end of the claim.



(*Id.*) (annotated, edited to move “adding” claim element last).

Nor does the specification “directly or implicitly require[] such a narrow construction”

[REDACTED]

[REDACTED]

Altiris, 318 F.3d at 1369-70. Dr. Schonfeld argues that if the order is not maintained, “[i]nstead of the correct current probability model being added, the probability model is updated . . . throughout the entire tile again and again.” (Tr. (Schonfeld) at 946:1-12). According to Dr. Schonfeld, “what you are finally adding *has no resemblance to what was used at the time of step 2 during the selection, which is required* by the antecedent basis between step 3 and step 2.” (*Id.* at 946:9-12 (emphasis added)). Staff agrees. (EDIS Doc. ID 830531 at 7). However, there is no requirement that when adding a current probability model to the subset, it must have “a resemblance to what was used *at the time of step 2 during the selection.*” (JX-0001 at claims 10, 15).

In fact, the evidence shows that, even after updating a current probability model, it is still “the current probability model.” In Figure 11, for example, the current probability model is used to decode other symbols after updating occurs when for example the answer to “switching point?” is “NO.” (Tr. (Richardson) at 761:23-762:18 (explaining FIG. 11 goes around the loop if stream F is continuing). Current model “Pc” has changed with the updates, but it is still the “current model” Pc that will be used for decoding other symbols in the stream. (*Id.*; *see also* JX-0001 at FIG. 11). The claims simply require that the “current probability model” is added. Even with adding in the order recited, all the updates since the time a probability model was last selected are included in the probability model added to the subset. (Tr. (Schonfeld) at 1095:17-21; 1100:10-18). Indeed, the patent explains the point of adding is to increase the probability models available for selection. (JX-0001 at 8:21-23; Tr. (Richardson) at 599:6-600:8). Nothing in the claim or specification requires that the current probability model—with no subsequent modification after selection—be added to the subset. Antecedent basis does not foreclose intervening updates.

(ii) Claim 15.3 is Also Met Under the Doctrine of Equivalents

Even if an order were required for literal infringement, Complainants proved infringement for claim 15.3 under the doctrine of equivalents (DOE). *See, e.g., Certain Products Containing*

[REDACTED]

Interactive Program Guide and Parental Control Technology, Inv. No. 337-TA-845, Final Initial Determination, 2013 ITC LEXIS 1070 at *115-6 (June 7, 2013). If an order of steps were required, adding in AV1 (via “save_cdfs” at the end of the frame) performs substantially the same function, in substantially the same way, to achieve substantially the same result, as adding in the order listed in claim 15. (Tr. (Richardson) at 635:21-637:19; Tr. (Schonfeld) at 1102:23-1103:14); *Ajinomoto Co. v. Int’l Trade Comm’n*, 932 F.3d 1342, 1356 (Fed. Cir. 2019).

According to the AV1 Specification, CDF arrays are added to a subset at the end of a frame by calling “save_cdfs(ctx) []” a function call that indicates that all the CDF arrays are saved into frame context number ctx in the range 0 to (NUM_REF_FRAMES – 1).” (Tr. (Richardson) at 597:17-600:8, 625:24-629:20; CX-0247.0363-64). In AV1, like in the ’859 patent, adding a probability model to the subset is part of an iterative process applied at each switching point. (Tr. (Richardson) at 598:1-4; 797:21-798:22; Tr. (Schonfeld) at 1092:24-1093:9). The save_cdfs function adds the current CDF array to the subset and, as a result, the added probability model is preserved with its latest updates and is available for selection in future frames to decode symbols. (Tr. (Richardson) at 637:7-15; 599:6-600:8; 625:9-23). In other words, adding in AV1 preserves the updated probability model for subsequent selection and use. (*Id.* at 627:5-627:25; CX-0247.172 (load previously saved model), 0363-64 (save model)). Thus, adding probability models to the subset in AV1, like adding in the ’859 patent, results in the identical set of probability models being available for selection and use in future frames. (Tr. 1101:24-1102:4; *see also* 637:7-19).

Adding a probability model to the subset at the end of the frame according to the AV1 Specification (via save_cdfs) performs substantially the same function—increasing the number of probability models in the set—as adding a probability model in the third limitation of claim 15. (Tr. (Richardson) at 635:21-636:3, 636:13-16). Regardless of when adding occurs, the number of

probability models (e.g., books) in the subset of available probability models (e.g., bookshelf) increases. (Tr. (Richardson) at 598:6-599:5). Dr. Schonfeld admitted that in AV1, when the probability model is added to the subset at the end of the frame, the number of probability models in the subset increases:

Q. Let's just talk about AV1. Let's put the books aside for a second. Now you appreciate that the new probability model is added to the subset of probability models at the end of a frame; is that right?

A. There is no subset in AV1, but at the end of the frame the updated probability model probability models [*sic*] are entered or saved into the array or libraries, I sometimes call it.

Q. When they are saved to that array or library, unless we have already filled it up and hit the threshold, ***now there is going to be one additional probability model*** in that array or library?

A. Until the threshold, ***correct***; otherwise, the same.¹¹

(Tr. (Schonfeld) at 1100:10-24). Thus, Dr. Schonfeld admitted that adding in AV1 performs substantially the same function—increasing the number of probability models in the subset—as adding a probability model in the third limitation of claim 15.

Adding a probability model to the subset at the end of the frame according to the AV1 Specification (via `save_cdfs()`) is performed in substantially the same way—the updated probability model is saved to the subset increasing the number of probability models—as adding a probability model in the third limitation of claim 15. (Tr. (Richardson) at 635:21-636:3, 636:17-21). As illustrated above, after a probability model (book) is updated, it is added to the subset (bookshelf) and increases the number of available models (books). Dr. Schonfeld admitted that in

¹¹ While Dr. Schonfeld seemed to suggest there would be a different result after the threshold was reached (Tr. (Schonfeld) at 1101:24-1102:4), there is no evidence that is true since the same probability model (e.g., the oldest) would be replaced in each case. But even if true that there was a difference after the threshold, there would still be infringement before the threshold was reached.

AV1, a new probability model is added to the subset by saving it, even if the model is added at the end of the frame:

Q. Okay. The way that it works in AV1 is when we get to that end of frame area that you were talking about earlier, we're just going to go ahead and save it at that point in time, true?

A. That's correct.

Q. So we're going to put it in our library within that same frame, but before we go to the next frame; is that right?

A. That's correct.

(Tr. (Schonfeld) at 1095:17-25; *see also id.* at 1097:19-1098:19, 1100:25-1101).

Adding a probability model to the subset at the end of the frame according to the AV1 Specification (via `save_cdfs()`) achieves substantially the same result—one additional probability model is added to the subset and available for selection in future frames—as adding a probability model in the third limitation of claim 15. (Tr. (Richardson) at 635:21-636:3, 637:7-19). Dr. Richardson explained that the point of adding is to have more probability models available to select, which provides better choices for decoding. (*Id.* at 599:6-600:8). Dr. Richardson further explained that in AV1, after adding, the decoder is able to choose (1) the current probability model with all the current updates (in CDX-0005C.120), this is shown in red and with the added copy in yellow being placed on the shelf) (*Id.* at 597:17-598:20) and (2) the probability model *last* added with the previous frame's updates (in CDX-0005C.120,129), this is shown on the shelf in purple). (*Id.* at 625:9-20). In other words, the same exact books are available for the decoder to choose. As a result, there is no difference in how the symbols are decoded or the available probability models adapted to the stream that are in the set and available to be selected. (Tr. (Schonfeld) at 1102:6-1102:22; Tr. (Richardson) at 598:1-4; 797:21-798:22). Dr. Schonfeld also admitted that the **result** of adding in AV1 is substantially the same as adding in the third limitation of claim 15—i.e., the

same probability models are available for selection at the beginning of the next frame.

Q. Okay. And not only do we have the same number available to us, *the exact same probability* models are available to us when we go to select in that frame; is that right?

A. Assuming you're before the threshold, that would be correct.

Q. Okay.

A. In the hypothetical of the AV1 versus the modified AV1, where you do it later at the beginning of the next frame.

Q. Right. *Either way, same number of models are available to me, and the exact same models are available to me.*

A. *That's right.* And that's all under the theory of doing the saving step 3a at the end of the previous frame and not at the end of the current frame.

(*Id.* at 1101:17-1102:14). Dr. Schonfeld tries to limit the equivalence of AV1 to a theory not presented by Complainants—one where adding occurs at the end of the previous frame. (*Id.* at 1102:12-14). Regardless, adding (in AV1) at the end of a previous frame provides the same choices for selection in the next frame. (*Id.* at 1102:15-22 (“Q. I want to make sure that we’re not shortening AV1. When it gets to the selecting point at the next frame, it has the same number of probability models to choose from regardless of whether the last one was saved in the top part of the current frame or at the end of the frame before, right? A. That is Correct”). And Dr. Schonfeld admitted the result is true for the current frame as well. (*Id.* at 1102:9-22). The available choices for each frame are no different for each selection, and the result is thus substantially the same.

Thus, Complainants demonstrated, and Dr. Schonfeld conceded, that adding a probability model according to the AV1 Specification performs substantially the same function in substantially the same way to achieve substantially the same result. Assuming an order of steps is required, the Accused Products’ implementation of the AV1 arithmetic decoding process infringes this limitation under the doctrine of equivalents.

[REDACTED]

[REDACTED]

(iii) “The selected probability model becoming the current probability model” is Not Part of the “means for adding”

At the Hearing, Respondents introduced a new noninfringement argument—that the recited function of the “means for adding in said subset said current probability model, the selected probability model becoming the current probability model” includes “swapping” the current probability model for the selected probability model. However, “swapping” appears nowhere in the claim, the specification, Dr. Schonfeld’s report (Tr. (Schonfeld) at 1108:17-25), or Respondents’ Pre-Hearing Brief. Respondents rely on this new function to argue that “the selected probability model becoming the current probability model” has to happen as “a swap” as part of adding in “a single-step operation.” (Tr. (Schonfeld) at 947:11-21). That argument is not credible.

First, Complainants, Respondents, and Staff all agreed that the phrase “the selected probability model becoming the current probability model” is *not* part of the claimed function of the “means for adding in said subset said current probability model” limitation. (CDX-0005C.134; EDIS Doc. ID 814712 at 8). Furthermore, as illustrated in Figure 10 of the patent and explained by Dr. Richardson, “the selected probability model” can become the current probability model during the selecting step. (Tr. (Richardson) 637:20-638:18; JX-0001 at FIG. 10). Therefore, as the patent explicitly shows, “the selected probability model becoming the current probability model,” denoted as “ $P_c \leftarrow P_m$ ” does not have to occur during the “adding” step. In fact, the ’859 patent explains that the “selecting” step (step 204) in FIG. 10 is identical to the selecting step (step 204) in FIG. 11. (JX-0001 at 10:61-63 (“The steps of FIG. 11 [that are] *identical* to the steps of FIG. 10 are identified on FIG. 11 by the same numerical references”) (emphasis added), FIG. 10 (selecting step 204 shown *with* $P_c \leftarrow P_m$), FIG. 11 (selecting step with same numerical reference 204 shown *without* $P_c \leftarrow P_m$)). Step 204 in both FIG. 10 and FIG. 11 are only “identical” because, consistent with all proposed claim constructions, $P_c \leftarrow P_m$ is not part of the step or function itself, but is a

separate requirement of the claims, untethered to selecting or adding. (*Id.*). There is thus no “swapping” required by the step “adding in said subset said current probability model.” Even Dr. Schonfeld admitted the ’859 patent discloses embodiments where the selected probability model becomes the current probability model separate from adding. (Tr. (Schonfeld) at 1110:23-111:6).

Second, the “swapping” argument conflicts with Dr. Schonfeld’s admission that FIG. 8 of the patent shows the adding step. (*Id.* at 970:18-21; *see also* JX-0001 at 4:15-16 (“FIG. 8 illustrates a particular step of the arithmetic coding method,” where the adding step achieving more probability models “is detailed on FIG. 8”)). Dr. Schonfeld has failed to identify any part of FIG. 8 (or its corresponding description that states the “selected probability model becoming the current probability model”) is part of the adding step. Adding is the only function of the patent with its own dedicated figure—yet nowhere in FIG. 8 does the selected probability model become the current probability model. Instead, FIG. 8 describes adding the probability model to increase the number of probability models until a threshold is reached. (JX-0001 at FIG. 8; 8:36-52). In fact, the patent explains that “[t]he selected probability model becoming the current probability model” is something that happens separately: “During a step 105, the current probability model Pc is added to the subset E.” (JX-0001 at 8:8-12). The patent explains that “*then* the probability model selected Pm is re-copied in the model Pc, i.e. the probability model Pm selected in step 102 becomes the current probability model Pc.” (JX-0001 at 8:8-12) (emphasis added).

Therefore, Dr. Schonfeld’s opinion that “adding” requires “swapping” as one immediate step is divorced from the intrinsic evidence and Dr. Schonfeld’s own admission that “the selected probability model becoming the current probability model” is not necessarily tethered to the adding step. The evidence and claim construction positions the parties have taken in this case indicate that “the selected probability model becoming the current probability model” is a claim limitation

separate from the “means for adding in said subset said current probability model.” That limitation is required, but not as part of the “means for adding.”

(iv) Other Noninfringement Arguments

In their Pre-Hearing Brief, but not at the Hearing, Respondents argued that, when adding out of order, the “selecting” step (claim 10.2) is not performed—but here too the argument addresses a theory not raised by Complainants in which adding occurs at the end of the previous frame. Complainants are not advancing this theory, making Respondents’ argument irrelevant. But Respondents are wrong nonetheless.¹² The Accused Products comprise an arithmetic decoder that performs all the infringing functions or algorithms, including claim 15.3. (*Supra* claim 15.P). The parties do not dispute the Accused Products comprise the structure that performs the function of claim 15.3. (*Id.*)

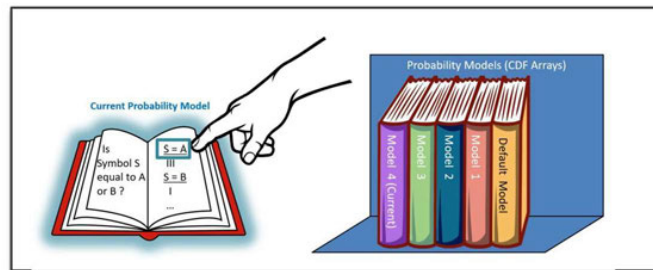
e. Claim 15.4 (“means for decoding said current symbol with said current probability model”)

Complainants proved the Accused Products literally infringe claim 15.4.¹³ (Tr. (Richardson) at 638:25-639:24). Dr. Richardson explained that this step is analogous to looking up the corresponding value of the current symbol in a book and determining the value of that

¹² Respondents argue that the “current probability model” cannot be selected from the set because it has been saved in the subset. (RPre at 54). The probability model that is selected is in the subset *as well as* the set, so the claim requirement (that the current probability model be in the set) is met when the probability model is in the subset. (JX-0005.0211-12 (reading modifications to the subset modifies the set, therefore indicating selecting from the subset selects from the set); JX-0001 at 11:14-17.). Staff provides a conclusory footnote that Complainants would not show adding saves into a “subset” as opposed to a set. (SPre at 56 n. 15). But Dr. Richardson testified that the current probability model is copied into the *subset* available for the next frame (Tr. (Richardson) at 625:24-626:13, 629:8-13, 625:3-25; 622:19-623:6; 614:4-10), which includes the default probability model. (*Id.* at 623:7-624:10). Such a subset is part of the set of all probability models from which subsequent selection can be performed. (*Id.* at 622:19-23; 624:9-625:2). AV1 includes 8 probability models to choose from (*Id.*), the default and any of the other models are thus a subset of the entire set. (*Id.*; *see also id.* at 625:24-626:13, 629:8-13).

¹³ Analysis of the function of claim 15.4 applies to claim 10.4.

symbol (the book representing the current probability model or CDF array). (Tr. (Richardson) at 593:24-594:18; CDX-0005C.137 (excerpt)).



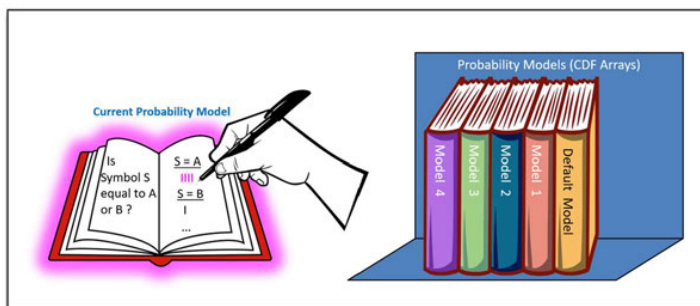
In AV1, each arithmetically encoded symbol in a frame (such as “is_inter”) is decoded from the AV1 bitstream using a selected CDF array. (Tr. (Richardson) at 638:25-639:24, 623:20-624:10; CX-0247.0372-0377 (AV1 “Symbol decoding process”). Dr. Richardson explained that the “symbol decoding process” in AV1 uses the selected, current CDF array (i.e., the current probability model) to decode the current symbol. (*Id.*; CDX-0005C.138).

The Accused Products comprise an arithmetic decoder that performs all the infringing functions or algorithms, including claim 15.4. (*See supra* claim 15.P). The parties do not dispute the Accused Products comprise the structure that performs the function of claim 15.4. (*Id.*)

f. Claim 15.5 (“means for updating said current probability model according to the decoding of said current symbol”)

Complainants proved the Accused Products infringe claim 15.5.¹⁴ (Tr. (Richardson) at 594:19-597:16; CX-0247.0221,.0372-73). Dr. Richardson explained this step is like tallying in the book (probability model)—that is, writing a tally mark for each time a decoded symbol takes a certain value—and adjusting the probabilities accordingly.

¹⁴ Analysis of the function of claim 15.5 applies to claim 10.4.



(*Id.*). In the Accused Products, the CDF arrays are updated each time a symbol is decoded according to Section 8.2.6 of the AV1 Specification. (Tr. (Richardson) at 639:25-641:3; CDX-0005C.140). Even under Respondents’ proposed construction, the Accused Products infringe. Because updating in AV1 includes counting or tallying the value of each decoded symbol for each time it appears (*id.* at 595:617-20), updating according to the AV1 Specification also meets Respondents’ construction which requires an “algorithm wherein an occurrence number for the current symbol is increased by 1.” (*Id.* at 594:19-597:16; CX-0247.0221,.0372-73; EDIS Doc. ID 814712).

The Accused Products comprise an arithmetic decoder that performs all the infringing functions or algorithms, including claim 15.5. (*See supra* claim 15.P). The parties do not dispute the Accused Products comprise the structure that performs the function of claim 15.5. (*Id.*).

C. Indirect Infringement

Respondents induce infringement of the claims and contribute to infringement by its customers to use the Accused Products for the same reasons as discussed above with respect to the ’877 patent. (*Supra*, § III.C). In addition, the AV1 decoders of the Accused Products are a material part of the invention of the ’859 patent and also have no substantial non-infringing uses because they are specially designed and/or programmed to infringe the asserted patents, and specifically, with respect to the ’859 patent, to arithmetic decoding according to the AV1 Specification. (Tr. (Richardson) at 645:6-10, 589:13-590:15, 613:8-22).

D. Domestic Industry – Technical Prong

The DI Products are operable to decode AV1 bitstreams according to the AV1 Specification. (*Supra*, § III.D). Therefore, the DI Products practice claims 10 and 15 of the '859 patent for the same reasons the Accused Products infringe. Complainants accordingly incorporate their above analysis regarding infringement of claims 10 and 15 of the '859 patent into this section.

V. U.S. PATENT NO. 9,674,556

A. Claim Construction

The Parties conducted *Markman* briefing with respect to two terms in the '556 Patent: “sparse denoising filter” and “adaptive sparse denoising filter.” Complainants construe “sparse denoising filter” as having its plain and ordinary meaning, i.e. “a filter that reduces noise based on a sparse representation of the signal.” (CX-0337.0003). Staff agrees with Complainants. (*Id.*). Respondents propose two alternative constructions: (1) “sparse de-noising filter for performing a second pass to reduce noise, which is not a deringing filter”; and (2) “[a]lternatively, a filter which exploits a sparse image model using an over complete set of linear transforms and hard thresholding, which is not a deringing filter.” (*Id.*). For the reasons explained below in connection with claim limitation 5.d, AV1’s Constrained Directional Enhancement Filter (“CDEF”) comprises a “sparse denoising filter” under every proposed construction.

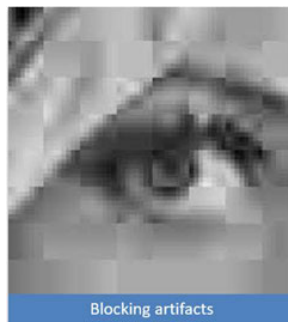
For the second disputed claim term, Complainants propose that the plain and ordinary meaning of “adaptive sparse de-noising filter” is “a sparse denoising filter . . . that can adjust its own parameters according to the image region,” while Respondents and Staff propose the term be construed as a “sparse de-noising filter . . . that can adjust its own parameters automatically.” (*Id.*). Complainants’ proposal is correct for the reasons set forth in the *Markman* briefing and hearing. Additionally, as explained when discussing claim limitation 5.d, Respondents do not dispute that

CDEF is “adaptive” under either parties’ construction.¹⁵

B. Direct Infringement

1. Overview of the ’556 Patent

The ’556 Patent is titled “Methods and Apparatus for In-Loop De-artifact Filtering.” (JX-0003). Artifacts, referred to as “noise” in the ’556 Patent, are disturbances created during the compression process. (Tr. (Richardson) at 418:16-419:8; JX-0003 at 1:12-20). These artifacts are visible in decoded (decompressed) images like the example below. (*Id.*; JX-0003 at 1:12-20).



(CDX-0005C.19). This image shows blocking artifacts, which are disturbances that create the appearance of “blocks.” (Tr. (Richardson) at 423:9-424:4). Filtering is one way to reduce/remove artifacts. (*Id.* at 419:12-17). “In-loop” filtering means that the filters are placed in the coding loop. (JX-0003 at 10:10-13). Figure 4 of the ’556 patent shows the output of the in-loop filters going into the reference picture buffer (e.g., memory), allowing the encoder to make predictions using the filtered frames, resulting in an improved prediction process. (Tr. (Richardson) at 420:1-421:23). The ’556 patent improves in-loop filtering to remove artifacts. (*Id.* at 422:9-11).

The ’556 Patent improved upon the prior art by, among other things, implementing a two-stage process that successively uses a deblocking filter and an adaptive sparse de-noising filter in-loop to more effectively remove or reduce noise or artifacts in decoded images. (Tr. (Richardson)

¹⁵ In the *Markman* proceeding in the related district court case, captioned *InterDigital, Inc. et al v. Lenovo (United States) Inc. et al*, Case No. 5:23-cv-00493-FL-RN, Lenovo agreed that this term should be given its plain and ordinary meaning.

[REDACTED]

at 424:5-24; JX-0003 at 10:45-53 (noting that the filter solution of the '556 Patent results in “different kinds of artifacts and quantization errors . . . [being] handled by different filters. Hence . . . the decoded sequence is substantially better in both subjective and objective measures.”). This specific combination of filters improves de-artifact filtering because it results in the deblocking filter first reducing blocking artifacts, changing the signal to make it a better fit for the adaptive sparse denoising filter to effectively reduce or remove remaining artifacts. (JX-0003 at 14:24-36).

The Asserted Claims of the '556 Patent claim a *sparse* denoising filter, which is a filter that reduces noise by transforming the signal, or pixel data, into a different representation that distinguishes the true signal (relatively few large values) from the noise (relatively many zero or near zero values). (Tr. (Richardson) at 453:5-22, 454:15-455:12, 458:9-18, 849:21-857:11; Tr. (Schonfeld) at 1052:17-20); CX-0103.20). The filter uses this different representation to filter the noise. (*Id.*). The filter also retains data such that it is possible to get back to the original representation. (Tr. (Richardson) at 453:19-454:5, 454:15-455:12).

2. Executive Summary

The evidence presented at the evidentiary Hearing proves that Respondents infringe claims 1, 3, 5, and 7 of the '556 Patent. (Tr. (Richardson) at 428:22-429:9). Respondents largely admit (or do not contest) infringement, leaving only two narrow disputes: (1) whether CDEF is a “sparse denoising filter” (addressed in limitation 5.d), and (2) whether CDEF is “selectively enabled or disabled” (discussed in limitation 5.e). As to the first argument, Respondents allege that CDEF is not a “sparse denoising filter” for three reasons: (1) CDEF allegedly does not create a representation of the signal, (2) CDEF allegedly does not create a representation of mostly zeros and therefore does not create a sparse representation, and (3) CDEF allegedly is only a deringing filter, which was allegedly disclaimed during prosecution.

The undisputed evidence shows that none of Respondents’ noninfringement arguments are

credible. CDEF creates and operates on a sparse representation of the signal using pixel values (i.e., the signal). The evidence, including admissions by Respondents' own expert Dr. Orchard, prove that a sparse representation of the signal does not need to be composed of mostly zeros; instead, it may be composed of a majority of *near* zero values. Thus, Respondents' first and second arguments are incorrect. Respondents' third argument, that deringing filters were disclaimed during prosecution, is refuted by the prosecution history itself. The Examiner addressed the very issue now asserted by Respondents and confirmed that the applicant, rather than disclaiming all deringing filters (as Respondents argue), distinguished the prior art (the Lee reference) on the ground that Lee's deringing filter was not a *sparse* filter.

Respondents' only remaining noninfringement argument is that CDEF is not selectively enabled or disabled. Respondents contend that *the decoder itself* must selectively enable or disable the filter, but the claim requires no such thing. Regardless, all parties agree that the encoder enables and disables CDEF, and there is no dispute that the decoder follows the encoder's instructions. Accordingly, Complainants have shown that the Accused Products infringe both disputed claim limitations (as well as the undisputed claim limitations) by a preponderance of the evidence.

3. Infringement of Claim 5 of the '556 Patent

a. Claim 5.p ("An apparatus comprising at least a memory and one or more processors, the one or more processors being configured to")

Neither party has alleged that the preamble of claim 5 is limiting, and Respondents do not dispute that the Accused Products meet the preamble. (*See* RPre at 75-87 (not disputing this limitation); RDX-0002.309). To the extent the preamble is limiting, the evidence proved that the Accused Products infringe claim limitation 5.p. (Tr. (Richardson) at 433:11-13; CDX-0005.28). Dr. Richardson testified that his review of documents and product testing confirmed that each Accused Product "is an apparatus comprising at least memory and one or more processors, which

[REDACTED]

are configured to do certain tasks.” (Tr. (Richardson) at 432:24-433:7). Further, as discussed with respect to claim limitation 5.b, Respondents’ corporate deponent verified that the Accused Products have a processor and memory. *See infra*, Section V.B.3.c. Similarly, CX-0105C, a list of Respondents’ PC, tablet, and phone products imported into the United States, including the Accused Products, indicates that each Accused Product has a CPU, an OS, and /or a GPU. (CX-0158C (Pitarra Dep. Tr.) at 99:6-21 (explaining that CX-0105C, which is referred to as Appendix A, is a listing of Respondents’ products)).

b. Claim 5.a (“decode an image region”)

Respondents do not dispute that the Accused Products meet claim limitation 5.a. (*See* RPre at 75-87 (not disputing this limitation); RDX-0002.309). At the evidentiary Hearing, Dr. Richardson testified that, based on his review of the Accused Products, documentation, and the AV1 Specification, the Accused Products decode an image region. (Tr. (Richardson) at 433:14-20). Specifically, Dr. Richardson testified that AV1 uses open bitstream units (OBUs), which are data corresponding to video frames, as inputs and that the outputs are decoded frames or decoded video sequences. (Tr. (Richardson) at 434:3-14; CX-0247.0208, .0017; CDX-0005C.30). Dr. Richardson’s analysis confirmed “what the AV1 Specification describes in a lot of detail, which is that the AV1 products [the Accused and DI Products] each decode an image region.” (Tr. (Richardson) at 434:15-17). Dr. Richardson also testified that he tested representative Accused Products, and all the products are “capable of decoding video that has been encoded according to the AV1 Specification.” (Tr. (Richardson) at 401:20-22). Respondents’ expert, Dr. Schonfeld, also testified that “as part of the decoder, it receives an image region, and that’s part of the decoding process that’s being fulfilled.” (Tr. (Schonfeld) at 984:24-985:1). Accordingly, Complainants proved that the Accused Products all decode an image region.

c. Claim 5.b (“the one or more processors including at least two

[REDACTED]

[REDACTED]

filters for successively performing in-loop filtering to reduce at least a first and a second type of coding artifact”)

Respondents do not dispute that the Accused Products meet claim limitation 5.b. (*See* RPre at 75-87 (not disputing this limitation); RDX-0002.309). Dr. Richardson testified that each Accused Product contains a processor. *See supra*, claim limitation 5.pre. Dr. Richardson also confirmed that processors in the Accused Products are capable of decoding AV1 video. (Tr. (Richardson) at 401:4-408:9; CDX-0005C.6-14; CPX-0001-3, 0006-9, 0014). In sum, all of the Accused Products “are capable of decoding video that has been encoded according to the AV1 Specification.” (Tr. (Richardson) at 401:16-25; Tr. (Xiong) at 183:23-184:14; 186:23-25; 188:1-13; 192:2-7; 197:2-9; 203:10-204:8). Lenovo’s corporate designee verified that each processor in the Accused Products includes dedicated hardware for decoding AV1 encoded videos.

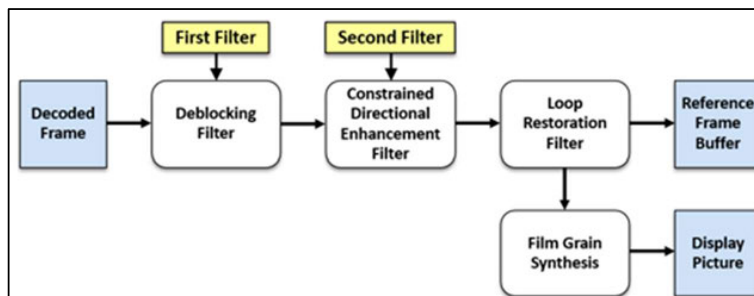
Q. And the chips that you buy that support AV1, there’s hardware on those chips that’s dedicated to supporting, decoding, or encoding AV1, correct?

A. Yes.

(CX-0158C (Pitarra Dep. Tr.) at 67:14-19; *see also id.* at 67:5-11; 67:20-68:10). Finally, the evidence showed that software decoders (i.e. Google Chrome) in the Accused Products execute instructions to comply with AV1 through use of a processor. (Tr. (Richardson) at 416:5-12 (“so everything is being done by software instructions executing on a processor”).

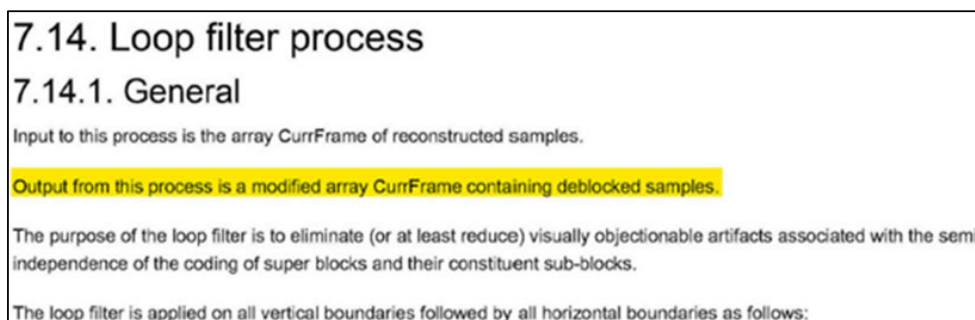
The un rebutted evidence also demonstrated that the Accused Products, through their processors, contain at least two filters for successively performing in-loop filtering to reduce at least a first and a second type of coding artifact. (*Id.* at 434:23-435:8). Specifically, as illustrated below and in CX-2105, each AV1 decoder in the Accused Products includes a loop filter—i.e., the first filter, which is a deblocking filter—and a second filter—i.e., CDEF. (Tr. (Richardson) at 436:15-437:24; *Id.* at 435:24-436:14; CDX-0005C.33; CX-0247.0216 (stating that AV1 decoding

includes “post processing filtering” “following ordered steps,” with the loop filter being the first filter and the CDEF being the second)). The following diagram illustrates these two filters and their successive orientation in the Accused Products.



(CDX-0005C.34; CX-2105.0019 (technical paper describing AV1 processes); Tr. (Richardson) at 436:15-437:24 (noting CX-2105 is a technical overview of AV1)).

The evidence at the Hearing also proved that the loop (or deblocking) filter removes blocking artifacts, which are the first type of artifact. (Tr. (Richardson) at 438:1-23). This is confirmed by the AV1 Specification, which explicitly states that the output from the Loop Filter consists of deblocked samples, meaning that the filter “has attempted to remove or reduce blocking artifacts in the frame, if there are any.” (Tr. (Richardson) at 438:1-23; CX-0247.0320).



(CDX-0005C.35; CX-0247.0320).

The AV1 Specification and evidence adduced at the evidentiary Hearing also proved that CDEF is a second filter for reducing a second type of artifact. As Dr. Richardson testified and as

shown in the following excerpt of the AV1 Specification, CDEF reduces or eliminates artifacts that are still present after the deblocking filter has reduced blocking artifacts, such as ringing artifacts and “other types of coding noise or quantization noise.” (Tr. (Richardson) at 439:2-25; CDX-0005C.36; CX-0247.0331).

The evidence also shows that the deblocking filter and CDEF successively perform in-loop filtering. As the image above shows, the input to CDEF is the “array CurrFrame,” which is the same array that was modified by the deblocking filter. (Tr. (Richardson) at 439:6-16). In other words, the output of the deblocking filter is the input of CDEF, meaning that the filters operate successively. (*Id.* at 425:18-426:13, 439:6-16; CX-0247.0216).

Finally, the two filters operate in-loop. Looking at Figure 4 of the ’556 Patent, Dr. Richardson testified that the figure shows in-loop filtering because a “reference picture buffer” or “memory” stores previously decoded frames to be used as reference frames in the coding process. (Tr. (Richardson) at 439:6-16). As seen above in CDX-0005C.34 and in CX-2105.0019, AV1 includes a reference frame buffer after the deblocking filter and CDEF, and the two filters are explicitly referred to as “in-loop filter[s].” (CX-2105.0019; *see also id.* (“The filtered output frame is used as a reference frame for later frames”); Tr. (Richardson) at 440:1-3). Respondents’ expert, Dr. Schonfeld, agrees that the deblocking filter and CDEF perform in-loop filtering. (Tr. (Schonfeld) 986:12-20 (“So here we see parts of the in-loop filtering, and this is part of the AV1 Specification.”)). Complainants have therefore proved that the Accused Products each contain a processor including at least two filters (a deblocking filter and CDEF) for successively performing in-loop filtering to reduce at least a first and a second type of coding artifact.

d. Claim 5.c (“the at least two filters including a deblocking filter for performing a first pass to reduce blocking artifacts”)

Respondents do not dispute that the Accused Products meet claim 5.c. (*See* RPre at 75-87

[REDACTED]

(not disputing this limitation); RDX-0002.309). As explained above for claim limitation 5.b, each of the Accused Products has a deblocking filter for performing a first pass to reduce blocking artifacts. (*See* Tr. (Richardson) at 440:4-441:1). Complainants therefore incorporate by reference the above analysis regarding claim limitation 5.b. Furthermore, the AV1 Specification, technical documentation, and Dr. Richardson’s testimony show that all AV1 decoders in the Accused Products have a deblocking filter that reduces blocking artifacts. (CDX-0005C.35; CX-0247.0320; CX-2105.0019; Tr. (Richardson) at 436:15-438:23). Respondents’ expert, Dr. Schonfeld, admitted that AV1 decoders have a deblocking filter. (Tr. (Schonfeld) at 986:12-20).

e. Claim 5.d (“and an adaptive sparse de-noising filter for performing a second pass to reduce noise”)

Complainants proved that each of the Accused infringes claim 5.d.

(i) CDEF is Adaptive.

It is undisputed that CDEF is an adaptive filter. While the parties initially briefed “adaptive sparse denoising filter” during Markman, Respondents did not dispute that CDEF is adaptive at the evidentiary Hearing or in their Pre-Hearing Brief. (*See* RPre at 75-87 (not disputing CDEF is adaptive); RDX-0002.309). The evidence also proves that CDEF is an adaptive filter. Dr. Richardson testified that CDEF is adaptive and supported his opinion by reference to a paper written by developers of the CDEF process, titled “The AV1 Constrained Directional Enhancement Filter (CDEF).” (Tr. (Richardson) at 442:17-443:4). This paper explicitly states that “CDEF works by identifying the direction . . . of each block . . . and then *adaptively filtering* along the identified direction . . . and to a lesser degree along directions rotated 45 degrees from the identified direction.” (CX-1608.0001 (emphasis added); *see also* CDX-0005C.41; CX-1608.0001). The evidence also shows that CDEF will automatically change the parameters it uses to filter depending on the features present in the blocks that it is filtering. (CX-1608.0001; Tr.

(Richardson) at 449:24-450:15; 467:3-6). CDEF is “adaptive” under all proposed constructions.

(ii) CDEF is a Sparse Denoising Filter.

Complainants showed that CDEF is a sparse denoising filter. Also, the very evidence Respondents presented in this Investigation proves that CDEF is a sparse denoising filter. Complainants first address this claim limitation under Complainants’ and Staff’s construction before turning to Respondents’ constructions.

Complainants’ and Staff’s Constructions:

Both Complainants and Staff construe “sparse denoising filter” as “a filter that reduces noise based on a sparse representation of the signal.” To demonstrate the concept of a sparse representation in the context of the ’556 Patent, Dr. Richardson utilized the same slides Dr. Orchard—Respondents’ expert during claim construction—presented to the ALJ.



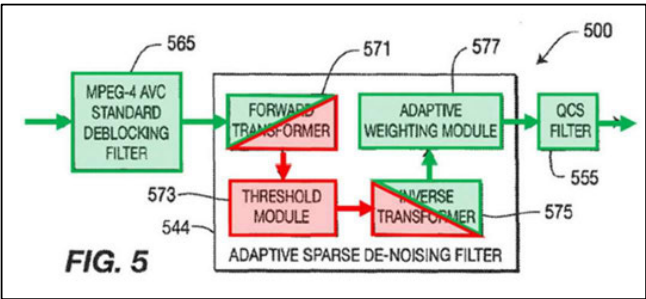
(CDX-0005C.42; RMDX-0001.155). Referring to the above images, Dr. Richardson explained that “the concept here is that we have the same data . . . basically the buildings of Manhattan and we’re looking at it here in two different representations, or the analogy here is that these viewpoints are each a representation.” (Tr. (Richardson) at 443:16-20). Continuing, Dr. Richardson testified that “a sparse representation . . . is one that allows us to view or process the data in such a way that we can begin to discriminate between things, if its filtering, we can discriminate between things that we want to filter and things that we do not want to filter.” (*Id.* at 443:21-25). At least through the *Markman* hearing, Respondents agreed. Respondents’ expert, Dr. Orchard, explained that “a

good way to address signals that are found in the presence of noise is to find a domain, a different way, a different perspective to look at that signal in such a way that it highlights or it uncovers some quality of the signal that we're interested in." (EDIS Doc. ID 829259 at 48:1-5).

A sparse representation of the signal creates a representation in which the true signal can be distinguished from noise. (Tr. (Richardson) at 849:21-850:23; CX-0103.20). As Respondents' expert Dr. Orchard explained: "The matrix coefficients in the sparse representation that *should be* zero will in practice be *near-zero* – representing the noise. Thus, the sparse representation provides a useful exploit: the 'true signal' (represented by the few large non-zero values) can be separated from, or decoupled from, the noise (represented by the near-zero values)." (CX-0103.20 (emphasis in original)). While a sparse representation of the signal is a different representation of the data, the filter retains data so one could get back to the original representation of the signal. (Tr. (Richardson) at 453:19-454:5, 454:15-455:12; CX-0103.0020 at ¶ 63). "And, again, by analogy, I haven't leveled any buildings in Manhattan, I haven't touched the buildings, I've just moved my viewpoint of the buildings." (*Id.* at 455:5-12).

In the context of the '556 Patent, a POSITA would understand that "images can be sparsely represented in the transform domain." (Tr. (Richardson) at 848:1-12; *see also*, Tr. (Schonfeld) at 1051:23-1052:3). According to Dr. Orchard, Respondents' original expert, "while images are not sparse *in the pixel domain* (i.e., before a transform has been applied), images can be 'sparsely represented' *in the transform domain* (after a transform has been applied)." CX-0103.0020 at ¶ 63 (emphasis in original); *see also* CX-0103.0021-22 at ¶ 68 ("Critically, the data flowing into and out of the sparse de-noising filter is not 'sparse'—that data is in the 'pixel domain.' The data is only 'sparse' in the 'transform domain—between when the image has been transformed and when the image has been inversed transformed"). In the context of the '556 Patent, Dr. Orchard

explained that “image data is ‘sparsely represented’ in the ‘transform domain’ during the process steps in red over Figure 5 of the ‘556 patent.” (CX-0103.0021-22 at ¶ 68).

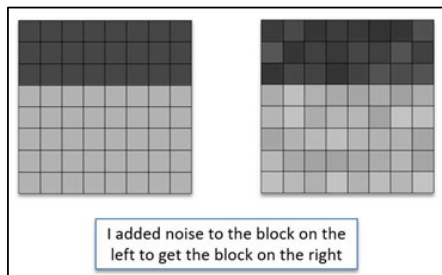


(CX-0103.0022). In other words, the image data is sparse after a forward transform is applied. *Id.*

With the above principles in mind, the evidence demonstrates that CDEF is a filter that reduces noise based on a sparse representation of the signal. As Dr. Richardson testified, “pixels on the screen are represented by numbers.” (Tr. (Richardson) at 446:8-15). Dr. Richardson conducted testing using MATLAB to demonstrate how CDEF operates. (*Id.* at 447:23-448:5, 454:7-11 (“It’s in the process of AV1, and these are results that I didn’t just kind of make up, I *calculated them by applying the CDEF process in my test simulation*, my MATLAB software.”) (emphasis added); CX-2058). To demonstrate the CDEF process, Dr. Richardson started with an exemplary image and a highlighted block of pixels. (Tr. (Richardson) at 444:25-445:16; CDX0005C.44). Next, using MATLAB testing, Dr. Richardson calculated pixel values for an eight-by-eight block of pixels.

	102	102	102	102	102	102	102	102
	102	102	102	102	102	102	102	102
	102	102	102	102	102	102	102	102
	136	136	136	136	136	136	136	136
	136	136	136	136	136	136	136	136
	136	136	136	136	136	136	136	136
	136	136	136	136	136	136	136	136
	136	136	136	136	136	136	136	136

(CDX-0005C.46; CX-2058; Tr. (Richardson) at 446:3-447:25). Dr. Richardson introduced noise into the block changing some pixel values. (CDX-0005C.47; (Tr. (Richardson) at 447:5-448:18).



(CDX-0005C.47; CX-2058). Through his MATLAB testing, Dr. Richardson demonstrated how CDEF works using a pixel with a value of 101 (highlighted blue). (Tr. (Richardson) at 450:16-18).

99	103	97	99	98
107	97	100	98	102
97	102	101	96	101
134	140	135	133	132
137	141	134	137	137

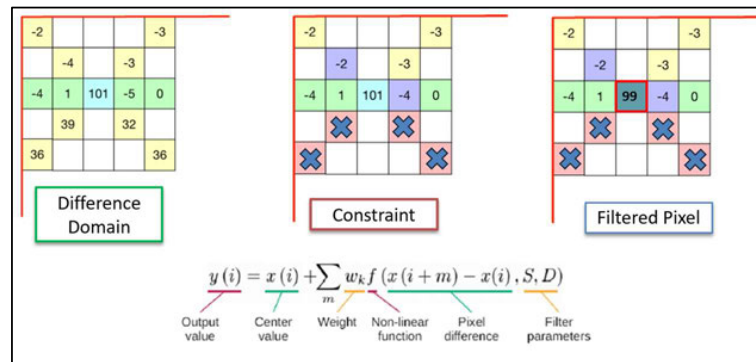
-2				-3
	-4		-3	
-4	1	101	-5	0
	39		32	
36				36

(CDX-0005C.50; CX-2058). For every pixel, CDEF “takes each of the 12 yellow and green positions and subtracts from each of those the center position. So it’s creating or calculating difference values.” (Tr. (Richardson) at 452:11-16). The process of determining the difference values in AV1 is a transform. (*Id.* at 853:5-20). And, consistent with Dr. Richardson’s and Dr. Orchard’s opinions, the evidence shows that the initial pixel values are recoverable. (Tr. (Richardson) at 453:19-454:5, 454:15-455:12; CX-0103.0020).

CDEF transforms the data, or signal, into a difference domain, which is a sparse representation because it is “a different representation of the data, and it has made it possible for this filter to discriminate between data that it wants to take into account when filtering and data that it wants to ignore when filtering.” (Tr. (Richardson) at 453:5-22, 458:9-18). As shown in the image above and in CDX-0015, the difference domain is a sparse representation because, of the twelve transformed values, 4 are large (36, 39, 32, and 36) and the remaining eight are zero or

near-zero. The majority of values are zero or near-zero. (Tr. (Richardson) at 853:2-857:11).

CDEF *reduces noise* based on the sparse representation of the signal described above. The evidence demonstrates that CDEF uses a constraint (or constrain) function to ignore the large values and utilize only the smaller values to filter a pixel. (Tr. (Richardson) at 457:13-23; 461:3-462:13). In other words, CDEF discriminates between data that it wants to consider when filtering (the smaller values) and data that it wants to ignore (the larger values). This is illustrated below:



(CDX-0005C.51; CX-1608.0002; CX-2058). Dr. Richardson testified that utilizing the small values (and not the large values) for filtering resulted in the value of the pixel of interest (101) getting closer to the values near it. (Tr. (Richardson) at 460:19-461:24). Applying the CDEF process to every pixel has the effect of making them “get a little bit more similar to each other, and that is what CDEF does. It reduces the noise. It reduces those random variations. It makes [the pixels] a little bit more similar to each other.” (Tr. (Richardson) at 461:20-462:13).

Dr. Richardson testified that CDEF operates to find the dominant feature of a block (shown in green in CDX-0005C.51), which influences the pixel values CDEF utilizes. (Tr. (Richardson) at 451:23-452:4). Complainants proved that CDEF reduces ringing noise and therefore meets claim 5.d’s requirement that the filter “reduce noise.” (Tr. (Richardson) at 439:20-25, 441:23-442:6; Tr. (Schonfeld) at 987:22-988:5 (“the filtering is designed to remove ringing artifacts”), 1044:17-20).

(iii) Respondents’ Arguments that CDEF is Not a Sparse

Denoising Filter are Incorrect.

At the evidentiary Hearing, Respondents made three arguments as to why CDEF does not meet claim limitation 5.d. (Tr. (Schonfeld) at 997:15-20). None are persuasive. First, Respondents' repeat their erroneous claim construction argument that the applicant disclaimed all deringing filters during prosecution. Complainants address this argument below when discussing Respondents' constructions of "sparse denoising filter."

a) CDEF Generates a Representation of the Signal.

Respondents argue that CDEF does not operate on a "representation of the signal." (Tr. (Schonfeld) at 1000:17-1001:11). Respondents allege that claim limitation 5.d is met by CDEF only if the "sparse representation of the signal" is an eight-by-eight image block. (*Id.* at 1001:6-11 (stating that all constructions require "an 8x8 block representing the original image")). Thus, Respondents argue that there must be an eight-by-eight image grid generated by CDEF for claim limitation 5.d to be met. (Tr. (Schonfeld) at 1002:5-12 ("it's not an image representation, because the underlying image is an 8x8 array.")). As a preliminary matter, *none* of the constructions require that a "sparse representation of the signal" constitutes an eight-by-eight image grid. (CX-0337). Respondents' main construction does not require a "representation of the signal" at all. (*Id.*). Rather, Respondents' argument appears to be a novel third proposed construction of the term "sparse denoising filter" that was not raised during claim construction. The ALJ should therefore reject this untimely argument as waived. (*See* G.R. 1.14.1).

Moreover, Respondents' argument is based on the flawed premise that a "representation" must be a pictorial image of an eight-by-eight block. Respondents' expert, Dr. Schonfeld, provides no support for his allegation that a "sparse representation of the signal" must be an eight-by-eight image grid. To the contrary, the undisputed evidence shows that "pixels on the screen are represented by numbers." (Tr. (Richardson) at 446:8-15; Tr. (Schonfeld) at 1047:7-10 (agreeing

that values on his demonstrative titled “Constraint Function” (RDX-0002.287) are pixel values)). Thus, there can be no dispute that the “signal” (i.e., pixels) are represented as data or numbers on a computer. There is also no dispute that CDEF transforms these pixel values into the difference domain. As Dr. Richardson explained, CDEF “takes each of the 12 yellow and green positions and subtracts from each of those the center position. So it’s creating or calculating difference values.” (Tr. (Richardson) at 452:11-16; Tr. (Schonfeld) at 1046:15-20).

99	103	97	99	98
107	97	100	98	102
97	102	101	96	101
134	140	135	133	132
137	141	134	137	137

-2				-3
	-4		-3	
-4	1	101	-5	0
	39		32	
36				36

(*Id.* CDX-0005C.50; CX-2058; *see also* Tr. (Richardson) at 853:8-9 (“The slide on the left is a 5x5 region of a block of pixel values. I’ve highlighted pixel value 101. And the diagram on the right shows that center pixel value and 12 offset values, which are all difference values.”)). Stated differently, CDEF is operating on the pixel values themselves (i.e., the signal) to create a “sparse representation” of the signal that allows it to differentiate between things it wants to consider when filtering (the small difference values) and things that it wants to ignore in filtering (the large difference values). (Tr. (Richardson) at 853:8-857:11).

Respondents do not dispute that CDEF conducts the same process illustrated above with each pixel in an image. (*See, e.g.*, Tr. (Richardson) at 461:25-462:3 (“if you think about doing that for every single pixel, then those pixels are going to get a little bit more similar to each other, and that is what CDEF does.”); Tr. (Schonfeld) at 988:3-5 (“And then you repeat the whole process again, and you just do it for all 64 elements of the image representation in that block.”)). Accordingly, Dr. Schonfeld’s argument that CDEF operates on one pixel at a time (instead of 64

[REDACTED]

pixels as once) is not a basis for noninfringement and does not mean that CDEF is no longer operating on the signal or creating a “sparse representation” of that signal.

The evidence adduced at the Hearing shows that Dr. Schonfeld’s belated claim construction position places arbitrary and untenable restrictions on the phrase “sparse representation of the signal.” Dr. Richardson’s testimony, on the other hand, clearly shows that CDEF reduces noise based on a sparse representation of the *signal* because the “signal” corresponds to pixels (shown in a computer as numbers) and the evidence shows that CDEF creates a sparse representation of these values through use of the difference domain.

Even Dr. Schonfeld *admits* that the CDEF process creates a “pixel representation.” (Tr. (Schonfeld) at 1002:13-17). In doing so, Dr. Schonfeld fatally undermines his opinion that CDEF does not create a representation of the signal. Further, Dr. Schonfeld fails to identify any reason why a “sparse representation of the signal” must include “64 points” and that anything less somehow stops being a “sparse representation of the image.” (Tr. (Schonfeld) at 1003:1-3).

Dr. Schonfeld’s opinion that the claim limitation requires an eight-by-eight grid was rejected by Lenovo’s original expert. Specifically, Dr. Schonfeld alleges that CDEF does not create a sparse representation of the signal because “[t]here is no image there. It’s just a series of mathematical computations. And, therefore, it cannot be viewed as an image representation.” (Tr. (Schonfeld) at 1003:13-15; *see also id.* at 1003:25-1004:2 (“When you are done with all 64 pixels, you end up with an image representation which is the output of CDEF, and that’s shown on the right-hand side.”)). In contrast, Respondents’ original expert Dr. Orchard notes that the “key here is to distinguish the image itself from the ‘sparse image model’ or ‘sparse representation of the image.’ *Images* (i.e., frames of video) are not sparse.” (CX-0103.0020 (emphasis added)). Dr. Schonfeld is thus conflating the “sparse representation of the signal” or “sparse image model” with

[REDACTED]

the image itself. Dr. Richardson and Respondents’ original expert both clearly opined that the representation of the signal or image in the context of this claim limitation is the transformation of the data (the pixel values) into a different domain such that “the ‘true signal’ (represented by the few large non-zero values) can be separated from, or decoupled from, the noise (represented by the near-zero values).” (CX-0103.20; Tr. (Richardson) at 849:21-850:23).¹⁶ Respondents’ allegation that CDEF does not generate a sparse representation of the signal—an allegation proffered only by their replacement expert—is without merit.

Dr. Schonfeld also argues that CDEF “computes the difference for one tap element, computes the constraint and then the weight, and then adds it one at a time to the value sum and then discards it.” (Tr. (Schonfeld) at 1003:9-12). This is incorrect. Dr. Richardson looked at specific source code showing all twelve values are in the difference domain at the same time. (Tr. (Richardson) at 485:6-16; CX-1604C.0101-18). Further, he confirmed that none of the source code operated in the manner that Dr. Schonfeld suggests. (*Id.* at 642:22-643:16; *id.* at 471:9-23 (noting that all of his opinions are based “on the software and hardware, not purely on the pseudocode” and specifically citing relevant source code for NVIDIA, Intel, MediaTek, and AMD chipsets); *id.* at 487:12-14 (noting that he conducted the same analysis for all the code he looked at); CDX-5C.0053; CX-1967C.0566-570 (lines 1271025-545), CX-1967C.0571 (lines 1271623-96); CX-1674C (INTEL_1373-SC-0000380-85); CX-2021C (NV-ID-SC-000009-14, lines 85-194, 221-392)). Despite being aware of Dr. Richardson’s testimony on source code (and despite being present at trial to hear it live), Dr. Schonfeld did not rebut Dr. Richardson’s conclusions.

Even if Dr. Schonfeld were correct, it would not alter the analysis because “regardless of

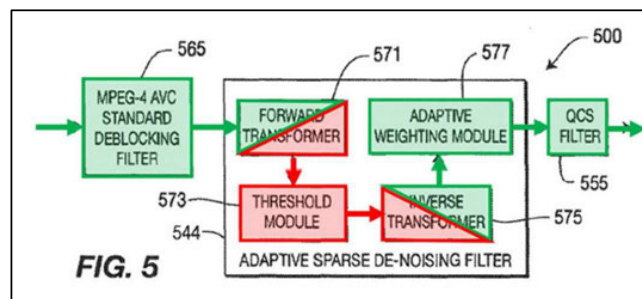
¹⁶ Further contradicting Dr. Schonfeld, Dr Orchard stated that after thresholding “you might say this looks like the signal, And it looks very much like the signal, but it is not. It’s actually the result of keeping all the values from the previous slide but setting to zero anything that was below some threshold.”) (EDIS Doc. ID 829259 at 50:25-51:7).

whether all those difference values are available and used at the same time or if they are used one after the other, the end result is that that pixel is filtered to reduce noise, that the filtering process, the way the filtering is done is based on a sparse representation, it's based by that representation in the difference domain." (Tr. (Richardson) at 497:8-21; Tr. (Schonfeld) at 1002:13-18 (admitting CDEF creates a "pixel representation"); 1046:15-23 (admitting constraint function operates on the difference between a pixel and 12 neighboring pixels)).

b) CDEF Generates a Sparse Representation.

Respondents' second argument is that CDEF does not generate a "sparse representation." (Tr. (Schonfeld) at 1005:21-23). Dr. Schonfeld made it clear he believes that a "sparse representation" can occur only after thresholding. Dr. Schonfeld testified: "That's why you have a threshold to begin with, to create sparsity." (Tr. (Schonfeld) at 1051:2-6) (Q: "When you gave all your testimony about zeros or predominately zeros, you're talking about what it looks like after the thresholding, true?" A: "That's correct.")

Dr. Schonfeld is wrong. The testimony of Respondents' first expert, Dr. Orchard, proves as much. Dr. Orchard testified that "image data is 'sparsely represented' in the 'transform domain' during the process steps in red over Figure 5 of the '556 patent. Where in green, the data is not sparse, as it is in the 'pixel domain.'" (CX-0103.0022). In other words, Dr. Orchard confirmed that in the context of the '556 Patent, data is first sparsely represented once it has been transformed (e.g., the difference domain), which is prior to thresholding.



[REDACTED]

(CX-0103.0022). Dr. Richardson confirmed this, stating that “once the transform has been applied in this context, the data is now sparse, and I think that’s consistent with Dr. Orchard’s text here.” (Tr. (Richardson) at 849:14-16).

Dr. Schonfeld also testified that a sparse representation requires that the majority of values in the representation must be zeros and, for that reason, CDEF does not generate a sparse representation. (*Id.*, 1155:25-1156:1). Staff took a similar position in their Pre-Hearing Brief, stating that “sparse systems are those in which the data or information being analyzed has many coefficients that are zero.” (SPre at 80).¹⁷ However, once again, Dr. Schonfeld’s opinion contradicts the sworn testimony of Dr. Orchard who testified that “the matrix coefficients in the sparse representation that should be zero will in practice *be near-zero* – representing the noise. Thus, the sparse representation provides a useful exploit: The true signal (represented by the few large non-zero values) can be separate from, or decoupled from, the noise (represented by *the near-zero values*).” (CX-0103.0020; Tr. (Richardson) at 849:21-851:5) (emphasis added). At trial, Dr. Richardson explained likewise, making it clear that a sparse representation can be, in practice, near-zero. (Tr. (Richardson) at 850:8-20). Even Dr. Schonfeld agreed with the statement that a sparse representation can have a “few large non-zero values” that are “separated from or decoupled from the noise represented by near zero values.” (Tr. (Schonfeld) at 1052:17-20). Thus, Dr. Schonfeld ultimately contradicted his own testimony and failed to reconcile his incompatible testimony that a sparse representation *must* be made up of a majority of only zeros with his admission that a sparse representation could have near zero values as Dr. Orchard explained.

The testimony of Dr. Orchard is once again helpful to understand why values in the

¹⁷ In the Markman hearing, Staff noted both that a sparse representation could include a few large values (representing the true signal) separated by *near-zero* values (representing the noise) and that “everyone understands what sparsity is, and that the experts do, in fact, understand what a sparse representation is.” (EDIS Doc. ID 829259 at 101:23-102:10).

difference domain will, in practice, be near zero and not exactly zero. He noted that, “[w]here the original image is contaminated with independent and identically distributed (i.i.d) noise, however, the matrix coefficients in the sparse representation that *should be* zero will in practice be *near-zero* – representing the noise.” (CX-0103.0020 (emphasis in original)). This is exactly what happens in the CDEF filtering process. As shown below, pixel values are identical (left matrix) prior to being contaminated with noise (right matrix):

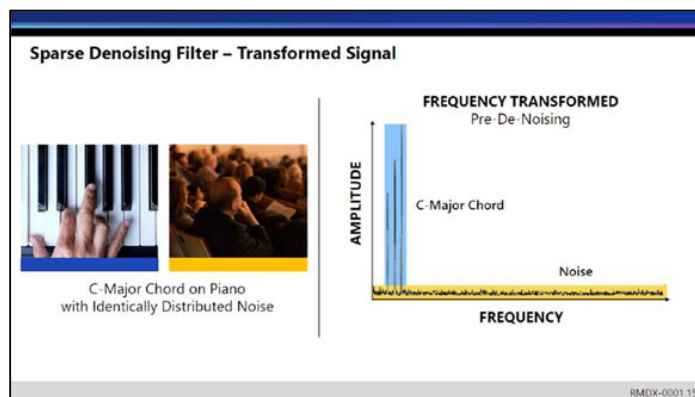
102	102	102	102	102	102	102	102	99	103	97	99	98	96	97	105
102	102	102	102	102	102	102	102	107	97	100	98	102	100	106	100
102	102	102	102	102	102	102	102	97	102	101	96	101	106	104	106
136	136	136	136	136	136	136	136	134	140	135	133	132	134	130	134
136	136	136	136	136	136	136	136	137	141	134	137	137	131	141	140
136	136	136	136	136	136	136	136	132	136	138	140	137	136	136	132
136	136	136	136	136	136	136	136	138	133	131	131	133	134	137	132
136	136	136	136	136	136	136	136	140	138	135	141	136	139	137	141

(Tr. (Richardson) at 447:5-448:18; CX-2058; CDX-0005C.46, .48). If CDEF operated on the pixels to the left, which do not have noise, it would return mostly zeros (e.g., $102 - 102 = 0$). (See Tr. (Richardson) at 452:11-16). Because there is noise in the pixels, in the difference domain CDEF provides *near-zero* values representing the noise, just as Dr. Orchard explained.

Dr. Richardson also pointed to the text of his 2010 book talking about wavelet transforms, which stated that “the sparse nature of LH, HL, and HH sub-bands makes them amenable to compression” and that “[m]any of the samples (coefficients) in the higher-frequency sub-band images are close to zero” making it “possible to achieve compression by removing these insignificant coefficients prior to transmission.” (Tr. (Richardson) at 845:3-846:4; RX-0632.0081-82). Dr. Richardson testified that a POSITA “would be completely comfortable” with calling the data described in the 2010 book “sparse” even though “many of the samples in these images are close to zero” and not precisely zero. (Tr. (Richardson) at 846:5-19).

Dr. Richardson also looked at other slides presented by Dr. Orchard and confirmed that

they were “consistent with the way I would view a sparse representation in the field, yes, or in the general field of signal processing.” (Tr. (Richardson) at 851:12-23).



(CDX-0004.22; RMDX-0001.152). The evidence showed that the “large amplitude peaks” are “meant to represent the frequency content of that C-major chord, and I think the three peaks are meant to represent the notes of the chord” while the portion in orange labeled “noise” contains only “near-zero” values. (Tr. (Richardson) at 852:2-11). The slide also represents values prior to thresholding. (EDIS Doc. ID 829259 at 48:6-49:25). Dr. Schonfeld is, therefore, incorrect that a sparse representation only appears after thresholding and that a sparse representation must be made up of a majority of zeros. Indeed, it appears that once Dr. Orchard would not adopt (and in fact contradicted) Respondents’ trial theories, he was promptly replaced with Dr. Schonfeld.

Respondents’ attempt to “impeach” Dr. Richardson at trial not only failed but also served to highlight Respondents’ (and Dr. Schonfeld’s) incorrect theory that a representation is sparse only after thresholding. Respondents identified portions of Dr. Richardson’s textbooks as alleged support for their theory that a sparse representation *must* contain mostly zeros (not *near-zeros*). Dr. Richardson made clear, however, that each example shown by Respondents related to sparsity *after* quantization, in which insignificant values, such as near-zero values, are removed by the quantizer. (Tr. (Richardson) at 847:2-17, 716:17-25 (discussing sparsity after quantization),

719:11-16 (Respondents' counsel reading portion of Dr. Richardson's textbook stating, "The output of a forward quantizer is therefore typically a sparse array. . . .") (emphasis added), 721:7-722:25 (same), 724:15-725:5 (same). Dr. Richardson looked at examples in these same textbooks that showed sparse data that was not composed of mostly zeros but was instead composed of *near-zero* values. (Tr. (Richardson) at 845:3-846:19). Respondents' cherry-picked examples have no bearing on what a sparse representation looks like prior to quantization or thresholding, where both Dr. Orchard and Dr. Richardson agree that values representing noise can be *near zero* and not exactly zero. (Tr. (Richardson) at 846:11-850:11; *see also* EDIS Doc. ID 829259 at 48:6-49:25).

Finally, Dr. Schonfeld acknowledged that there would be portions of an image where CDEF "wouldn't zero out any of the values." (Tr. (Schonfeld) at 1007:25-1008:2). Dr. Schonfeld and Staff (*see* SPre at 80) argue this means CDEF cannot be a sparse denoising filter. But the idea that CDEF is not a sparse denoising filter simply because certain portions of an image will not have big edges was rebutted by Dr. Richardson, who testified:

In my opinion that's a completely incorrect interpretation, because CDEF is always going through this process, whether or not there's big edges or big discontinuities to exclude, it's still going through the same process. If I might make an analogy to the piano and the removal of noise in the background, if I'm the engineer setting that up, I'm going to set up my filter to remove noise. If the audience is really, really quiet, my filter is still a denoising filter. It's still working to reduce noise, even if the noise isn't there. Another little analogy is the deblocking filter. Sometimes there are blocks where there are no discontinuities to remove. It's still a deblocking filter. It's just that it basically does nothing if there's nothing for it to deal with. Just like here, if there are not edges to exclude, it doesn't exclude edges, but it's still going through this process, it's still, in my view, a sparse denoising filter for the reasons I suggested.

(Tr. (Richardson) at 468:15-469:8). Dr. Richardson confirmed that, when operating, CDEF is always going through the same process of transforming pixel data into the difference domain and using this representation to distinguish the true signal from noise. (*Id.*). The fact that certain portions of an image may not have large discrepancies or noise does not mean that CDEF stops

being a sparse denoising filter. Respondents' and Staff's inconsistency is also highlighted when comparing their disparate treatment of CDEF to the deblocking filter, which all parties agree is a deblocking filter even though it *does not* deblock each portion of the image (*see infra*, analysis of claims 3 & 7). It is also black-letter law that a device that infringes only sometimes still infringes. *See Broadcom Corp. v. Emulex Corp.*, 732 F.3d 1325, 1333 (Fed. Cir. 2013) ("It is well settled that an accused device that sometimes, but not always, embodies a claim nonetheless infringes."). Accordingly, the evidence demonstrates that CDEF is a sparse denoising filter regardless of the image region that it is filtering.

Respondents' Constructions:

(iv) Deringing Filters Were Not Disclaimed.

Respondents' final argument regarding limitation 5.d simply rehashes their erroneous claim construction position. Respondents' construction adds the phrase "which is not a deringing filter" to the claim language in an obvious, and strained, attempt to exclude all deringing filters. (CX-0337.0003). Respondents' argument (as put forth at the claim construction hearing) is that the applicant prosecuting a parent of the '556 Patent (the application that would eventually become U.S. Pat. No. 9,277,243) allegedly disclaimed deringing filters. (Tr. (Schonfeld) at 997:23-998:5). Dr. Schonfeld testified that his entire basis for construing "sparse denoising filter" with this negative limitation is his view of the prosecution history and that otherwise he would not allege that a denoising filter cannot be a deringing filter. (Tr. (Schonfeld) at 1044:17-20).

There was no disclaimer. Initially, the examiner rejected the claims over U.S. Patent Appl. No. 2003/0219073 ("Lee") because the examiner believed Lee disclosed a sparse denoising filter. (RX-0628.0258). The applicant, however, traversed the examiner's rejection explaining that Lee did not disclose a sparse denoising filter:

performing a second pass to reduce noise. While the cited portions of Lee may disclose deringing filtering, Lee does not disclose or suggest a sparse de-noising filter for performing a second pass to reduce noise.

Claim 1 has been amended to incorporate subject matter from dependent claim 4, and in particular, amended claim 1 specifies the at least two filters include a deblocking filter for performing a first pass to reduce blocking artifacts and a sparse de-noising filter for performing a second pass to reduce noise. Claim 4 has been canceled. This should be viewed as a traversal of the rejection of claim 4 under 35 U.S.C. § 102(b).

Lee's deringing filtering does not disclose or suggest a sparse de-noising filter for performing a second pass to reduce noise. The remaining cited reference, namely Francois, fails to

(RX-0628.0287). The applicant never stated that deringing filters are not covered, or that deringing filters could not be sparse. And the applicant never made a clear and unmistakable disclaimer using words or expressions of manifest exclusion or restriction as required by law. *Thorner v. Sony Computer Entm't Am. LLC*, 669 F.3d 1362, 1366-67 (Fed. Cir. 2012). In fact, the examiner made clear that Lee did not disclose a sparse denoising filter because Lee's filter is not a *sparse* filter:

Lee discloses an adaptive deringing filter (de-noising filter) (paragraph [0049]) but does not disclose that the de-noising filter is a sparse filter. Applicant's Admitted

(RX-0628.0304). Thus, the examiner explicitly recognized that a deringing filter can be a sparse denoising filter but found—correctly—that Lee's denoising filter was not a *sparse* denoising filter. (*Id.*). When faced with the above statement at trial, Dr. Schonfeld admitted that the examiner had concluded that Lee is not a *sparse* filter. (Tr. (Schonfeld) at 1045:1-18).

The applicants themselves confirmed the examiner's understanding that Lee's denoising filter is not a sparse filter, stating:

Arguments. Rather, in apparent agreement with Applicants' traversal, the final Office Action changes its position and acknowledges "Lee discloses an adaptive deringing filter (de-noising filter) (paragraph [0049]) but does not disclose that the de-noising filter is a sparse filter."¹⁰

(RX-0628.0322). Thus, the evidence conclusively refutes Respondents' position that the parent application of the '556 Patent disclaimed all denoising filters. Accordingly, Complainants' respectfully request that the ALJ deny Respondents' erroneous claim construction that all

[REDACTED]

deringing filters must be excluded from the term “sparse denoising filter.”

(v) Even if Deringing Filters Were Disclaimed, CDEF Meets the Claim Limitation.

Even if the ALJ finds that the above statements constitute disclaimer and holds that the term “sparse denoising filter” cannot include deringing filters, CDEF still meets the claim limitation. As the evidence shows, in addition to removing ringing noise, CDEF also “reduces or removes uniform noise or noise that does not necessarily have a ringing characteristic.” (Tr. (Richardson) at 442:2-6, 707:11-15). Dr. Schonfeld agrees that CDEF removes other types of noise beyond ringing noise, but offered the half-hearted opinion that CDEF must be a deringing filter because “it is designed to do exactly that.” (Tr. (Schonfeld) at 998:24-1000:8). In other words, although the unrebutted evidence demonstrates that CDEF reduces other types of noise besides ringing noise, Dr. Schonfeld’s opinion is that this noise does not make CDEF more than a deringing filter because CDEF was allegedly designed to be a deringing filter.

Dr. Schonfeld’s opinion is wrong as a matter of law. The fact that an apparatus was “designed” or “intended” for a specific purpose does not allow that apparatus to escape infringement solely on the basis of that intent because direct infringement is a strict liability offense. *See, e.g., Lifetime Indus., Inc. v. Trim-Lok, Inc.*, 869 F.3d 1372, 1377 (Fed. Cir. 2017); *Nanobebe United States Inc. v. Mayborn Uk Ltd.*, 2023 U.S. Dist. LEXIS 67916, at *39 (S.D.N.Y. Apr. 18, 2023). Because the evidence demonstrates that CDEF reduces more than ringing noise, the ALJ should find that CDEF meets claim limitation 5.d even under Respondents’ erroneous claim construction. (Tr. (Schonfeld) at 1001:1-16; 1004:11-16).

(vi) CDEF Meets Respondents’ Alternative Claim Construction.

Respondents’ alternative construction for “sparse denoising filter” is “a filter which exploits a sparse image model using an over complete set of linear transforms and hard thresh-

[REDACTED]

holding, which is not a deringing filter.”¹⁸ (CX-0337.003). Consistent with the backup nature of this construction, Respondents offered no evidence to support the construction during the evidentiary Hearing. Instead, apart from the negative limitation in Respondents’ construction, Dr. Schonfeld simply alleged that his analysis of infringement was the same irrespective of which construction is adopted. (Tr. (Schonfeld) at 1001:1-16; 1004:11-16).

Dr. Richardson, on the other hand, provided un rebutted testimony that CDEF does in fact use an overcomplete set of linear transforms. (Tr. (Richardson) at 455:16-22). Specifically, the evidence shows that CDEF uses an overcomplete representation because each one of the twelve “differences is a simple linear transform. We don’t actually need all 12 to get back to the original data, we can get back to it from any one of the 12.” (*Id.* at 456:8-12). Further, CDEF performs hard thresholding by ignoring large positive or negative values. (*Id.* at 462:18-24 (“exclude the ones whose values are particularly large, or I could have shown it the other way around, CDEF will also exclude values that are particularly low in the negative regions and leave behind everything that’s quite close to zero, small, plus or minus values.”), 467:12-17). Thus, even if the ALJ were to construe “sparse denoising filter” in line with Respondents’ backup construction, which improperly limits the phrase to a portion of one exemplary embodiment and excludes preferred embodiments (*see* EDIS Doc. ID 812766), CDEF would still satisfy the claim limitation.

f. Claim 5.e. (“wherein the adaptive sparse de-noising filter is selectively enabled or disabled at a given level, the given level being at least a macroblock level, a slice level, a picture level or a sequence level”)

Complainants proved that the Accused Products infringe claim 5.e. Specifically, the evidence shows “enable_cdef flag” is set to either zero or one, and if it is set to zero, the decoder

¹⁸ Complainants have already discussed why Respondents’ negative limitation is erroneous when discussing Respondents’ disclaimer argument. Accordingly, Complainants incorporate by reference that reasoning into this section.

does not perform any CDEF filtering, and if it is set to one, CDEF does perform filtering. (Tr. (Xiong) at 218:5-15; *see also* Tr. (Richardson) at 472:24-473:2 (“What I mean by that is that if certain flags or values are set to a certain value; CDEF is applied by the decoder. If these values are set to a different value, CDEF is not applied by the decoder.”); Tr. (Schonfeld) at 1055:25-1056:7 (agreeing that decoder disables CDEF if `cdef_enable` is zero, and that the decoder will filter using CDEF when the parameter is set to one).

The AV1 specification clearly indicates that “`cdef_enable`” is set at the sequence level. (CX-0247.0125, .0129). Specifically, `enable_cdef` is clearly listed and defined in Section 6.4, which lays out the sequence level semantics. (*Id.*; *see also* Tr. (Schonfeld) at 1009:11-13 (“The first one is an enable CDEF that comes as part of the entire *sequence* for the video.”) (emphasis added)). Consistent with the testimony produced at the evidentiary Hearing, the AV1 Specification also states that `enable_cdef` disables and enables the CDEF process. (CX-0247.0129).

Indeed, there is no dispute that the decoder disables CDEF filtering if `enable_cdef` is set to zero and enables it if it is set to one. The only dispute between the parties is whether CDEF is “selectively enabled or disabled” based on `enable_cdef`. Specifically, Respondents attempt to advance another belated claim construction argument,¹⁹ alleging that the claim limitation is met only if the *decoder* provides the initial instructions to turn the sparse denoising filter on or off. (Tr. (Schonfeld) at 1009:1-22). Stated differently, in Respondents’ eyes, the fact that the decoder turns CDEF on or off based on certain parameters identified at the sequence level is not enough.

Respondents’ position is contradicted by the plain language of the claim which requires only that “the adaptive sparse denoising filter is selectively enabled or disabled at a given level.” (JX-0003). The claim does not require that the *decoder* perform that task (as Respondents

¹⁹ As with their other belated claim construction positions, the ALJ should find this argument waived as it was not presented in Respondents’ Markman briefing. (*See* G.R. 1.14.1).

[REDACTED]

[REDACTED]

contend). In other words, there is no requirement that a decoder provide the initial instruction, here enable_cdef, which leads to the enabling or disabling. Rather, the claim limitation is met if the sparse denoising filter “is selectively enabled or disabled” (regardless of whether the instruction comes from the encoder or decoder). The ’556 patent specification supports the same conclusion. The specification never requires the restriction Respondents now propose; instead, the specification simply notes that the “sparse de-noising filter . . . can be turned on/off at the macroblock level, slice level, picture level, and/or sequence level.” (JX-0003 at 11:50-55,16:65-17:4 (noting that the encoder can “transmit[] side information” at a “sequence level.”). The evidence at the evidentiary Hearing confirmed this. (Tr. (Richardson) at 473:6-9).

Dr. Schonfeld never denied this. When addressing this claim, Dr. Schonfeld mentioned that one had to *assume* that the claim limitation required that the decoder must make the initial selection. (Tr. (Schonfeld) at 1009:1-22). Yet, Dr. Schonfeld provided no testimony as to why a person of skill in the art would make this assumption, particularly here where such a notion is at odds with both the plain claim language and the specification (and was directly refuted by Dr. Richardson’s testimony that a POSITA would not read the claim in the manner suggested by Respondents). The ALJ should reject Respondents’ belated claim construction and find this claim element met based on the undisputed evidence presented at the Hearing.

4. Infringement of Claim 1 of the ’556 Patent

The Accused Products satisfy all the elements of claim 1 for the same reasons, and based on the same evidence, discussed above for claim 5. Dr. Richardson showed that claim 5 and claim 1 have very similar language and testified that he did not understand that there was any unique dispute between the parties. (Tr. (Richardson) at 498:6-14; *see also* Tr. (Schonfeld) at 984:14-18 (“Well, one is a method claim, the other one is an apparatus claim, and for the purpose of my analysis, there is no distinction.”)). Looking at the two claims, it is apparent that the limitations

[REDACTED]

are almost identical. (JX-0003; CDX-0005.57). Accordingly, Complainants incorporate by reference the above analysis regarding claim 5.

Dr. Schonfeld testified that he had seen no evidence of claim 1 practiced in the United States because he had only seen the “enable_cdef” function enabled (he had not seen it disabled). (Tr. (Schonfeld) at 1010:17-1011:7). This argument is meritless. Claim 1.e, which requires selectively enabling *or* disabling CDEF, is met if CDEF is selectively enabled. (JX-0003). Dr. Schonfeld admits that CDEF is enabled if enable_cdef is set to one and disabled if it is set to zero. (Tr. (Schonfeld) at 1055:25-1056:7). To the extent Dr. Schonfeld is arguing that CDEF cannot be disabled, this is contradicted by his own testimony and by the AV1 Specification, which explicitly notes that CDEF can be selectively enabled and disabled. (CX-0247.0125, .0129).

Further, Lenovo’s corporate designee (Mr. Pitarra) testified all new products over the past few years have chips that supported AV1. (CX-0158C (Pitarra Dep. Tr.) at 71:5-8). Additionally, Mr. Pitarra answered confirmed that for those chips that do support AV1, there is dedicated hardware on those chips for actual performing the encoding or decoding of AV1 material. (*Id.* at 68:5-10). Accordingly, there can be no dispute that method claim 1 has been practiced by at least Lenovo’s customers streaming video using the Accused Products. *See also* (Tr. (Xiong) at 183:23-184:2 (discussing testing that shows that Accused Products decode AV1 video), 202:19-23; Tr. (Richardson) at 399:16-401:25 (same)). Based on the above, Complainants proved that the Accused Products infringe claim 1 of the ’556 patent.

5. Infringement of Claims 3 and 7 of the ’556 Patent

Respondents do not dispute that the additional limitations of claims 3 and 7 are met. (Tr. (Richardson) at 498:19-499:4). The evidence put forward at the Hearing confirms that the Accused Products infringe claims 3 and 7. For example, the AV1 Specification states that the deblocking filter has a “filterMask,” which enables and disables the deblocking filter based on samples near a

[REDACTED]

boundary. (CX-0247.0326, .328; CDX-0005C.59). Dr. Richardson testified that the AV1 deblocking filter is enabled if filterMask is equal to one or more, and is disabled if it is equal to zero. (Tr. (Richardson) at 499:24-500:8). Further, the evidence shows that the deblocking filter is adaptively enabled or disabled depending upon at least data characteristics corresponding to the image region because the final paragraph above “says that the enabling or disabling, that’s the value of filterMask, depends on the four samples on either side of the boundary. . . . So it’s adaptively enabled or disabled, and the adaption depends on the samples, that’s the pixels, next to the boundary, so it depends on data corresponding to image region, because those pixels or samples are pixel data and that’s data corresponding to an image region.” (*Id.* at 500:6-17). Complainants have therefore demonstrated (and Respondents do not dispute) that the Accused Products infringe dependent claims 3 and 7 if their associated independent claims are infringed.

C. Indirect Infringement

Respondents induce infringement of the claims and contribute to infringement by its customers to use the Accused Products for the same reasons as discussed above with respect to the ’877 patent. (*Supra*, § III.C). AV1 decoders are a material part of the invention of the ’556 patent and also have no substantial non-infringing uses because they are specially designed and/or programmed to infringe the asserted patents, and specifically, with respect to the ’556 patent, to successively performing in-loop filtering with deblocking and CDEF filters according to the AV1 Specification. (Tr. (Richardson) at 433:3-437:12).

D. Domestic Industry – Technical Prong

The DI Products are operable to decode AV1 bitstreams according to the AV1 Specification. (*Supra*, § III.D). Therefore, the DI Products practice claims 1, 3, 5, and 7 of the ’556 patent for the same reasons the Accused Products infringe. Complainants accordingly incorporate their analysis regarding infringement of claims 1, 3, 5, and 7 of the ’556 patent into this section.

[REDACTED]

VI. DOMESTIC INDUSTRY – ECONOMIC PRONG

InterDigital proved its significant domestic industry through the investments made by two of its licensees—Apple and Vizio.²⁰ Mr. Herrington’s testimony regarding Apple and Vizio’s substantial investments in the United States—[REDACTED] respectively—was unrebutted. These qualifying domestic investments are “significant,” and Lenovo cannot meaningfully dispute that the economic prong is satisfied in this Investigation. In fact, Lenovo does not dispute Vizio’s total qualifying expenditures (pre-allocation) or the extent of Vizio’s R&D activities in the United States. (EDIS Doc. ID 830484, SUMF #s 13–18, 21, 22, 35–41). And with respect to Apple, Lenovo disputes how much of the billions of R&D expenses upon which InterDigital relies should be attributed to Apple DI Products. But Apple’s alleged investments in non-revenue generating products should not be excluded, especially considering that [REDACTED]

Even if the alleged non-revenue generating product investments are excluded, Apple’s investments are still significant and satisfy the economic prong. (Tr. (Herrington) at 229:2-233:20; CX-2364C).

A. Overview of InterDigital’s Licensees’ Domestic Industry

1. Apple’s Domestic Industry

Founded in 1976, Apple is a renowned consumer electronics company that designs and manufactures smartphones, which includes Apple’s well-known iPhone, as well as a variety of other products. Apple is one of the biggest job creators in the United States and employs roughly 80,000 people in the United States alone. Apple also spends billions of dollars in the United States on R&D each year. (Tr. (Herrington) at 237:10-238:12; CX-0284; CX-0125.20, .26, .27). Thus, it is unsurprising that Apple owns, leases and operates many facilities in the U.S., all of which house

²⁰ Staff supports all issues related to economic prong, including the use of a sales-based allocation and a conservative one-quarter lag. (Tr. (Opening) at 139:11-21; EDIS Doc. ID 828850 at 127-141).

[REDACTED]

the employees, capital, and equipment necessary for Apple’s domestic activities, including the R&D that is necessary to bring the Apple DI Products to life. (*Id.*).

As Apple explains, in order to compete successfully in the market, “Apple must make significant investments in R&D.” (CX-0126.10). [REDACTED]

[REDACTED]

[REDACTED]

As explained further below, Apple has made significant domestic investments in the employment of plant, equipment, labor and/or capital related to the Apple DI Products. Apple’s R&D investments in the U.S. have been necessary to bring the Apple DI Products to market and are critical to producing a saleable product. The Apple DI Products have been overwhelmingly successful, and Apple’s sales and revenues of these products demonstrate the significance and importance of Apple’s R&D investments in those products.

2. Vizio’s Domestic Industry

Vizio is and has always been a U.S.-based company, with no foreign facilities or presence. Vizio is headquartered in Irvine, California and, as of 2023, [REDACTED]

²¹ Mr. Herrington reasonably approximated Apple’s R&D investments in Q4FY2023 to the date of the Original Complaint, September 1, 2023.

[REDACTED]
[REDACTED]
[REDACTED] (Tr. (Herrington) at 262:20-265:7; CX-0092.11). Vizio’s domestic facilities house employees, capital, and equipment involved in the research, design, and development of the Vizio DI Products. Vizio designs its products and “perform[s] high-value research and development in-house.” (*Id.*). [REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]
[REDACTED]

3. Summary of Domestic Industry Investments

The economic prong of the domestic industry requirement under 19 U.S.C. § 1337(a)(3)(A) and (B) is satisfied in this Investigation through domestic investments in articles protected by the Video Coding Patents. [REDACTED]
[REDACTED]

[REDACTED] Apple’s qualifying investments in the Apple DI Products total more than [REDACTED] in less than two fiscal year quarters, while Vizio’s qualifying investments in the Vizio DI Products total nearly [REDACTED] from January 1, 2021

through September 1, 2023. (Tr. (Herrington) at 250:12-251:15, 270:12-23; CDX-0010C. 28, .53). These investments, whether considered individually or collectively, satisfy the economic prong.

B. Apple's Domestic Industry Investments

The economic prong analysis below relates to Apple's U.S. product related R&D investments in its flagship iPhone product, the iPhone 15 Pro. (Tr. (Herrington) at 225:1-8). InterDigital presents two analysis below that both individually satisfy the economic prong.

1. Apple's Pre-Complaint Investments

Apple made significant domestic investments in the employment of plant, equipment, labor and/or capital related to the Apple DI Products prior to the filing of the Complaint in this Investigation. In total, from April 1, 2023 to September 1, 2023, Apple incurred over [REDACTED] dollars on qualifying R&D expenditures. (Tr. (Herrington) at 243:19-244:7; CDX-10C.22).

Allocation. Apple, like most companies, [REDACTED]

[REDACTED] Mr. Herrington testified that he performed a sales-based revenue allocation to reasonably allocate Apple R&D expenditures to the Apple DI Products. (Tr. (Herrington) at 244:18-246:1). A sales-based allocation is a reasonable way to allocate Apple's R&D investments for multiple reasons. First, [REDACTED]

[REDACTED] Second, Apple has previously used a sales-based allocation to allocate its own investments before the Commission. *Certain Cellular Base Station Communication Equipment*, Inv. No. 337-TA-1302, Order No. 17 (Nov. 2, 2022), *aff'd* by Notice, EDIS Doc. 785567 (Dec. 2, 2022). Finally, the use of a sales-based revenue allocation to allocate R&D expenses has routinely been accepted by the Commission. *Certain Computer Network Security Equipment and Systems*, Inv. No. 337-TA-1314, ID at 219 (Aug. 8, 2023) (citing *Certain Dental & Orthodontic Scanners & Software*, Inv. No.

337-TA-1144, ID at 162-63 (Apr. 30, 2020).

Mr. Herrington also employed a conservative one-quarter lag to account for Apple's new product R&D that necessarily pre-dates the launch of a product. (Tr. (Herrington) at 233:21-235:25; 249:2-250:11). In this case, Apple launched the iPhone 15 Pro just days after InterDigital filed its Original Complaint, on September 15, 2023. (CX-2132; CDX-0016). A conservative one-quarter lag was a reasonable method to attribute some of Apple's R&D investments to the Apple DI Products without forecasting future sales.²² (Tr. (Herrington) at 233:21-235:25; 249:2-250:11). To the extent that the ALJ disagrees, Mr. Herrington also analyzed Apple's investments in the Apple DI Products that post-date the date of the complaint and specifically whether Apple was in the process of establishing a domestic industry with respect to the Apple DI Products as of the date of the Original Complaint, as discussed below. (*Id.* at 235:18-235:25).

Plant & Equipment. From April 1, 2023 to September 1, 2023, Apple incurred [REDACTED] on qualifying R&D plant and equipment expenditures for the Apple DI Products. (Tr. (Herrington) at 250:12-20; CX-0134C; CDX-10C.26, .28).

Labor or Capital. From April 1, 2023 to September 1, 2023, Apple incurred [REDACTED] on qualifying R&D labor expenditures for the Apple DI Products. (Tr. (Herrington) at 250:21-251:6; CX-0134C; CDX-10C.27, .28). Together with capital (i.e., Apple's plant and equipment

²² The Commission has previously accepted the use of weighted sales-based allocations. For example, in *Certain Marine Sonar Imaging Devices*, the Commission accepted the use of a weighted sales-based allocation that used past sales to account for post-sale investments relating to the domestic industry products. Inv. No. 337-TA-921, Comm'n Op. at 61-62 (Dec. 1, 2015) ("*Marine Sonar Imaging Devices*"). While Complainants use sales to account for pre-sales investments, the Commission's rationale in *Marine Sonar Imaging Devices* is particularly apt. That is, allocating investments solely based on sales of the Apple DI Products in the same quarter would eliminate all investments related to the DI despite evidence that Apple was conducting R&D on the Apple DI Products prior to their launch.

[REDACTED]
[REDACTED]
expenditures)²³, Apple incurred [REDACTED] on qualifying R&D labor or capital expenditures for the Apple DI Products. (*Id.*).

Apple's Investments are Qualitatively Significant. Apple's [REDACTED] in qualifying investments represent the vital research, development, and testing of the Apple DI Products themselves, which are activities that are indisputably the reason that the Apple DI Products practice the Video Coding Patents. (Tr. (Herrington) at 237:10-238:12; JX-0030C (Spevak Dep. Tr.) at 40:2-41:11, 41:13-42:8, 42:17-22, 48:8-19). The investments upon which InterDigital relies include R&D and engineering investments that are necessary to bring the Apple DI Products to market as saleable products and also necessary post-sale activities like ongoing R&D and testing, especially considering that [REDACTED]
[REDACTED] (*Id.*). These investments also relate to employment of hundreds of highly skilled employees and in the U.S. to design, develop, and test the Apple DI Products. (*Id.*). There can be no dispute that without Apple's R&D, there would be no iPhone 15 Pro.

Apple's Investments are Quantitatively Significant. Apple's domestic investments in the Apple DI Products are sizeable in absolute terms and quantitatively significant in comparison to Apple's worldwide spend on iPhone R&D expenses and total worldwide R&D expenses. (Tr. (Herrington) at 252:1-253:7). Apple's domestic investments in R&D plant and equipment, labor, and labor or capital, are [REDACTED] respectively, of Apple's total worldwide iPhone R&D expenses. (Tr. (Herrington) at 252:1-253:7; CDX-0010C.29; CX-0127C; CX-0132C–CX-0136C). Apple's domestic investments in R&D plant and equipment, labor, and labor or capital, are [REDACTED] respectively, of Apple's total worldwide R&D expenses. (Tr.

²³ Apple incurred capital expenditures related to plant and equipment for R&D on the Apple DI Products. See *Certain X-Ray Breast Imaging Devices*, Inv. No. 337-TA-1063, Initial Determination, 269-272 (July 26, 2018) ("*X-Ray Breast Imaging Devices*") (finding a domestic industry under subprong (B), which included plant and equipment expenditures).

[REDACTED]

(Herrington) at 252:1-253:7; CDX-0010C.29; CX-0127C; CX-0132C–CX-0136C; CX-0126.26).

As Mr. Herrington testified, based on his experience in business financial operations and accounting, and considering the size and nature of Apple’s global operations, these figures and levels of investment are significant. (Tr. (Herrington) at 252:1-253:7).

2. Apple’s Post-Complaint Investments (Pre-Amended Complaint)

At minimum, Apple’s was in the process of establishing a domestic industry as of the date of the Original Complaint in this Investigation. That is, InterDigital produced ample evidence that Apple has taken the “the necessary tangible steps to establish such an industry in the United States” and “there is a significant likelihood that the industry requirement will be satisfied in the future.” *Certain Non-Volatile Memory Devices*, Inv. No. 337-TA-1046, Comm’n Op, at 33 (Oct. 26, 2018).

a. Apple’s Necessary Tangible Steps and Satisfaction of the Industry Requirement

The timeline below portrays the key dates that are highly relevant to Apple’s domestic industry that was in the process of being established and the release of the iPhone 15 Pro:



(CDX-0010C.32; *see also* CDX-0010C.18). While Apple’s release of the iPhone 15 Pro occurred after the Complaint was filed (but prior to Institution and the Amended Complaint), the iPhone 15 Pro’s release was a significant and unusual development that warrants consideration of post-filing activities. *See, e.g., Certain Collapsible Sockets for Mobile Electronic Devices*, Inv. No. 337-TA-

[REDACTED]

1056, Comm’n Op. at 15 n.10 (July 9, 2018) (“[I]n appropriate situations based on the specific facts and circumstances of an investigation, the Commission may consider activities and investments beyond the filing of the complaint”). Apple announced the latest model of its flagship iPhone product, the iPhone 15 days after the Complaint was filed in this Investigation—on September 12, 2023—and prior to Institution and InterDigital’s Amended Complaint. (Tr. (Herrington) at 240:5-243:18, 253:20-258:14; CX-2132). Apple provided detailed images of the iPhone 15 Pro and touted the advanced features of its newest model, including the new A17 Pro chipset that includes a dedicated AV1 decoder, enabling more efficient, high-quality video experiences for streaming services. (CX-2132; CDX-0016). Following the announcement, Apple [REDACTED] and taking pre-orders in advance of the release date. (*Id.*). Critically, in just two weeks, Apple generated over [REDACTED] of revenue from its sales of the Apple Video Coding DI products alone. (Tr. (Herrington) at 240:6-241:13; CX-0132C). Respondents argue that the release of an iPhone and Apple silicon is “common,” but this argument is belied by the facts in this Investigation, especially considering that the A17 chipset introduced AV1 decoding in the iPhone—the very technology at issue. (Tr. (Herrington) at 241:24-243:18).

By the date of the Complaint, Apple had already expended significant R&D activity on the iPhone 15 Pro, which is evident given that Apple launched a fully commercialized products within days of the Complaint. Importation records indicate that Apple began importing iPhone 15 Pro models at least as early as [REDACTED] (CX-0124C). Therefore, there is no question that at the time of the Complaint, Apple had designed, developed, and tested an iPhone 15 Pro prototype in the United States. Apple’s corporate representative confirmed that, [REDACTED] [REDACTED] (JX-0030C (Spevak Dep. Tr.) at 41:19-42:8). Moreover, [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

(CX-0130C; CX-0131C; CX-0129C). Apple also submitted the iPhone 15 Pro for FCC authorization on May 4, 2023, including block diagrams, product specifications, manuals, and photographs of the iPhone 15 Pro (CX-1426–CX-1431). In sum, Apple had undertaken significant investments related to the Apple DI Products (Tr. (Herrington) at 240:5-243:18, 253:20-258:14).

b. Apple's Significant Investments

To quantify Apple's investments subsequent to the filing of the Complaint, InterDigital calculated Apple's investments in plant and equipment, labor, and labor or capital from September 15, 2023 (the date pre-orders began for the iPhone 15 Pro) through December 30, 2023. (*Id.* at 258:17-25). Like Apple's pre-complaint investments, Mr. Herrington also employed a reasonable sales-based revenue allocation by quarter to properly allocate Apple's product R&D investments to the Apple DI Products. (*Id.* at 259:1-20). The Apple DI Products comprised [REDACTED] of Apple's total U.S. product revenue from 9/15/23 to 9/30/23 and in Q1FY2024, respectively. (*Id.*; CX-0132C; CX-0133C; CDX-0010C.38).

Plant & Equipment. From September 15, 2023 to December 31, 2023, Apple incurred approximately [REDACTED] on qualifying R&D plant and equipment expenditures for the Apple DI Products. (Tr. (Herrington) at 259:21-260:3; CX-0134C; CX-0135C; CDX-10C.39, .41).

Labor or Capital. From September 15, 2023 to December 31, 2023, Apple incurred [REDACTED] on qualifying R&D labor expenditures for the Apple DI Products. (Tr. (Herrington) at 260:4-13; CX-0134C; CX-0135C; CDX-10C.40, .41). Together with capital (plant and equipment expenditures)²⁴, Apple incurred [REDACTED] on qualifying R&D labor or capital expenditures for the Apple DI Products. (Tr. (Herrington) at 260:4-13; CX-0134C; CX-0135C; CDX-10C.39, .41).

²⁴ See *supra* n. 21.

[REDACTED]

Apple's Investments are Qualitatively Significant. Apple's [REDACTED] in qualifying investments represent the vital research, development, and testing of the Apple DI Products themselves, which are activities that are indisputably the reason that the Apple DI Products practice the Video Coding Patents. (Tr. (Herrington) at 237:10-238:12; JX-0030C (Spevak Dep. Tr.) at 40:2-41:11, 41:13-42:8, 42:17-22, 48:8-19). Apple's investments are qualitatively significant for the same reasons discussed above with respect to Apple's pre-complaint investments.

Apple's Investments are Quantitatively Significant. Apple's domestic investments in the Apple DI Products are sizeable in absolute terms and quantitatively significant in comparison to Apple's worldwide spend on iPhone R&D expenses and worldwide R&D expenses. (Tr. (Herrington) at 261:1-262:2). Apple's domestic investments in R&D plant and equipment, labor, and labor or capital, are [REDACTED] respectively, of Apple's total worldwide iPhone R&D expenses. (Tr. (Herrington) at 261:5-13; CDX-0010C.29; CX-0127C; CX-0132C–CX-0136C). Apple's domestic investments in R&D plant and equipment, labor, and labor or capital, are [REDACTED] respectively, of Apple's total worldwide R&D expenses. (Tr. (Herrington) at 261:14-22; CDX-0010C.29; CX-0127C; CX-0132C–CX-0136C; CX-0126.26). Mr. Herrington testified, based on his experience, and the size and nature of Apple's global operations, these figures and levels of investment are significant. (Tr. (Herrington) at 261:1-262:9).

In sum, given the size of Apple's qualifying investments and that Apple launched a fully commercial product just days after the filing of InterDigital's Original Complaint, which generated over [REDACTED], there is no question that the release of the iPhone 15 Pro was a significant and unusual event and that Apple had taken the necessary tangible steps to establish an industry and in fact satisfied the industry requirement with respect to the iPhone 15 Pro. (Tr. (Herrington) at 262:10-16).

[REDACTED]

[REDACTED]

3. All of Apple's Investments Should be Attributed to the Apple DI Products

Lenovo argues that InterDigital's claimed investments for Apple are "overstated" because Mr. Herrington failed to account for Apple's R&D investments on future, abandoned, and non-revenue generating products ("non-revenue generating products"). (RPre at 142-143). The evidence, however, showed that [REDACTED]

[REDACTED] A sales-based allocation is a reasonable and valid way to allocate Apple's R&D investments in this Investigation, despite Apple's non-revenue generating products. (Tr. (Herrington) at 246:2-248:7; JX-0030C at 105:7-108:1; CX-0136C.3 (line 45); *see also* Order No. 52 at 18). Moreover, Apple's alleged investments in non-revenue generating products are speculative, as the alleged amount stems from public articles and "industry" sources, *not Apple*. [REDACTED]

[REDACTED] it is entirely unclear how any of these public sources estimated Apple's R&D investments in certain individual products. Further, Lenovo did not introduce any evidence establishing that the complained of investments are reliable or accurate. Accordingly, none of these alleged investments should be excluded from the investments that Mr. Herrington attributed to the Apple DI Products. (Tr. (Herrington) at 229:2-230:15).

To the extent that the ALJ determines that Apple's alleged investments in non-revenue generating products should be excluded, Mr. Herrington performed an additional analysis where he excluded Apple's alleged investments in non-revenue generating products. (*Id.* at 230:16-233:20; CX-2364C; CDX-0010C.9, .10). If the alleged investments are excluded, Apple's investments in roughly two quarters still total [REDACTED]

[REDACTED] (*Id.*). Using these adjusted investments, Mr. Herrington ran the same significance comparisons comparing these investments to Apple's worldwide iPhone R&D and

worldwide R&D investments and determined that Apple's investments are still significant. (*Id.*).

C. Vizio's Domestic Industry Investments

Vizio has made significant domestic investments in the employment of labor and capital related to the Vizio DI Products. From January 1, 2021 to September 1, 2023, Vizio incurred over [REDACTED] dollars on qualifying R&D expenditures.

Allocation of Investments. In order to properly allocate Vizio's R&D investments to the Vizio DI Products, Mr. Herrington applied a sales-based revenue allocation by year based roughly on the percentage of sales revenue that Vizio generates from its sales of the Vizio DI Products. To do so, Mr. Herrington divided Vizio's sales revenue for the Vizio DI Products by Vizio's total U.S. sales revenue for years 2021, 2022, and 2023. (Tr. (Herrington) at 267:25-269:16; CX-0093C; CX-0094C; CDX-0010C.50). In total, the Vizio DI Products comprise approximately [REDACTED] of Vizio's total sales revenue for January 1, 2021 through August 31, 2023. (*Id.*).

Plant & Equipment. From January 1, 2021 to September 1, 2023, Vizio incurred [REDACTED] on qualifying R&D plant and equipment expenditures for the Vizio DI Products. (Tr. (Herrington) at 269:13-20; CX-0095C; CDX-0010C.51, .53).

Labor or Capital. From January 1, 2021 to September 1, 2023, Vizio incurred [REDACTED] on qualifying R&D labor expenditures for the Vizio DI Products. (Tr. (Herrington) at 269:21-270:11; CX-0095C; CDX-0010C.52, .53). Together with capital²⁵ (i.e., plant and equipment expenditures), Vizio incurred [REDACTED] on qualifying R&D labor or capital expenditures for the Vizio DI Products. (*Id.*).

Vizio's Investments are Qualitatively Significant. Vizio's [REDACTED] dollar investment in R&D labor or capital represents the vital research, development, and testing necessary to bring

²⁵ Vizio incurred capital expenditures related to plant and equipment for R&D on the Vizio DI Products. *X-Ray Breast Imaging Devices* at 269-272.

[REDACTED]

the Vizio DI Products to market, which are responsible for a substantial portion of Vizio's net revenue. (Tr. (Herrington) at 271:2-272:7; CX-0093C; CX-0094C; CDX-0010C.50). Vizio's T.V.s are U.S. designed and distributed, and to continue its legacy as the only U.S. based TV maker Vizio proclaims that it continues to develop new products and make enhancements to existing products, including through its own R&D activities. (CX-0092; CDX-0010C.46). As of December 2023, [REDACTED]

[REDACTED]. (Tr. (Herrington) at 264:4-265:7 CX-0096C; CX-0097C).

Vizio's Investments are Quantitatively Significant. Vizio's [REDACTED] in R&D labor or capital represents 100% of Vizio's R&D investments in the Vizio DI Products. In other words, it is undisputed that Vizio's in-house R&D activities are entirely within the United States. (Tr. (Herrington) at 264:4-265:7; EDIS Doc. ID 830484, SUMF #s 14-18). Further, Vizio's investments are quantitatively significant in comparison to Vizio's total U.S. labor R&D spend and total U.S. R&D spend. Vizio's investments in labor represent approximately [REDACTED] of Vizio's total U.S. labor R&D expenses and [REDACTED] of Vizio's total U.S. R&D expenses. (Tr. (Herrington) at 271:2-272:7; CX-0088C; CX-0094C; CX-0095C). Whereas Vizio's investments in labor or capital represent [REDACTED] of Vizio's total U.S. R&D expenses. (*Id.*). As Mr. Herrington testified, based on his experience, and considering the size and nature of Vizio's U.S. operations, these figures and levels of investment are significant. (Tr. (Herrington) at 271:2-272:7).

VII. REMEDY

A. Limited Exclusion Order

Section 337 requires that a limited exclusion order (LEO) be issued if a violation of Section 337 is found, unless such relief is determined to be contrary to the public interest. *See* 19 U.S.C. § 1337(d)(1). As public interest issues are not before the ALJ in this Investigation, the ALJ should recommend that the Commission issue an LEO containing the standard, customary language used

[REDACTED]

by the Commission, namely that the relief should be directed against infringing articles “manufactured by or on behalf of” or “imported by or on behalf of” any Respondent found to violate Section 337. *Spansion, Inc. v Int’l Trade Comm’n*, 629 F.3d 1331, 1358 (Fed. Cir. 2010). The exclusion order should also cover components, including software, associated with infringing products within the scope of the investigation. The LEO should apply to infringing products that are manufactured by, or on behalf of, or are imported by or on behalf of Respondents or any of their affiliated companies, parents, subsidiaries, agents, or other related business entities, or their successors or assigns. The inclusion of such related entities is particularly necessary here, where Respondents have a complex international network of parents, subsidiaries, holding companies, and affiliates and segment the steps behind a commercial sale (e.g., manufacturing, importation, distribution, inventory, and sale) across multiple entities.

B. Cease and Desist Order

The Commission has the authority to issue Cease and Desist Orders (CDOs) against Respondents found in violation of Section 337. “Cease and desist orders are generally issued when, with respect to the imported infringing products, respondents maintain commercially significant inventories in the United States or have significant domestic operations that could undercut the remedy provided by an exclusion order.” *Certain Elec. Skin Care Devices*, Inv. No. 337- TA-959, Comm’n Op. at 26 (Feb. 13, 2017). Respondents have stipulated that [REDACTED]

[REDACTED]

[REDACTED]

Dated: September 9, 2024

Respectfully submitted,

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CERTIFICATE OF SERVICE

I HEREBY CERTIFY that on this day, a true and correct copy of the foregoing document was served by the indicated means to the persons at the addresses below:

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Date: September 16, 2024

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COMPLAINANTS' INITIAL
POST-HEARING BRIEF

INV. No. 337-TA-1373

Exhibit 2003
Intel Corporation v. InterDigital, Inc.
IPR2024-01441, U.S. Patent No. 9,674,556
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