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BEFORE THE PATENT TRIAL AND APPEAL BOARD

INTEL CORPORATION,
Petitioner

v.

TELEFONAKTIEBOLAGET LM ERICSSON,
Patent Owner.

IPR2024-01009

U.S. Patent No. 10,142,659

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 10,142,659**

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PETITIONER’S EXHIBIT LIST

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1001	U.S. Patent No. 10,142,659 (“’659 Patent”)
1002	File History of the ’659 Patent
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LISTING OF CHALLENGED CLAIMS

Reference	Claim Limitation
Claim 1	
1[pre]	A method of reducing blocking artifacts at a block boundary between a block of multiple pixels and a neighboring block of multiple pixels in a video frame, said method comprises:
1[a]	calculating a first offset to be equal to $(9 \times (q_0 - p_0) - 3 \times (q_1 - p_1) + 8) \gg 4,$ wherein $\gg$ denotes a right shift operation, p_0 denotes a pixel value of a pixel closest to said block boundary in a line of pixels in said block, wherein said line of pixels is perpendicular to said block boundary, p_1 denotes a pixel value of a pixel next closest to said block boundary in said line of pixels, q_0 denotes a pixel value of a pixel closest to said block boundary in a corresponding line of pixels in said neighboring block, wherein said corresponding line of pixels is perpendicular to said block boundary and q_1 denotes a pixel value of a pixel next closest to said block boundary in said corresponding line of pixels;
1[b]	modifying said pixel value p_0 of said pixel closest to said block boundary in said line of pixels by adding said first offset to said pixel value p_0 of said pixel closest to said block boundary in said line of pixels to form a modified pixel value p_0' of said pixel closest to said block boundary in said line of pixels; and
1[c]	modifying said pixel value q_0 of said pixel closest to said block boundary in said corresponding line of pixels by subtracting said first offset from said pixel value q_0 of said pixel closest to said block boundary in said corresponding line of pixels to form a modified pixel value q_0' of said pixel closest to said block boundary in said corresponding line of pixels.
Claim 2	
2[a]	The method according to claim 1, further comprising clipping said first offset to be within an interval of $-t_c$ and t_c by setting said first offset to be equal to $-t_c$ if said first offset is smaller than $-t_c$ and by setting said first offset to be equal to t_c if said first offset is larger than t_c ,

Reference	Claim Limitation
2[b]	wherein t_c is a threshold value that is dependent on a quantization parameter value assigned to said block.
Claim 3	
3[a]	The method according to claim 1, further comprising: clipping said modified pixel value $p0'$ of said pixel closest to said block boundary in said line of pixels to be within an interval of zero and a defined maximum value by setting said modified pixel value $p0'$ of said pixel closest to said block boundary in said line of pixels to be equal to zero if said modified pixel value $p0'$ of said pixel closest to said block boundary in said line of pixels is smaller than zero and by setting said modified pixel value $p0'$ of said pixel closest to said block boundary in said line of pixels to be equal to said defined maximum value if said modified pixel value $p0'$ of said pixel closest to said block boundary in said line of pixels is larger than said defined maximum value; and
3[b]	clipping said modified pixel value $q0'$ of said pixel closest to said block boundary in said corresponding line of pixels to be within an interval of zero and said defined maximum value by setting said modified pixel value $q0'$ of said pixel closest to said block boundary in said corresponding line of pixels to be equal to zero if said modified pixel value $q0'$ of said pixel closest to said block boundary in said corresponding line of pixels is smaller than zero and by setting said modified pixel value $q0'$ of said pixel closest to said block boundary in said corresponding line of pixels to be equal to said defined maximum if said modified pixel value $q0'$ of said pixel closest to said block boundary in said corresponding line of pixels is larger than said defined maximum value.
Claim 4	
4[a]	The method according to claim 1, further comprising: calculating a second offset to be based on $(p_2 + p_0 - 2 \times p_1 + 2 \times \Delta)/4$, wherein p_2 denotes a pixel value of a pixel second next closest to said block boundary in said line of pixels and Δ denotes said first offset;
4[b]	calculating a third offset to be based on $(q_2 + q_0 - 2 \times q_1 - 2 \times \Delta)/4$, wherein q_2 denotes a pixel value of a pixel second next closest to said block boundary in said corresponding line of pixels;

Reference	Claim Limitation
4[c]	modifying said pixel value p1 of said pixel next closest to said block boundary in said line of pixels by adding said second offset to said pixel value p1 of said pixel next closest to said block boundary in said line of pixels to form a modified pixel value p1' of said pixel next closest to said block boundary in said line of pixels; and
4[d]	modifying said pixel value q1 of said pixel next closest to said block boundary in said corresponding line of pixels by adding said third offset to said pixel value q1 of said pixel next closest to said block boundary in said corresponding line of pixels to form a modified pixel value q1' of said pixel next closest to said block boundary in said corresponding line of pixels.
Claim 5	
5[a]	The method according to claim 4, wherein calculating said second offset comprises calculating said second offset to be equal to $((p2+p0+1)>>1)-p1+\Delta>>1$, wherein >> denotes a right shift operation; and
5[b]	calculating said third offset comprises calculating said third offset to be equal to $((q2+q0+1)>>1)-q1-\Delta>>1$
Claim 6	
6[a]	The method according to claim 4, further comprising: clipping said second offset to be within an interval of $-t_{c2}$ and t_{c2} by setting said second offset to be equal to $-t_{c2}$ if said second offset is smaller than $-t_{c2}$ and by setting said second offset to be equal to t_{c2} if said second offset is larger than t_{c2} ,
6[b]	wherein $-t_{c2}$ is a threshold value that is dependent on a quantization parameter value assigned to said block; and
6[c]	clipping said third offset within an interval of $-t_{c2}$ and t_{c2} by setting said third offset to be equal to $-t_{c2}$ if said third offset is smaller than $-t_{c2}$ and by setting said third offset to be equal to t_{c2} if said third offset is larger than t_{c2} .
Claim 7	
7[a]	The method according to claim 4, further comprising: clipping said modified pixel value p1' of said pixel next closest to said block boundary in said line of pixels to be within an interval of zero and a defined maximum value by setting said modified pixel value p1' of said pixel next closest to said block boundary in said line of pixels to be equal to zero if said

Reference	Claim Limitation
	modified pixel value $p1'$ of said pixel next closest to said block boundary in said line of pixels is smaller than zero and by setting said modified pixel value $p1'$ of said pixel next closest to said block boundary in said line of pixels to be equal to said defined maximum value if said modified pixel value $p1'$ of said pixel next closest to said block boundary in said line of pixels is larger than said defined maximum value; and
7[b]	clipping said modified pixel value $q1'$ of said pixel next closest to said block boundary in said corresponding line of pixels to be within an interval of zero and said defined maximum value by setting said modified pixel value $q1'$ of said pixel next closest to said block boundary in said corresponding line of pixels to be equal to zero if said modified pixel value $q1'$ of said pixel next closest to said block boundary in said corresponding line of pixels is smaller than zero and by setting said modified pixel value $q1'$ of said pixel next closest to said block boundary in said corresponding line of pixels to be equal to said defined maximum if said modified pixel value $q1'$ of said pixel next closest to said block boundary in said corresponding line of pixels is larger than said defined maximum value.
Claim 10	
10[pre]	A user equipment comprising a deblocking filter unit for reducing blocking artifacts at a block boundary between a block of multiple pixels and a neighboring block of multiple pixels in a video frame, wherein the deblocking filter unit comprises:
10[a]	a first offset calculator configured to calculate a first offset to be equal to $(9 \times (q0 - p0) - 3 \times q1 - p1) + 8 \gg 4$, wherein $\gg$ denotes a right shift operation, $p0$ denotes a pixel value of a pixel closest to said block boundary in a line of pixels in said block, wherein said line of pixels is perpendicular to said block boundary, $p1$ denotes a pixel value of a pixel next closest to said block boundary in said line of pixels, $q0$ denotes a pixel value of a pixel closest to said block boundary in a corresponding line of pixels in said neighboring block, wherein said corresponding line of pixels is perpendicular to said block boundary, and $q1$

Reference	Claim Limitation
	denotes a pixel value of a pixel next closest to said block boundary in said corresponding line of pixels; and
10[b]	a pixel value modifier configured to modify said pixel value p_0 of said pixel closest to said block boundary in said line of pixels by adding said first offset to said pixel value p_0 of said pixel closest to said block boundary in said line of pixels to form a modified pixel value p_0' of said pixel closest to said block boundary in said line of pixels
10[c]	and to modify said pixel value q_0 of said pixel value q_0 of said pixel closest to said block boundary in said corresponding line of pixels to form a modified pixel value q_0' of said pixel closest to said block boundary in said corresponding line of pixels.
Claim 11	
11[a]	The user equipment according to claim 10, wherein the deblocking filter unit further comprises a first clipping unit configured to clip said first offset within an interval of $-t_c$ and t_c by setting a first offset to be equal to $-t_c$ if said first offset is smaller than $-t_c$ and by setting a first offset to be equal to t_c if said first offset is larger than t_c ,
11[b]	wherein t_c is a threshold value that is dependent on a quantization parameter value assigned to said block.
Claim 12	
12[a]	The user equipment according to claim 10, wherein the deblocking filter unit further comprises a second clipping unit configured to clip said modified pixel value p_0' of said pixel closest to said block boundary in said line of pixels to be within an interval of zero and a defined maximum value by setting said modified pixel value p_0' of said pixel closest to said block boundary in said line of pixels to be equal to zero if said modified pixel value p_0' of said pixel closest to said block boundary in said line of pixels is smaller than zero and by setting said modified pixel value p_0' of said pixel closest to said block boundary in said line of pixels to be equal to said defined maximum value if said modified pixel value of p_0' of said pixel closest to said block boundary in said line of pixels is larger than said defined maximum value and

Reference	Claim Limitation
12[b]	to clip said modified pixel value q_0' of said pixel closest to said block boundary in said corresponding line of pixels to be within an interval of zero and said defined maximum value by setting said modified pixel value q_0' of said pixel closest to said block boundary in said corresponding line of pixels to be equal to zero if said modified pixel value q_0' of said pixel closest to said block boundary in said corresponding line of pixels is smaller than zero and by setting said modified pixel value q_0' of said pixel closest to said block boundary in said corresponding line of pixels to be equal to said defined maximum if said modified pixel value q_0' of said pixel closest to said block boundary in said corresponding line of pixels is larger than said defined maximum value.

I. INTRODUCTION

When encoding video into digital data, each image is broken into smaller “blocks” that are processed separately for efficiency. After the image is reconstructed from the digital data, however, the image may look “blocky” as an artifact of this block-based encoding. These “blocking artifacts”—which occur at the boundaries between neighboring blocks—have long been reduced using a “deblocking” filter, which first evaluates the pixels near the boundary to determine whether and how much filtering is needed, and, if needed, filters (blurs) the boundary between adjacent blocks to make them look less “blocky.” But it was also known that, sometimes, what looks like a blocking artifact may actually be part of the original image—such as an edge between two objects—that should not be blurred.

The ’659 Patent is directed to a deblocking filter and method of reducing blocking artifacts that uses first, second, and third offset equations with specific coefficients. But such offset equations were well known, where the prior art taught nearly identical equations that preserved true image details and defined the boundaries within which those in the art experimented. Using a trivially different equation for filtering was not inventive.

Intel Corporation (“Intel” or “Petitioner”) petitions for *inter partes* review (“IPR”) of claims 1-7 and 10-12 (“Challenged Claims”) of the ’659 Patent.

II. GROUNDS FOR STANDING

Petitioner certifies that the '659 Patent is available for IPR and Petitioner is not barred or estopped from requesting IPR on the grounds herein.

III. STATEMENT OF PRECISE RELIEF REQUESTED FOR EACH CLAIM CHALLENGED

A. Prior Art

Petitioner respectfully requests review and cancellation under 35 U.S.C. §311 of the Challenged Claims in view of:

Prior Art
Fu (WO 2009/033390), filed August 21, 2008, published March 19, 2009; prior art under §102(b). ¹ (Ex-1021). A certified translation is provided. (Ex-1022).
List (Peter List et al., <i>Adaptive Deblocking Filter</i>), published July 2003; prior art under §102(b), and Applicant Admitted Prior Art (“AAPA”), Ex-1001, 2:14-17. (Ex-1024)
B205 (JCT-VC, Test Model under Consideration), published July 2010; prior art under §102(a), and AAPA, Ex-1001, 2:19-3:36. (Ex-1018)
Bjontegaard (Gisle Bjontegaard et al., Definition of the new coding elements from Telenor, VCEG Document Q15-J-28), published May 9, 2000; prior art under §102(b). (Ex-1009)
Bjontegaard’s Code (Gisle Bjontegaard et al., VCEG Document Q15-J-29), published May 9, 2000; prior art under §102(b). (Ex-1010-1015)
B118 (JVT, Working Draft Number 2, Revision 2), published March 15, 2002; prior art under § 102(b). (Ex-1023)

¹ References are to pre-AIA 35 U.S.C. §§102, 103. Because the ’659 Patent is a transitional patent, even if post-AIA law applies, that changes only which §102 provision each reference qualifies as prior art. *See Platinum Optics Tech. Inc. v. Viavi Sols. Inc.*, IPR2021-00631, Paper 28, 9 n.5 (Oct. 3, 2022).

B. Grounds for Challenge

Ground		Claims	References
1	§103	1-7, 10-12	Fu as evidenced by List, Bjontegaard, B205, B118
2	§103	1-7, 10-12	Bjontegaard as evidenced by Bjontegaard's Code, B118, Fu, List, B205

IV. TECHNOLOGY BACKGROUND

The '659 Patent concerns “deblocking” filters applied during the encoding and/or decoding of digital videos. To store or transmit digital videos, each image making up the video must be “encoded” into binary digital data. Ex-1003, ¶¶40-43; Ex-1001, Fig. 11, 21:43-22:15. For efficient processing, “the original video frames are split into blocks which are processed relatively independently,” Ex-1001, 1:27-29, 21:43-22:15; Ex-1003, ¶41, as the example below shows:



Ex-1070, 4.

When a decoder reconstructs the image from the digital data, the reconstructed image may contain “blocking artifacts” due to its block-based encoding. Ex-1001, 1:12-18. For instance, one encoding step is to “quantize” (compress) each block, which reduces the amount of data that represents the block’s contents by eliminating smaller details. Ex-1003, ¶41. This can produce perceptible changes in pixel color at the block boundaries that make the image look “blocky.” *Id.*, ¶¶44-45.

“Deblocking filters are used...to combat blocking artifacts,” Ex-1001, 1:11-12, by blurring the pixels near the boundaries of adjacent blocks, as shown below:

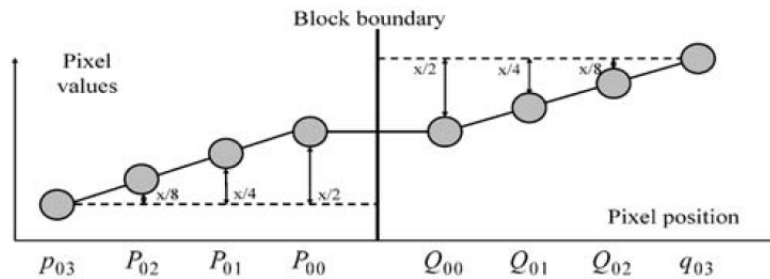
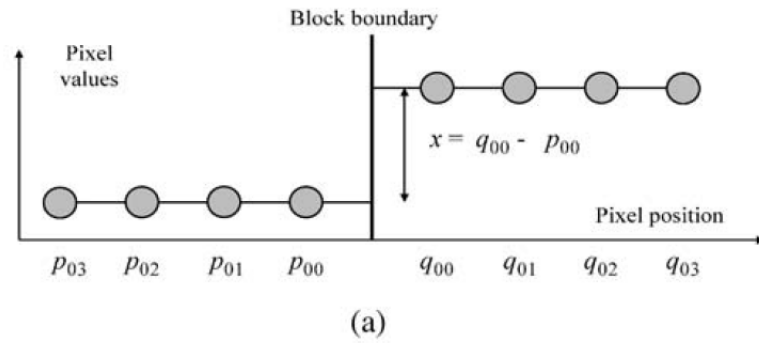


Ex-1052, 1372. Each pixel in an image is assigned a numerical value. Ex-1003, ¶¶46-47. For instance, in black-and-white images, each pixel can have a value of 0-255, with 0 representing black, 255 representing white, and values in between representing different greys. *Id.*, ¶47. For color, each color component (red, green, and blue) can have a value of 0-255, which combined produce millions of colors.

Id., ¶¶48-50. By representing pixel colors as numbers, pixel colors can be changed using “filters” based on mathematical equations.² *Id.*, ¶¶51-53.

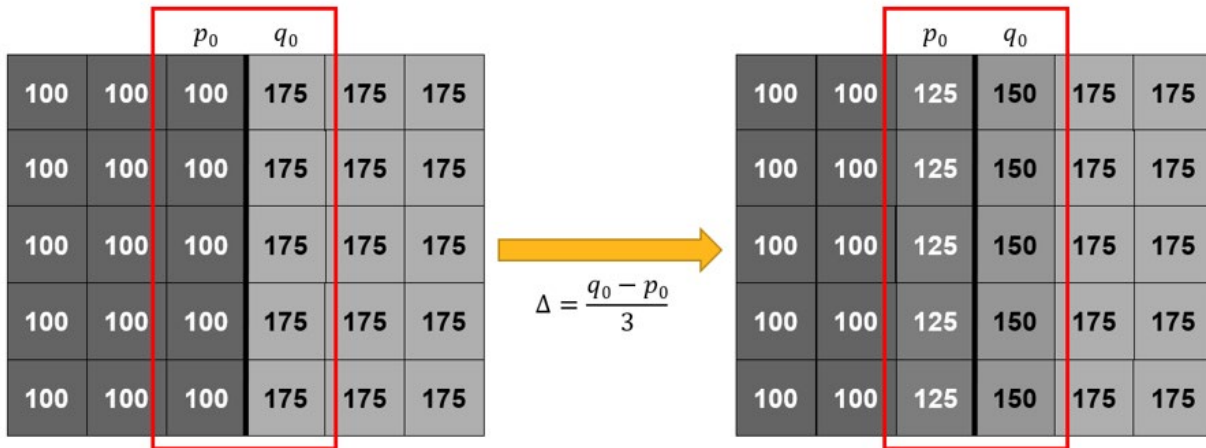
Deblocking filters first decide *whether* to filter a block boundary. *Id.*, ¶65. If a decision to filter is made, some number of pixel values nearest the block boundary are modified using a “filter” equation that typically involves calculating an “offset”—representing how much the pixel values should be changed to blur the blocking artifact—which is then added to the pixel values in one block and subtracted from the pixels in the neighboring block, shown below (offset shown as a function of “x”):

² For example, “low-pass” filters can blur images by reducing color differences in nearby pixel values, and “high-pass” filters can sharpen images by increasing color differences. Ex-1003, ¶¶54-64.



Ex-1039, 215; Ex-1003, ¶53.

For instance, if one (“P”) block has pixel values of “100,” and a neighboring (“Q”) block has pixel values of “175,” that produces a perceptible change at the boundary. To blur this boundary, an offset (Δ) can be calculated using pixel values closest to the boundary (p_0 , q_0), which is then added to the p_0 pixels and subtracted from the q_0 pixels, smoothing the transition from the P to Q block.



Deblocking filters have long been used in the prior art, tending to differ as to:

(1) what conditions control whether deblocking is performed; (2) how many pixels are modified; and (3) the filter/offset equations used (how “weak” or “strong” the filter is). Ex-1003, ¶¶53, 65-94.

V. ’659 PATENT OVERVIEW

Application No. 15/639,229 was filed on June 30, 2017. It claims priority to provisional application No. 61/432,751, filed on January 14, 2011.

A. Specification

The ’659 Patent describes a deblocking filter that incorporates specific offset equations for blurring blocking artifacts. The ’659 Patent begins by describing the deblocking filter proposed for the “High Efficiency Video Coding” (“HEVC” or “H.265”) standard, intended to be the successor to H.264. Ex-1001, 2:19-3:33; Ex-1003, ¶¶98-104. Under the draft HEVC standard, the deblocking filter first decides whether to perform deblocking filtering, and then selects the appropriate strength

(weak or strong) of the filter. H.264. Ex-1001, 2:26-48. For the weak filter, the draft HEVC standard proposed the following offset equation:

$$\Delta = \text{Clip}(-t_c, t_c, (13(q_{0_i} - p_{0_i}) + 4(q_{1_i} - p_{1_i}) - 5(q_{2_i} - p_{2_i}) + 16) \gg 5))$$

Id., 2:26-67. This equation has two parts: (1) an expression (red) to calculate the value of the offset; and (2) a “clipping” function (blue) to ensure the offset stays between a minimum (“- t_c ”) and maximum (“ t_c ”) value. *Id.*; Ex-1003, ¶102.

The offset expression (red) can be written in: (1) “bit-shift” form intended to run on computer hardware, which always outputs an integer, and (2) division form, which is rounded to the closest integer. *Id.* To convert between the two, the “bit shift” (“ $\gg n$ ”) becomes a denominator of 2^n , and the rounding integer ($2^n/2$, or “+16” for the draft HEVC standard) is removed. *Id.*, ¶¶79-84, 102.

Bit-Shift Form	Division Form
$13(q_{0_i} - p_{0_i}) + 4(q_{1_i} - p_{1_i}) - 5(q_{2_i} - p_{2_i}) + 16 \gg 5$	$\frac{13(q_0 - p_0) + 4(q_1 - p_1) - 5(q_2 - p_2)}{32}$

The offset (Δ) is then applied to the “p” and “q” pixels using the following “filter” equations:

$$p_{0_i} = \text{Clip}_{0-255}(p_{0_i} + \Delta)$$

$$q_{0_i} = \text{Clip}_{0-255}(q_{0_i} - \Delta)$$

$$p_{1_i} = \text{Clip}_{0-255}\left(p_{1_i} + \frac{\Delta}{2}\right)$$

$$q_{1_i} = \text{Clip}_{0-255}\left(q_{1_i} - \frac{\Delta}{2}\right)$$

Ex-1001, 2:58-3:3. These equations also include a clipping function to ensure each modified-pixel value stays between 0 and 255 (the valid pixel-value range). Ex-

1003, ¶¶103-04. The draft HEVC standard filtered two pixels in each block, modifying the pixels closest to the boundary (p_0/q_0) by the full offset, and the second-closest pixels (p_1/q_1) by half the offset. *Id.*, ¶¶99-104.

According to the '659 Patent, however, the draft HEVC standard's offset equation is insufficient at "remov[ing] high frequencies" associated with blocking artifacts, and may inadvertently *amplify* higher frequencies when filtering pixels p_1/q_1 . Ex-1001, 3:18-28; Ex-1003, ¶¶105-09. The '659 Patent also criticizes applying an offset ($\Delta/2$) to pixels p_1/q_1 that does not account for "local structures" in each block. Ex-1001, 3:28-33.

Accordingly, the '659 Patent proposes a different offset equation for filtering the p_0/q_0 pixels, which simply: (1) uses four pixels instead of six (by omitting (q_2-p_2)); and (2) changes the coefficients applied to each pixel difference (changing 13 to 9 for (q_0-p_0) and 4 to 3 for (q_1-p_1)):

$$\Delta = \text{Clip}(-t_c, t_c, (9(q_{0_i} - p_{0_i}) + 3(q_{1_i} - p_{1_i}) + 8) \gg 4))$$

Ex-1001, 3:44-4:7; Ex-1003, ¶¶110-16. A comparison between the draft HEVC standard's and '659 Patent's offset expressions is below, with the top shown in bit-shift form, and the bottom shown in division form.

Draft HEVC Standard (<i>Id.</i> , 2:47-48)	'659 Patent (<i>Id.</i> , 17:5-6, 18:30-33)
$(13(q_0-p_0)+4(q_1-p_1)-5(q_2-p_2)+16)>>5$	$(9(q_0-p_0)-3(q_1-p_1)+8)>>4$
$\frac{13(q_0 - p_0) + 4(q_1 - p_1) - 5(q_2 - p_2)}{32}$	$\frac{18(q_0 - p_0) - 6(q_1 - p_1)}{32}$

Ex-1003, ¶¶117-19.

The '659 Patent also proposes that, instead of just using $\Delta/2$ to filter the p_1/q_1 pixels, an additional high-pass filter component $((p_2-2p_1+p_0)/4$ for p_1 , and $(q_2-2q_1+q_0)/4$ for q_1) should be incorporated for additional high-frequency filtering:

$$p_1' = p_1 + \frac{p_2 + p_0 - 2p_1}{4} + \frac{2\Delta}{4} \quad q_1' = q_1 + \frac{q_2 + q_0 - 2q_1}{4} - \frac{2\Delta}{4}$$

Ex-1001, 4:20-38; Ex-1003, ¶¶120-24.

B. Prosecution History

The Examiner issued a single office action, which rejected all original claims for double patenting and unpatentability under §101. Ex-1002, 91-98. No prior-art rejection was made. *Id.* Applicant overcame the rejections, and a notice of allowance issued on July 23, 2018. *Id.*, 133-37; Ex-1003, ¶¶125-30.

VI. LEVEL OF ORDINARY SKILL

A person of ordinary skill in the art (“POSITA”) would have had a bachelor’s degree in electrical engineering, computer science, or a similar field and two to three years of experience in the design and development of relevant multimedia processing, such as video and/or imaging coding or compression. Ex-1003, ¶¶226-

28. Advanced graduate studies with coursework and/or research focusing on topics of video encoding and decoding could substitute for work experience in the field. *Id.*, ¶227.

VII. CLAIM CONSTRUCTION

Petitioner is unaware of any “prior claim construction determination” related to the ’659 Patent. 37 C.F.R. §42.100(b). Nor does Petitioner believe the Challenged Claims need construction to demonstrate their unpatentability. *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017).

In separate proceedings before the ITC, however, the parties dispute the extent that the preamble of claim 10 is limiting. Ericsson contends that the entire preamble is limiting, whereas Respondent Lenovo contends everything but the phrase “user equipment comprising” is limiting. Ex-1026, 7.

Petitioner agrees with Lenovo’s construction, but even if Ericsson’s construction is adopted, the prior art discloses the entire preamble of claim 10. Ex-1003, ¶¶230-35. The parties also agreed that “configured to” should be afforded its plain and ordinary meaning, “programmed to, as opposed to being merely capable of, performing a task.” Ex-1026, 4.

VIII. DETAILED EXPLANATION OF GROUNDS

A. **Ground 1: Obviousness over Fu in view of a POSITA's understanding of the art, as evidenced by List, Bjontegaard, JCTVC-B205, and B118**

1. **Fu**

Fu is an International Patent Application filed on August 21, 2008, and published on March 19, 2009. Fu constitutes prior art under §102(b).

Fu is directed to “the field of image processing, and particularly to a method and device for...reducing block distortion.” Fu, 1:10-15. Fu notes that block distortion is caused by “a quantization error from block processing during quantization,” *id.*, 1:20-33, and proposes a method to reduce that distortion, *id.*, 1:34-38.

Fu teaches that the “flatness” of the region near the block boundary is determined by evaluating pixels on both sides of the boundary. *Id.*, 2:1-12. Depending on the “flatness” and an assessment of the block type being filtered, a “boundary strength” (“BS”) value is determined to control the filter strength (e.g., weak or strong). *Id.*, 4:3-14; Ex-1003, ¶¶131-37. A “BS” value of zero means no deblocking is needed, and a higher “BS” value means a more-significant blocking artifact may exist, and thus stronger filtering is required. Ex-1003, ¶¶137-40.

After selecting the filter strength, pixels on both sides of the block boundary are filtered. Fu, 4:19-28; Ex-1003, ¶¶141-49. An exemplary horizontal line of pixels used by Fu is shown below:

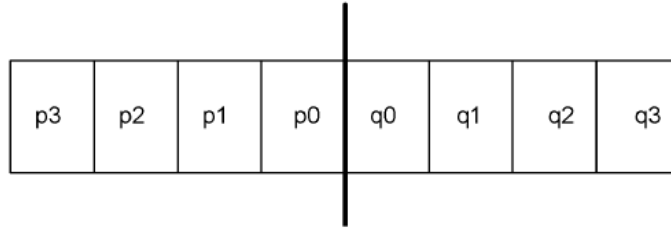


Figure 2

When “BS” equals one, a weaker filter is applied, and Fu teaches that pixels p0/q0 are filtered using the following equations:

$$delta = Clip3 \left(-C, C, \left(((q0 - p0) \times 3 + (p1 - q1) + 4) \gg 3 \right) \right)$$

$$P0 = Clip1(p0 + delta)$$

$$Q0 = Clip1(q0 - delta)$$

where, Clip3 ensures the offset expression stays between cutoffs -C and C, and Clip1 ensures the final pixel value stays between 0 and 255. Fu, 8:3-11.

After q0/p0 are filtered, a determination of whether to filter p1/q1 is made. *Id.*, 8:12-20. If p1 is filtered, its filtered value is defined by:

$$P1 = Clip1 \left(p1 + Clip3 \left(-C, C, \left((P0 - p1) \times 3 + (p2 - Q0) + 4 \right) \gg 3 \right) \right)$$

And if q1 is filtered, its filtered value is defined by:

$$Q1 = Clip1 \left(q1 - Clip3 \left(-C, C, \left((q1 - Q0) \times 3 + (P0 - q2) + 4 \right) \gg 3 \right) \right).$$

Id.

2. List/AAPA

List is an article titled *Adaptive Deblocking Filter*, published by the Institute of Electrical and Electronics Engineers (“IEEE”) in July 2003. List constitutes prior art under §102(b),³ and is Applicant-Admitted Prior Art. Ex-1001, 2:15-17; Ex-1003, ¶¶155-171.

List describes H.264’s deblocking filter. List, 614. List recognizes that coding errors for a pixel block are typically larger near the block boundary than in the middle of the block. *Id.* Like Fu, List recognizes that boundary strength (BS) determines the strength of the filtering performed, if at all, near the block boundary. *Id.* If BS is from 1-3, List acknowledges that a weak filter should be applied to smooth a block boundary, in a situation like that in Figure 2 below.

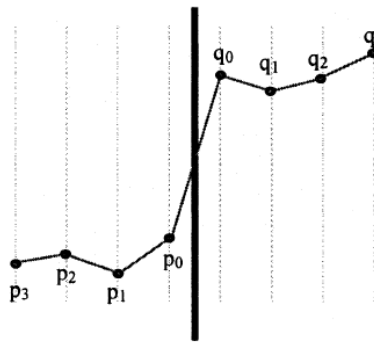


Fig. 2. One-dimensional visualization of a block edge in a typical situation where the filter would be turned on.

³ List was publicly accessible. Ex-1007, ¶¶11-17.

List, 616-17. For edges with a BS value from 1-3, List proposes the below offset equations to calculate p_0' and q_0' :

$$p_0' = p_0 + \Delta_0$$

$$q_0' = q_0 - \Delta_0$$

where Δ_0 is calculated by first computing the offset (Δ_{0i}) using:

$$\Delta_{0i} = (4(q_0 - p_0) + (p_1 - q_1) + 4) \gg 3$$

Id., 617. Next, the offset (Δ_{0i}) is run through a clipping function to ensure it stays within a prescribed range (to prevent over-blurring):

$$\Delta_0 = \text{Min}(\text{Max}(-c_0, \Delta_{0i}), c_0)$$

Id. List then explains that pixels p_1/q_1 may be filtered based on certain conditions, and if they are filtered, the following equations are used to calculate the offset for those pixels:

$$\Delta p_{1i} = (p_2 + ((p_0 + q_0 + 1) \gg 1) - 2p_1) \gg 1$$

$$\Delta q_{1i} = (q_2 + ((p_0 + q_0 + 1) \gg 1) - 2q_1) \gg 1$$

Id.

3. B205/AAPA

B205 is a working draft of the HEVC standard, and was published on October 9, 2010. Ex-1094. B205 constitutes prior art under §102(a),⁴ and is Applicant-Admitted Prior Art. Ex-1001, 2:19-22.

As discussed previously, Section V.A, B205 discloses a deblocking filter that provides the following equations for the weak-deblocking filter:

$$\Delta = \text{Clip}(-t_C, t_C, (13 \times (q0_i - p0_i) + 4 \times (q1_i - p1_i) - 5 \times (q2_i - p2_i) + 16) >> 5)$$

$$p0_i = \text{Clip}_{0-255}(p0_i + \Delta)$$

$$q0_i = \text{Clip}_{0-255}(q0_i - \Delta)$$

$$p1_i = \text{Clip}_{0-255}(p1_i + \Delta/2)$$

$$q1_i = \text{Clip}_{0-255}(q1_i - \Delta/2)$$

Id., 2:58-3:3; Ex-1003, ¶¶179-82.

⁴ B205 was publicly accessible. Ex-1005, ¶¶104-24, and those interested knew where to find it, Ex-1127, 618; Ex-1128, 11; Ex-1129 ¶84; Ex-1130, 3.

4. B118

B118 is a working draft of a Joint Video Team (“JVT”) standard (what became H.264), and was published on March 15, 2002. Ex-1023. B118 constitutes prior art under §102(b).⁵

Like Fu and List, B118 first determines a boundary strength for the block boundary. B118, 47. If weak filtering is used, B118 discloses that p_0/q_0 ⁶ are modified by the following equations, where Clip() denotes a clipping function:

$$\begin{aligned}\Delta &= \text{Clip}(-C, C, ((q_1 - p_1) \ll 2 + (p_2 - q_2) + 4) \gg 3) \\ P_1 &= \text{Clip}(0, 255, (p_1 + \Delta)) \\ Q_1 &= \text{Clip}(0, 255, (q_1 - \Delta))\end{aligned}$$

Id., 48.

B118 also determines whether pixels p_1/q_1 should be filtered, and, if so, filters p_1/q_1 using the following equations:

⁵ B118 was publicly accessible. Ex-1005, ¶¶71-88, and those interested knew where to find it, Ex-1118, 20:2-6; Ex-1119 ¶7; Ex-1120, 2:42-45; Ex-1121 ¶3; Ex-1122 ¶4.

⁶ B118 labels the pixels closest to the block boundary p_1/q_1 instead of p_0/q_0 , as in the ’659 Patent. Apart from the reproduced equations, Petitioner uses the ’659 Patent’s pixel naming convention instead of B118’s naming convention.

$$P_2 = p_2 + \text{Clip}(-C0, C0, (p_3 + P_1 - p_2 \ll 1) \gg 1)$$

$$Q_2 = q_2 + \text{Clip}(-C0, C0, (q_3 + Q_1 - q_2 \ll 1) \gg 1)$$

Id.; Ex-1003, ¶¶183-92.

5. Claim 1

a. 1[pre]

If limiting, Fu discloses or suggests 1[pre]. Ex-1003, ¶¶237-44.

Fu recognizes that “[i]n video coding standards such as H.264...block processing is required for all images....” Fu, 1:16-18. Fu discloses “[a] specific method for reducing block distortion...using an 8x8 block boundary as an example....” *Id.*, 1:34-38. Figure 1 depicts two neighboring blocks with the boundary between them identified by the thick solid line. *Id.*, 2:5-8. As shown in Figures 1, 2, Fu’s block boundary is between a block of multiple pixels and a neighboring block in a video frame. Ex-1003, ¶¶240-41.

		N0	R0	L0	M0		
		N1	R1	L1	M1		
		N2	R2	L2	M2		
		N3	R3	L3	M3		
		N4	R4	L4	M4		
		N5	R5	L5	M5		
		N6	R6	L6	M6		
		N7	R7	L7	M7		

Figure 1

Fu recognizes that, “[a]fter transformation and quantization of each block, block distortion of varying degrees, that is, a discontinuous visual mutation appears on the block boundary between blocks,” where “[b]lock distortion is caused by quantization error from block processing during quantization.” Fu, 1:18-20. To correct this, Fu proposes a multi-step process that includes “filter[ing] the samples on both sides of the luma block boundary.” Fu, 8:3-5.

Specifically, Fu discloses a filter equation to modify pixels p_0/q_0 on each respective side of the block boundary (vertical line below). Fu, 4:19-28 (“Below, the

filtering process of p_0 , p_1 , p_2 , q_0 , q_1 and q_2 in Figure 2 is illustrated with a schematic diagram of the distribution of pixels of a row/column on both sides of the block boundary shown in Figure 2, and the filtered values of p_0 and q_0 are expressed by P_0 and Q_0 , respectively. If $P_1(Q_1)$ is not assigned a value during filtering, $p_1(q_1)$ is not filtered; otherwise, P_1 or Q_1 is the filtered value of p_1 or q_1 . P_2 or Q_2 is the filtered value of p_2 or q_2 ”).

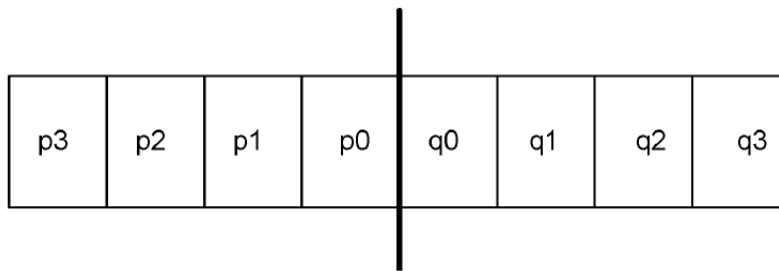


Figure 2

A POSITA would have recognized that “block distortion” indicates the presence of block artifacts, and that employing a deblocking filter corrects these artifacts, as was convention. Ex-1003, ¶¶132-36, 239-40; *e.g.*, List, 614 (“It can be seen that the main coding artifact in the loop-filter case is the blockiness on the 4x4 grid caused by prediction error coding. This artifact can be efficiently compensated by the deblocking filter described in this paper.”); *Samsung Elecs. v. Lynk Labs, Inc.*, IPR2022-00100, Paper 30, 23-24, 34-35 (June 7, 2023) (conventional teachings supported by background references obvious); *I/P Engine, Inc. v. AOL Inc.*, 576 F. App’x 982, 987-88 (Fed. Cir. 2014).

b. 1[a]

Fu in view of a POSITA's understanding of the art discloses or suggests 1[a].
Ex-1003, ¶¶245-92.

Fu discloses a process to reduce block distortion. After calculating the flatness of a region, Fu determines the block-boundary-filter strength ("BS"). Fu, 4:3-18. BS may determine the filtering process used. *Id.*, 4:21-23; *see also* Ex-1003, ¶246; List, 615 ("Bs determines the strength of the filtering performed on the edge.").

Fu teaches that, "[a]fter the BS value is determined, filter the pixels on both sides of the block boundary according to the flatness of different non-zero BS values." Fu, 4:19-20. For a BS of one, Fu discloses applying a deblocking filter to a set of pixels perpendicular to the block boundary (vertical line below). Fu, 4:21-28.

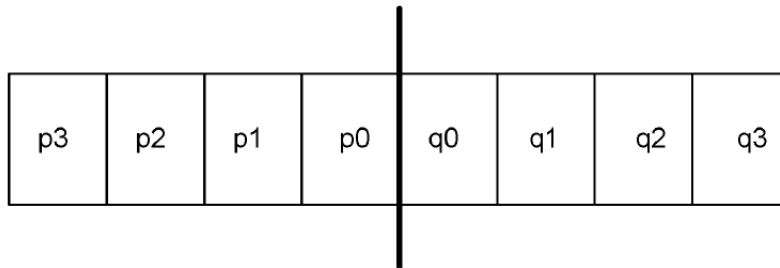


Figure 2

Pixel p0 represents the pixel value of the pixel closest to the block boundary in the "p" block, and q0 represents the pixel value of the pixel value closest to the block boundary in the neighboring "q" block, with each increasing number

representing the pixel's distance from the boundary in each respective block. Ex-1003, ¶¶248-50.

When BS equals one, Fu teaches filtering pixels p_0/q_0 to produce new pixel values P_0/Q_0 , respectively. Specifically, Fu discloses calculating a first offset (“delta”) and then applying that offset to original-pixel values p_0/q_0 according to the following equations:

$$\text{delta} = \text{Clip3}\left(-C, C, ((3 * (q_0 - p_0) + 1 * (p_1 - q_1) + 4) \gg 3)\right)$$

$$P_0 = \text{Clip1}(p_0 + \text{delta})$$

$$Q_0 = \text{Clip1}(q_0 - \text{delta})$$

Fu, 8:3-11; Ex-1003, ¶¶251-53.

A POSITA would have understood that the “right-shift” operation ($\gg n$) is a hardware alternative to division (by 2^n), effectively with a built-in rounding function to always produce an integer. See Section V.A; Ex-1003, ¶254; Fu, 3:5-8 (“wherein $\gg 1$ indicates shifting one place to the right, in the binary computer system, this means division by 2....”); Ex-1001, 2:55 (discussing, in the context of B205 that “ $\gg$ denotes a right shift operator”); B205, §3.4 (“ $x \gg y$ Arithmetic right shift of a two's complement integer representation of x by y binary digits.”). Thus, the *value* of the right-shift operation can be adjusted (i.e., $\gg n+m$) as long as the other coefficients are consistently adjusted (i.e., by multiplying them by 2^m). Ex-

1003, ¶¶79-84, 254. For instance, $2 \gg 1$ (which equals $2/2=1$) is exactly the same as $4 \gg 2$ (which equals $4/4=1$). Ex-1003, ¶¶79-84. Accordingly, Fu's equation can be re-written:

$$\text{delta} = \text{Clip3}(-C, C, ((6 * (q_0 - p_0) + 2 * (p_1 - q_1) + 8) \gg 4))$$

Ex-1003, ¶255.

A POSITA would have recognized that the " $2x(p_1 - q_1)$ " is mathematically the same as " $-2x(q_1 - p_1)$," and can therefore also be re-written (for ease of comparison).

$$\text{delta} = \text{Clip3}(-C, C, ((6 * (q_0 - p_0) - 2 * (q_1 - p_1) + 8) \gg 4))$$

Ex-1003, ¶256.

Fu teaches that its first offset is clipped, where the first offset is within the range of $(-C$ to $C)$. Fu, 8:3-11. A POSITA would have understood that Fu's clipping function constrains the range of the first offset, but does not otherwise alter the first offset if the result is within the clipping range. Ex-1003, ¶¶257-60; *Unwired Planet, LLC v. Google Inc.*, 841 F.3d 995, 1002 (Fed. Cir. 2016) ("[C]ombinations of prior art that sometimes meet the claim elements are sufficient to show obviousness.").

A comparison of Fu's first offset (without the clipping function) and the first offset recited in 1[a] is below.

Reference	First Offset Expression
'659 Patent	$(9(q_0 - p_0) - 3(q_1 - p_1) + 8) \gg 4$
Fu	$(6(q_0 - p_0) - 2(q_1 - p_1) + 8) \gg 4$

The only difference between the first offset in Fu and that of the '659 Patent is the coefficient applied to each set of pixels (colored above). Although the coefficients have different numerical values, they both are a 3:1 ratio, where the $(q_0 - p_0)$ and $(q_1 - p_1)$ terms receive the same respective weight. Ex-1003, ¶¶261-62. The coefficients of the first offset equation in both Fu and the '659 Patent have coefficients that maintain a ratio of 3, which will preserve (i.e., not filter) a ramp signal. Ex-1003, ¶262; Ex-1001, 8:57-60. The '659 Patent provides no indication that the coefficients of its first offset are critical or produce unexpected results compared to those used in prior art expressions. To the contrary, another patent by the same inventors involving the same equations notes that “[d]ifferent such functions...can be used” in the deblocking filter. Ex-1063, 17:1-8, 18:23-24. A POSITA would have recognized that the coefficient applied to each set of pixels is a known result-effective variable that can be optimized through routine experimentation. Ex-1003, ¶263.

A table⁷ of different prior-art offset-filter equations for the two pixels closest to the block boundary (also normalized to a common denominator, 16) is below:

'659 Patent	$\frac{9(q_0 - p_0) - 3(q_1 - p_1)}{16}$
Fu	$\frac{6(q_0 - p_0) - 2(q_1 - p_1)}{16}$
H.264, List	$\frac{8(q_0 - p_0) - 2(q_1 - p_1)}{16}$
B118	$\frac{8(q_0 - p_0) - 2(q_1 - p_1)}{16}$
Bjontegaard	$\frac{8(q_0 - p_0) - 3(q_1 - p_1)}{16}$
VCEG-M21	$\frac{8(q_0 - p_0) - 2.5(q_1 - p_1)}{16}$
Bjontegaard '048	$\frac{8(q_0 - p_0) + 4(q_1 - p_1) - 4(q_2 - p_2)}{16}$
B205	$\frac{7.5(q_0 - p_0) + 2(q_1 - p_1) - 2.5(q_2 - p_2)}{16}$

A POSITA would have understood, consistent with the above prior-art offset-filter equations, that they followed a similar pattern that differed only with respect to: (1) the coefficient applied to each set of pixel differences **X**(q₀-p₀), **Y**(q₁-p₁), **Z**(q₂-p₂); and (2) the number of pixels used to calculate the offset. Ex-1003, ¶¶263-74. It was well-understood that these variables control the filter's frequency response, and how much offset would be applied to pixels p₀/q₀ to blur blocking

⁷ For ease of reference, the first offset equations in the table below are shown in terms of division by 16 instead of right-shifting by 4, with rounding to the closest integer assumed. Ex-1003, ¶272.

artifacts without reducing overall image quality. Ex-1003, ¶¶263-73; Gonzalez, 153, 273.

Because of the prevalence of first-offset equations modifying these two variables, a POSITA would have recognized that they were points of routine experimentation. Ex-1003, ¶263-64. A POSITA would have further understood that several design constraints limited the first-offset filter design. Ex-1003, ¶274.

First, the magnitude of the coefficient applied to $X(q_0 - p_0)$ would generally be two to four times larger than the coefficient applied to $Y(q_1 - p_1)$ and, if included, $Z(q_2 - p_2)$. Ex-1003, ¶275. This ratio controls the “width” of the filter. *Id.*; Gonzalez, 153, 273.

Second, summing the coefficients in the numerator and dividing by the denominator produces a fraction between $\frac{1}{4}$ and $\frac{1}{2}$, meaning the total offset would be approximately $\frac{1}{4}$ to $\frac{1}{2}$ the pixel-value differences across the boundary. Ex-1003, ¶276. This controls how much offset is applied and ensures pixels are not over-filtered (e.g., if p_0 started with a value lower than q_0 , it would not become higher than q_0 after filtering). *Id.*

Third, the “window” used to calculate the offset is conventionally between four (p_1, p_0, q_0 , or q_1) and six ($p_2, p_1, p_0, q_0, q_1, q_2$) pixels. *Id.*, ¶277. The number of pixels used controls the “length” of the filter, but it was known that using more

than six pixels increased computational burden and risks inducing “ringing” artifacts into the filtered image. *Id.*, ¶¶105, 277.

Fourth, the “DC” gain of the offset should equal one, meaning that applying a “flat” signal to the offset equations produces a value of zero. *Id.*, ¶278; Gonzalez, 153-54; Ex-1072, 7. The numerator coefficients must, therefore, sum to zero. Gonzalez, 696, 699. For Fu: $\frac{6(q_0-p_0)-2(q_1-p_1)}{16} = \frac{6q_0-6p_0-2q_1+2p_1}{16}$, thus $6-6-2+2=0$. Ex-1003, ¶¶273, 278. And when the offset is applied to the original pixel value to determine the modified value (e.g., $p_0' = p_0 + \Delta$), summing the coefficients and dividing by the denominator (or alternatively right-shifting) should equal one. For Fu: $p_0' = p_0 + \frac{(6q_0-p_0)-2(q_1-p_1)}{16} = \frac{16p_0}{16} + \frac{6q_0-6p_0-2q_1+2p_1}{16} = \frac{6q_0+10p_0-2q_1+2p_1}{16}$, thus: $\frac{6+10-2+2}{16} = \frac{16}{16} = 1$. Ex-1003, ¶¶272-73, 278; Gonzalez, 153-54. Although not relevant for coefficients applied to pixel differences (since each coefficient applied to the q pixel will be cancelled by its opposite coefficient applied to the p pixel), it is relevant for other offset equations like p_1/q_1 , discussed below. Ex-1003, ¶278.

Fifth, the value of the offset’s right-shift is typically between three and six (i.e., divided by 8, 16, 32, or 64). Ex-1003, ¶279. Using a larger right-shift allows for more precise filters because more integer coefficients are available for the numerator but increases computational complexity. *Id.* Larger numbers use more

bits, which is why three-digit and up coefficients are generally not used (e.g., $128=2^7$, or seven bits). *Id.*

Finally, integer coefficients (not decimals) are used to reduce computational complexity. *Id.*, ¶280; Ex-1001, 12:53-55, 13:11-14.

A POSITA would have experimented within these known constraints to optimize Fu's offset equation. And "where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation." *In re Aller*, 220 F.2d 454, 456 (CCPA 1955); *see also Sony Corp. v. Fujifilm Corp.*, IPR2017-00800, Paper 14, 19-22 (Aug. 18, 2017) (obvious to experiment with three variables according to "Wallace's Law" to design a magnetic recording medium); *Google LLC v. Singular Comput. LLC*, IPR2021-00165, Paper 57, 30-35 (May 11, 2022) (obvious to experiment with the number of "mantissa bits" to balance power consumption and computational precision); *LG Elecs. Inc. v. Immervision, Inc.*, IPR2020-00195, Paper 6, 27-30 (May 13, 2020) (obvious to experiment with various lens-design parameters to achieve a "±10%" divergence of certain wavelengths to balance tradeoffs in image quality).

Here, the decision on which coefficient to apply to each set of pixel differences is nothing more than a design choice as the result of routine experimentation. While changing the coefficients of the offset equation affects

filtering (e.g., if every coefficient is zero, no filtering is performed), the prior art above demonstrates a workable range of coefficients a POSITA would have experimented within. Ex-1003, ¶¶281-88. A POSITA would have been driven to experiment due to competing demands for filtering (e.g., filter quality versus computational complexity; performance of the filter across a range of scenarios). *Id.*, ¶282. But a POSITA would have operated within the design constraints discussed above and would have recognized that a minor difference in filter coefficients would not have produced new or unexpected results.

Here, a POSITA experimenting with Fu's coefficients (6 and 2) would have appreciated that coefficients 9 and 3 simply meant scaling Fu's coefficients by 50%, meaning that the first offset would be expected to perform similarly to Fu for any given signal, but would ultimately apply slightly more filtering (e.g., approximately $\frac{3}{8}$ the difference in pixel values across the boundary, rather than $\frac{1}{4}$ for Fu). *Id.*, ¶¶282-83; *Friskit, Inc. v. Real Networks, Inc.*, 306 F. App'x 610, 615 (Fed. Cir. 2009) (noting "insignificant differences" between prior art and claims not patentable). Moreover, a POSITA would have arrived at the claimed coefficients by applying the known, relevant design considerations: the coefficients maintain a ratio of 3 (between 2-4), have a total weight of approximately $\frac{3}{8}$ (between $\frac{1}{4}$ and $\frac{1}{2}$), use 4-pixel values as inputs, and do not impose any additional gain. Ex-1003, ¶¶283-88.

Such a modification is merely one of degree and would not produce any unexpected results. Ex-1003, ¶¶290-92.

c. 1[b]

Fu in view of a POSITA's understanding of the art discloses or suggests 1[b]. Ex-1003, ¶¶293-98.

Fu teaches or suggests that after the first offset is calculated, it is added to pixel value p_0 to arrive at a modified pixel value p_0' . Ex-1003, ¶¶294-96. Fu discloses the following equation to filter pixel p_0 (where P_0 is p_0'):

$$P_0 = \text{Clip1}(p_0 + \text{delta})$$

Fu, 8:7-11.

As discussed in Section VIII.A.5.b, a POSITA would have understood that the clipping function constrains the range of pixel values but otherwise does not alter the modified pixel value. Ex-1003, ¶¶297-98.

d. 1[c]

Fu in view of a POSITA's understanding of the art discloses or suggests 1[c]. Ex-1003, ¶¶299-304.

Fu teaches or suggests that after the first offset is calculated, it is subtracted from pixel value q_0 to arrive at a modified pixel value q_0' . Ex-1003, ¶¶300-02. Fu discloses the following equation to filter pixel q_0 (where Q_0 is q_0'):

$$Q_0 = \text{Clip1}(q_0 - \text{delta})$$

Fu, 8:7-11.

As discussed in Section VIII.A.5.b, a POSITA would have understood that the clipping function constrains the range of pixel values but otherwise does not alter the modified pixel value. Ex-1003, ¶¶303-04.

6. Claim 2

a. 2[a]

Fu discloses or suggests 2[a]. Ex-1003, ¶¶306-10.

As discussed in Section VIII.A.5, Fu in view of the knowledge of a POSITA, renders claim 1 obvious. Fu further teaches that its first offset is clipped using following equation:

$$\text{delta} = \text{Clip3}(-C, C, ((q_0 - p_0) \times 3 + (p_1 - q_1) + 4) \gg 3))$$

where Clip3 (a, b, c) equals a if c<a, b if c>b, and c if other. Fu, 8:5-11. If the result of $((q_0 - p_0) \times 3 + (p_1 - q_1) + 4) \gg 3$ is less than -C, the first offset is equal to -C. If the result is greater than C, the first offset is equal to C. *Id.*; Ex-1003, ¶¶308-10.

b. 2[b]

Fu discloses or suggests 2[b]. Ex-1003, ¶¶311-19.

The '659 Patent discloses that “ t_c is a threshold value that is dependent on a quantization parameter value assigned to the block.” Ex-1001, 4:1-7. Fu teaches that its first offset equation is clipped, as shown below:

$$\text{delta} = \text{Clip3}(-C, C, ((q0 - p0) \times 3 + (p1 - q1) + 4) \gg 3))$$

where Clip3 (a, b, c) equals a if c<a, b if c>b, and c if other. Fu, 8:5-11. In other words, -C and C are threshold values. Ex-1003, ¶¶313-14. Fu teaches that “C is called the filtering clipping parameter” and has a relationship with IndexA. Fu, 8:21-25. IndexA is derived from the following equation:

$$\text{IndexA} = \text{Clip3}(0, 63, QP_{av} + \text{AlphaCOffset})$$

Id., 5:20. Fu further teaches that “the average QP_{av} may be first calculated based on the quantization parameters (QPs) of the two blocks.” *Id.*, 2:24-30 (“...and then the QP_{av} is used to determine the table lookup index *IndexA*.”). Specifically, “[t]he QP of each block is the data known when the block is quantized, and QP_{av} may be expressed as” the following formula:

$$QP_{av} = (QP_p + QP_q + 1) \gg 1$$

Id., 3:3-5. A POSITA would have understood that Fu’s clipping parameter C is dependent on the quantization parameter of the p block. Ex-1003, ¶¶315-19.

7. Claim 3

a. 3[a]

Fu in view of a POSITA’s understanding of the art discloses or suggests 3[a]. Ex-1003, ¶¶321-26.

As discussed in Section VIII.A.5, Fu in view of the knowledge of a POSITA, renders claim 1 obvious.

Fu teaches clipping the modified pixel value p_0' . Fu's filtered value (modified value) of pixel p_0 , P_0 , is derived from the following equation:

$$P_0 = \text{Clip1}(p_0 + \text{delta})$$

where $\text{Clip1}(a)$ is expressed as $\text{Clip1}(x) = \text{Clip3}(0, 255, x)$. Fu, 8:7-11. Applying Fu's Clip3 function, if $p_0 + \text{delta}$ is less than 0, P_0 is set to 0, and if $p_0 + \text{delta}$ is greater than 255 (maximum value), P_0 is set to 255. *Id.*; Ex-1003, ¶¶323-24.

The '659 Patent similarly discloses that the prior art, specifically B205, teaches that a maximum value of a Clip function can be 255—a common defined maximum value for clipping pixels. Ex-1001, 2:58-3:3; Ex-1003, ¶¶325-26. The '659 Patent also teaches that its purported invention can include clipping modified pixel values to be within an allowed interval, where the maximum value is defined as 255. Ex-1001, 11:64-12:17. A POSITA would have understood that pixels are typically represented as 8-bit values, such that the maximum value is 255. Ex-1003, ¶¶46-48, 325-26.

b. 3[b]

Fu in view of a POSITA's understanding of the art discloses or suggests 3[b]. Ex-1003, ¶¶327-32.

Fu teaches clipping the modified pixel value q_0' . Fu discloses that the filtered value (modified value) of pixel q_0 , Q_0 , is derived from the following equation:

$$Q_0 = \text{Clip1}(q_0 - \text{delta})$$

where Clip1(a) is expressed as $Clip1(x) = Clip3(0, 255, x)$. Fu, 8:7-11. Applying Fu's Clip3 function, if q0-delta is less than 0, Q0 is set to 0 and if q-delta is greater than 255 (maximum value), Q0 is set to 255. Ex-1003, ¶¶329-30. As discussed in VIII.A.7.a, the '659 Patent similarly teaches that it was known in the prior art that the maximum value of the clipping function can be 255. Ex-1003, ¶¶46-48, 331-32.

8. Claim 4

a. 4[a]

Fu in view of a POSITA's understanding of the art discloses or suggests 4[a]. Ex-1003, ¶¶334-69.

As discussed in Section VIII.A.5, Fu in view of the knowledge of a POSITA, renders claim 1 obvious.

Fu further teaches calculating a second offset based on pixels p2, p1, p0, and the first offset. Fu discloses that new pixel p1 is calculated using the following:

$$P1 = Clip1(p1 + Clip3(-C, C, ((P0 - p1) \times 3 + (p2 - Q0) + 4) \gg 3))$$

Fu, 8:15-17. This "second offset" (red box) is added to pixel value p1 (the value of a pixel second next closest to the block boundary) to calculate modified P1. Ex-1003, ¶¶335-40.

Because Fu includes the *modified* version of P0 and Q0 in the second-offset equation, Fu's second offset can be rewritten in division form, replacing P0 with

$p_0 + \text{delta}$ and Q_0 with $q_0 - \text{delta}$ (omitting the clipping functions⁸ for simplicity and assuming rounding):

$$\begin{aligned} & \frac{3(p_0 + \text{delta} - p_1) - 1(q_0 - \text{delta} - p_2)}{8} \\ &= \frac{(p_2 - 3p_1 + 3p_0 - q_0 + 4(\text{delta}))}{8} \\ &= \frac{(p_2 - 3p_1 + 3p_0 - q_0)}{8} + \frac{2(\text{delta})}{4} \end{aligned}$$

Ex-1003, ¶341.

Fu discloses a second offset that is calculated based on consecutive pixel values (e.g., p_2 , p_1 , p_0 , with p_2 being the second closest pixel to the block boundary, shown below), added to the first offset ($2(\text{delta})/4$) used to modify pixel p_0 . Ex-1003, ¶¶340-42.

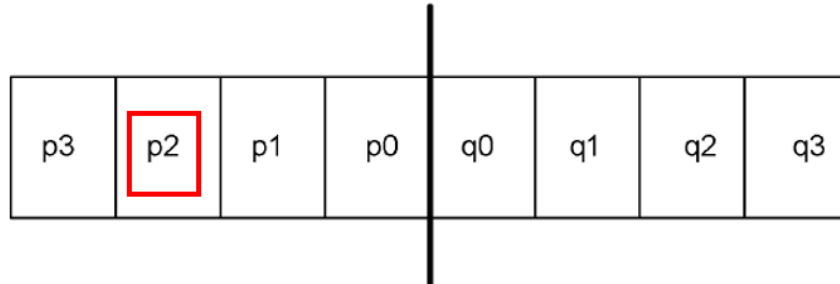


Figure 2

⁸ As discussed in Section VIII.A.5.b, a POSITA would have understood that the clipping function constrains the range of pixel values but otherwise does not alter the modified pixel value. *E.g.*, Ex-1003, ¶330.

A POSITA would have known that Fu combines a high-pass filter component $(\frac{(p2-3p1+3p0-q0)}{8})$ with a first-offset component $(\frac{2(delta)}{4})$, like the equation in 4[a]. Ex-1003, ¶342. And besides the rounding attributable to Fu’s bit-shift form (not present in 4[a]’s division form),⁹ the only differences between Fu’s second-offset equation and that of 4[a] is: (1) the exact high-pass filter used (blue); and (2) the coefficient applied to that component (red).

Fu’s Equation	Claimed Equation
$\Delta = \frac{1(p2 - 3p1 + 3p0 - q0)}{8} + \frac{2\Delta}{4}$	$\Delta = \frac{1(p2 - 2p1 + p0)}{4} + \frac{2\Delta}{4}$

Ex-1003, ¶¶343-44. However, a POSITA also would have known that each of these differences are known result-effective variables that control the frequency response of the filter, and how much pixel p1 is filtered to achieve a desired balance between reducing blocking artifacts without sacrificing overall image quality. Ex-1003, ¶345.

⁹ A POSITA would have understood that rounding and truncation are the only two options when limiting the results of a division operation to a finite bit field. The rounding term used in the right shift form of the first offset equation would be dropped when stated in division form. Ex-1003, ¶343.

A POSITA would have understood that the exact high-pass filter component used, and the coefficients that component is assigned are two variables subject to routine experimentation and optimization because others in the art had similarly combined these two components and used different high-pass filter components and applied different coefficients. *Id.*

For instance, B118 discloses a second-offset equation ($p_2 + p_0 - p_1 \ll 1 \gg 1$), B118, 48, which can be rewritten (omitting clipping) as:

$$\frac{1(p_2 - 2p_1 + p_0)}{2} + \frac{2\Delta}{4}$$

Id.; Ex-1003, ¶¶346-352. Bjontegaard (discussed in Section VIII.B below) similarly discloses a second-offset equation ($\text{Diff} = b - 2c + d$), Bjontegaard, 20; Section VIII.B.5.a, which a POSITA would understand uses an already-modified version of pixel “d,” Ex-1003, ¶¶354-56, and can be re-written as:

$$\frac{5(p_2 - 2p_1 + p_0)}{16} + \frac{5\Delta}{16}$$

Ex-1003, ¶¶353-58. Thus, the prior art demonstrated that POSITAs were experimenting with different high-pass filter components and the coefficient assigned to that component to achieve a second-offset equation that produced a desired amount of filtering of pixel p_1 . Ex-1003, ¶¶359-64.

Although a POSITA would have been found it obvious to replace Fu’s four-pixel (“four-tap”) high-pass filter component with a prior-art three-pixel (“three-

tap”) high-pass filter component through routine experimentation, a POSITA would have been expressly motivated to make that modification because a three-tap equation is more computationally efficient than a four-tap equation. Ex-1003, ¶364. The three-tap equation ($p_2-2p_1+p_0$) used by B118 and Bjontegaard was regarded as among the simplest and most-efficient equations to characterize high frequencies. Ex-1003, ¶365. Moreover, a POSITA would have known that replacing Fu’s four-tap equation with that three-tap equation would work, because B118 and Bjontegaard had already done so in the same context as Fu. *Id.*

For the coefficient applied to the high-pass filter component, a POSITA would have found applying a coefficient of $\frac{1}{4}$ obvious for several reasons. First, as the ’659 Patent recognizes, the coefficient assigned to this component is merely a design choice that controls how much additional low-pass filtering is applied to pixel p_1 . Ex-1001, 15:42-45 (disclosing $\frac{(p_2-2p_1+p_0)}{2} + \frac{\Delta}{2}$ (like B118) *or* $\frac{(p_2-2p_1+p_0)}{4} + \frac{\Delta}{2}$, depending on desired amount of filtering); Ex-1003, ¶366. But a POSITA would have also known that, when replacing Fu’s four-tap filter of $(p_2-3p_1+3p_0-q_0)$ with a simpler three-tap filter of $(p_2-2p_1+p_0)$, consistent with B118 and Bjontegaard, the three-tap filter would *need* to have a coefficient of $\frac{1}{4}$ applied to produce similar offsets as Fu. Ex-1003, ¶367. Thus, a POSITA looking to simplify Fu’s second-offset equation to make it more efficient—but maintain approximately the same

amount of filtering—would have found the equation of $4[a] \left(\frac{(p_2 - 2p_1 + p_0)}{4} + \frac{\Delta}{2} \right)$ or $\frac{(p_2 - 2p_1 + p_0) + 2\Delta}{4}$ obvious. Ex-1003, ¶¶368-69.

b. 4[b]

Fu in view of a POSITA's understanding of the art discloses or suggests 4[b].
Ex-1003, ¶¶370-83.

Fu teaches calculating a third offset based on pixels q_2 , q_1 , q_0 , and the first offset. Fu discloses that “when a_q is greater than 0 at the luma block boundary, filter q_1 , and the filtered value is as follows:”

$$Q_1 = \text{Clip1}(q_1 - \text{Clip3}(-C, C, ((q_1 - Q_0) \times 3 + (P_0 - q_2) + 4) \gg 3))$$

Fu, 8:18-20. This “third-offset” (red box) is subtracted from pixel value q_1 (the value of a pixel second next closest to the block boundary) to calculate q_1' . Ex-1003, ¶¶371-75.

Because Fu includes the *modified* version of P_0 and Q_0 in the third-offset equation, Fu's third offset can be rewritten in division form, replacing P_0 with

$p_0 + \text{delta}$ and Q_0 with $q_0 - \text{delta}$ (omitting the clipping functions¹⁰ for simplicity and assuming rounding):

$$\begin{aligned} & \frac{3(q_1 - q_0 + \text{delta}) - 1(q_2 - p_0 - \text{delta})}{8} \\ &= \frac{(p_0 - 3q_0 + 3q_1 - q_2 + 4(\text{delta}))}{8} \\ &= \frac{(p_0 - 3q_0 + 3q_1 - q_2)}{8} + \frac{2(\text{delta})}{4} \end{aligned}$$

Ex-1003, ¶377. Fu discloses a third offset that is calculated based on consecutive pixel values (q_2, q_1, q_0 , with q_2 being the second closest pixel to the block boundary in the neighboring block, shown below), added to the first offset ($2(\text{delta})/4$) used to modify pixel q_0 . Ex-1003, ¶¶376-78.

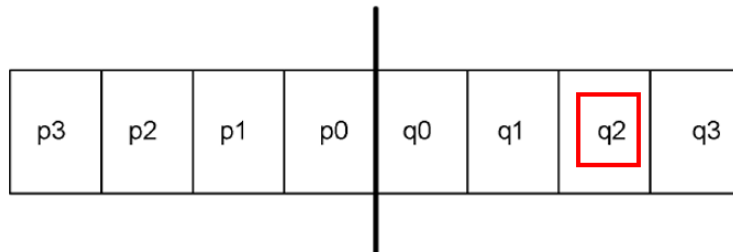


Figure 2

¹⁰ As discussed in Section VIII.A.5.b, a POSITA would have understood that the clipping function constrains the range of pixel values but otherwise does not alter the modified pixel value. *E.g.*, Ex-1003, ¶330.

Fu's third-offset equation differs from the third offset equation recited in 4[b] in the same two ways as Fu's second offset equation.¹¹

Fu's Equation	Claimed Equation
$\Delta = \frac{1(p0 - 3q0 + 3q1 - q2)}{8} + \frac{2\Delta}{4}$	$\Delta = \frac{1(q2 - 2q1 + q0)}{4} - \frac{2\Delta}{4}$

But B118 and Bjontegaard taught third-offset equations modifying: (1) which high-pass filter component was used in the third-offset equation; and (2) the coefficient applied to that component. *See* B118, 48 ($\Delta = \frac{1(q2-2q1+q0)}{4} + \frac{2\Delta}{4}$); Bjontegaard, 20 ($\Delta = \frac{5(q2-2p1+q0)}{16} + \frac{5\Delta}{16}$); Ex-1003, ¶¶381-82. But for the same reasons as p1, Section VIII.A.8.a, a POSITA would have found it obvious to modify Fu's third-offset equation to use: (1) a three-tap, high-pass filter component of $q2-2q1+q0$, like B118 and Bjontegaard; and (2) to apply a weight of ¼ to that component, not only because these were two known result-effective variables, but the modification would

¹¹ Fu adds the first offset because its third offset is subsequently subtracted from pixel q1 (versus added as recited in element 4[d]). A POSITA would have understood that Fu's equation can be re-written in its negative form, which is mathematically equivalent and produces the same modified value of q1. Ex-1003, ¶¶379-80.

have produced a more-efficient third-offset equation that provided similar filtering properties as Fu. Ex-1003, ¶¶382-83.

c. 4[c]

Fu in view of a POSITA's understanding of the art discloses or suggests 4[c]. Ex-1003, ¶¶384-89.

Fu teaches or suggests that after the second offset is calculated (red box; element 4[a]), it is added to pixel value p1 (where p1 is the next closest pixel to the block boundary, *see* Fu, Fig. 2) to arrive at a modified pixel value P1 (i.e., p1') using the following equation:

$$P1 = \text{Clip1}(p1 + \text{Clip3}(-C, C, ((P0 - p1) \times 3 + (p2 - Q0) + 4) \gg 3))$$

Fu, 8:15-17.

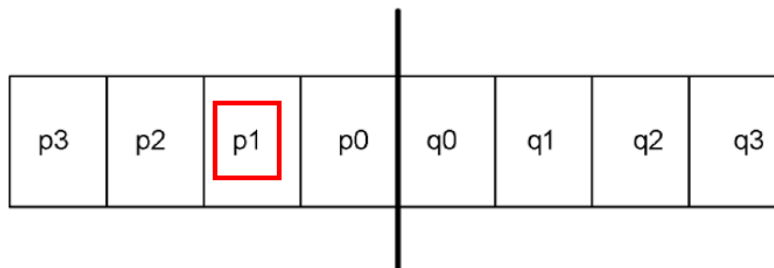


Figure 2

As discussed in Section VIII.A.5.b, a POSITA would have understood that the clipping function constrains the range of pixel values but otherwise does not alter the modified pixel value. Ex-1003, ¶¶387-89.

d. 4[d]

Fu in view of a POSITA's understanding of the art discloses or suggests 4[d].
Ex-1003, ¶¶390-95.

Fu teaches or suggests that after the third offset is calculated (red box; element 4[b]), it is subtracted from pixel value q1 (where pixel q1 is the next closest pixel to the block boundary, *see* Fig. 2) to arrive at a modified pixel value Q1 (i.e., q1') using the following equation. Ex-1003, ¶¶391-92.

$$Q1 = Clip1(q1 - Clip3(-C, C, ((q1 - Q0) \times 3 + (P0 - q2) + 4) \gg 3))$$

Fu, 8:18-20.

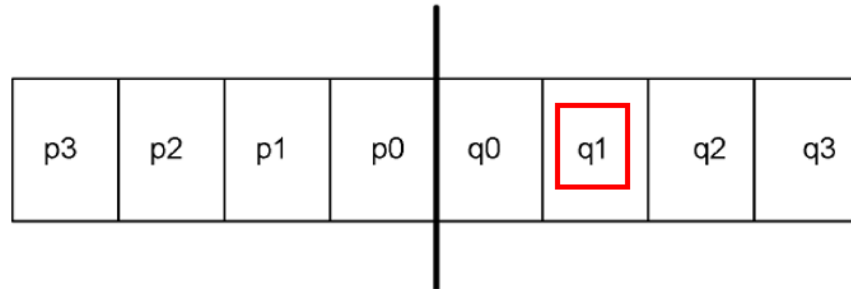


Figure 2

Although Fu subtracted the third offset, this is the mathematical equivalent of adding its negative, which simply depends on how the equation is written but does not change the result. Ex-1003, ¶391.

As discussed in Section VIII.A.5.b, a POSITA would have understood that the clipping function constrains the range of pixel values but otherwise does not alter the modified pixel value. Ex-1003, ¶¶393-95.

9. Claim 5

a. 5[a]

Fu in view of a POSITA's understanding of the art discloses or suggests 5[a]. Ex-1003, ¶¶397-406.

As discussed in Section VIII.A.8, Fu in view of the knowledge of a POSITA, renders claim 4 obvious.

The second offset equation in 5[a] uses right shifts instead of division in 4[a]. A mathematical equivalent to the second offset equation in 4[a] is below, where the entire expression is divided by 2:

$$= \left[\left(\frac{1}{2}p_2 + \frac{1}{2}p_0 - p_1 + \Delta \right) \right] / 2$$

Ex-1003, ¶¶399-400. If the $\frac{1}{2}$ terms are combined, that results in the following expression:

$$= \left[\left(\frac{1}{2}(p_2 + p_0) - p_1 + \Delta \right) \right] / 2$$

Ex-1003, ¶401. If right shifts are substituted for the divisions, that results in:

$$= \left(((p_2 + p_0) \gg 1) - p_1 + \Delta \right) \gg 1$$

A POSITA would have understood that a right shift operation truncates the value of the result obtained after the division function to an integer, even if a decimal would be the true result of a division by 2. Ex-1003, ¶403. As a design choice, to reduce the resulting inaccuracies, a POSITA would have recognized that a rounding value could be added prior to the right shift operation, which is half of the value of the denominator (e.g., if you have a right shift of 2, the rounding value would be +2). Ex-1003, ¶¶403-05. A POSITA would have found it obvious to round an integer to the nearest integer or truncate. To compensate for the inaccuracies introduced by the right shift operation for the $(p2 + p0) \gg 1$ output, a rounding value of 1 is added, resulting in:

$$= ((p2 + p0 + 1) \gg 1) - p1 + \Delta \gg 1$$

Ex-1003, ¶404. Applying the mathematical equivalents above to the second offset equation of 4[a], a POSITA would arrive at the second offset equation of 5[a]. See Section VIII.A.8.a.

b. 5[b]

Fu in view of a POSITA's understanding of the art discloses or suggests 5[b]. Ex-1003, ¶¶407-15.

The third offset equation in 5[b] uses right shifts instead of division in 4[b]. A mathematical equivalent to the third offset equation in 4[b] is below, where the entire expression is divided by 2:

$$= \left[\left(\frac{1}{2} q_2 + \frac{1}{2} q_0 - q_1 - \Delta \right) \right] / 2$$

Ex-1003, ¶¶408-09. If the $\frac{1}{2}$ terms are combined, that results in the following expression:

$$= \left[\left(\frac{1}{2} (q_2 + q_0) - q_1 - \Delta \right) \right] / 2$$

Ex-1003, ¶410. If right shifts are substituted for the divisions, that results in:

$$= \left(((q_2 + q_0) \gg 1) - q_1 - \Delta \right) \gg 1$$

A POSITA would have understood that a right shift operation truncates the value of the result obtained after the division function to an integer, even if a decimal would be the true result of a division by 2. Ex-1003, ¶412. As a design choice, to reduce the resulting inaccuracies, a POSITA would have recognized that a rounding value could be added, which is half of the value of the denominator (i.e., if you have a right shift of 2, the rounding value would be +2). Ex-1003, ¶¶412-14. Here, a rounding value of 1 is added to $q_2 + q_0$ to compensate for the inaccuracies introduced by the right shift operation, which would result in:

$$= \left(((q_2 + q_0 + 1) \gg 1) - q_1 - \Delta \right) \gg 1$$

Ex-1003, ¶413. Applying the mathematical equivalents above to the third offset equation of 4[b], a POSITA would arrive at the third offset equation of 5[b]. *See* Section VIII.A.8.b.

10. Claim 6

a. 6[a]

Fu discloses or suggests 6[a]. Ex-1003, ¶¶417-21.

As discussed in Section VIII.A.8, Fu in view of the knowledge of a POSITA, renders claim 4 obvious. Fu further teaches that its second offset is clipped within an interval of -C and C, shown in the following equation:

$$P1 = Clip1(p1 + Clip3(-C, C, ((P0 - p1) \times 3 + (p2 - Q0) + 4) \gg 3))$$

Fu, 8:15-17; *see also* Section VIII.A.6.a (explaining Fu's Clip3 operation).

b. 6[b]

Fu discloses or suggests 6[b] for the same reasons as 2[b]. Section VIII.A.6.b; Ex-1003, ¶¶422-23. Fu discloses that the second offset equation is clipped between threshold values -C and C, which are dependent on the quantization parameter of the p-block.

c. 6[c]

Fu discloses or suggests 6[c]. Ex-1003, ¶¶424-48.

Fu teaches that its third offset is clipped within an interval of -C and C, as illustrated in the following equation:

$$Q1 = Clip1(q1 - Clip3(-C, C, ((q1 - Q0) \times 3 + (P0 - q2) + 4) \gg 3))$$

Fu, 8:18-20; *see also* Section VIII.A.6.a (explaining Fu's Clip3 operation).

11. Claim 7

a. 7[a]

Fu discloses or suggests 7[a]. Ex-1003, ¶¶430-35.

As discussed in Section VIII.A.8, Fu in view of the knowledge of a POSITA, renders claim 4 obvious. Fu further teaches clipping the modified pixel value $p1'$. Specifically, Fu discloses that the filtered value (or modified value) of pixel $p1$, $P1$, is derived from the following equation:

$$P1 = \text{Clip1}(p1 + \text{Clip3}(-C, C, ((P0 - p1) \times 3 + (p2 - Q0) + 4) \gg 3))$$

Fu, 8:15-17; *see also* Section VIII.A.7.a (explaining Fu's Clip1 operation). Fu teaches that pixel $p1$ is the next closest pixel to the block boundary. Fu, Fig. 2 (below).

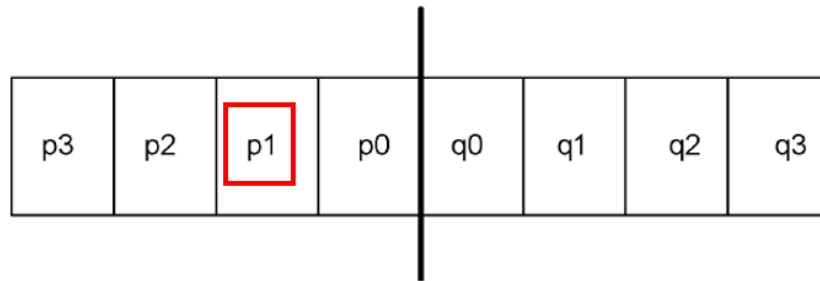


Figure 2

b. 7[b]

Fu discloses or suggests 7[b]. Ex-1003, ¶¶436-41.

Fu teaches clipping the modified pixel value $q1'$, $Q1$, using the following equation:

$$Q1 = \text{Clip1}(q1 - \text{Clip3}(-C, C, ((q1 - Q0) \times 3 + (P0 - q2) + 4) \gg 3))$$

Fu, 8:18-20. *see also* Section VIII.A.7.a (explaining Fu’s Clip1 operation). Fu teaches that pixel q1 is the next closest pixel to the block boundary. Fu, Fig. 2 (below).

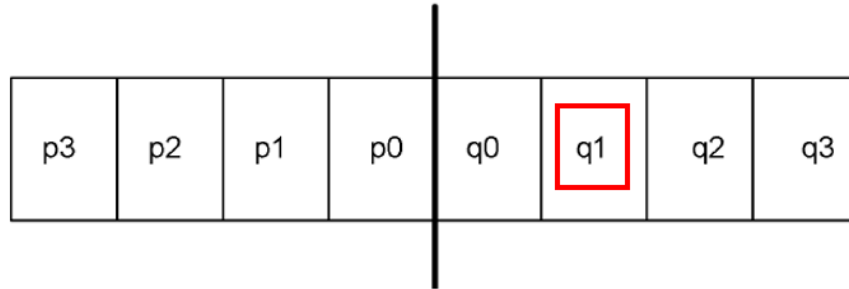


Figure 2

12. Claim 10

a. 10[pre]

As discussed in Section VII, Ericsson argues that 10[pre] is limiting in its entirety, while Lenovo argues that everything but “user equipment comprising” is limiting. Ex-1026, 7. Fu, in view of the knowledge of a POSITA, discloses or suggests 10[pre] under either construction. Ex-1003, ¶¶442-53.

Fu discloses “a device for reducing block distortion that is capable of improving the accuracy of the acquired block boundary filtering strength, thereby effectively reducing blocking distortion.” Fu, 10:21-25; *see also id.*, 11:28-38, 12:3-10. As shown in Figure 1, Fu’s device is used to reduce blocking artifacts, referred

to as blocking distortion (Ex-1003, ¶¶443-45), between neighboring blocks of multiple pixels.

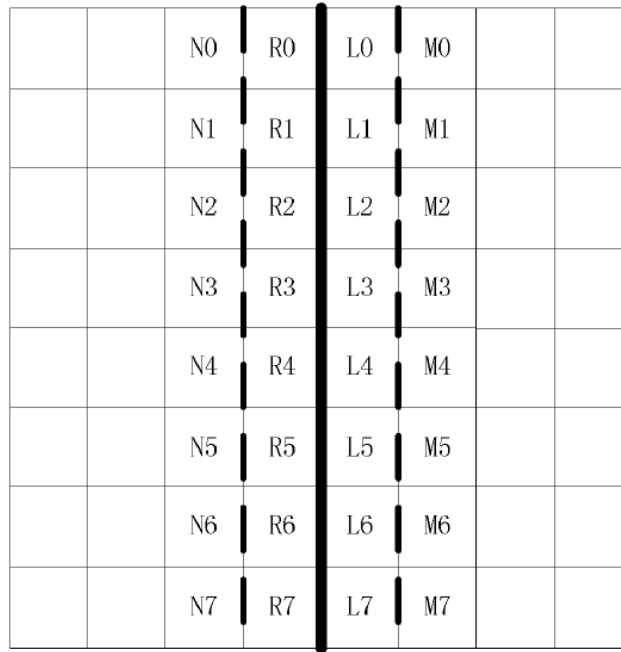


Figure 1

The device employs Fu's method of reducing blocking artifacts, discussed in Section VIII.A.5 above.

An example schematic diagram of the device for reducing blocking distortion (reducing blocking artifacts) disclosed in Fu is below. Fu, 18:32-35.

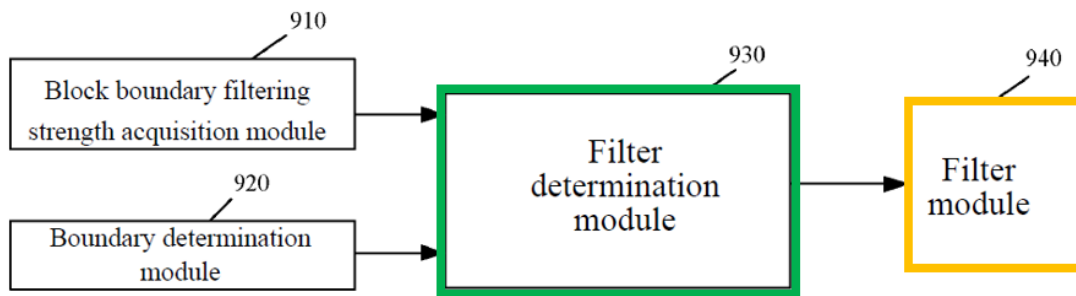


Figure 9

After Fu’s exemplary device acquires a block boundary filtering strength, Fu’s filter determination module 930 (green) “determines the corresponding filter combination.” Fu, 19:1-10. Fu’s filter module 940 (orange) then “filters the pixels of the blocks on both sides of the block boundary in the windows by using the filter combination determined by the filter determination module” using Fu’s method described in Section VIII.A.5 above. *Id.*, 19:11-12. The recited “offset calculator,” “pixel value modifier,” and “clipping unit[s]” of claim 10 and its dependents would reside in Fu’s filter module 940. Ex-1003. ¶¶447-49.

The ’659 Patent describes that offset calculators, clipping units, and pixel value modifiers can be implemented as “special purpose circuits, such as ASICs (Application Specific Integrated Circuits)” or “as computer program modules running on a general purpose processor.” Ex-1001, 20:50-59, 21:37-42 (stating the deblocking filter unit of a video decoder “can be implemented preferably in hardware but also in software”).

Fu teaches that its method “may be completed through a program instructing the relevant hardware, and the program may be stored in a type of computer-readable storage medium” such that “[w]hen the program is executed, it comprises one or a combination of the steps of the method” described in Section VIII.A.5 above. Fu, 19:13-16; Ex-1003, ¶¶450-51. Each module in Figure 9, above, can also “be integrated in a processing module” of user equipment and “may be implemented in the form of hardware or software functional modules.” Fu, 19:17-20. A POSITA would have understood that these components would have been included in user equipment. Ex-1003, ¶452. “If the integrated module is implemented in the form of a software functional module and sold or used as a stand-alone product, it may be stored in a computer-readable storage medium” such as “read-only memory, magnetic disk, optical disc, or the like.” Fu, 19:20-23.

Fu discloses that its method can be implemented in the form of a software functional module. A POSITA would have understood that Fu’s software functional module can be implemented on a user device, such as a cellular phone, which has a computer-readable storage medium. Implementing Fu’s software on a user device, versus a separate standalone component, would consolidate the number of components required for a media player on a user device and provide a simpler solution. Ex-1003, ¶453. A POSITA would have recognized that Fu’s exemplary

device is a deblocking filter of a user device. *Id.*; *see also* List, 614 (describing an adaptive deblocking loop filter); B205, §6 (describing the deblocking filter process).

b. 10[a]

Fu discloses or suggests 10[a] for the same reasons as 1[a]. Section VIII.A.5.b; Ex-1003, ¶454. As discussed in 10[pre], 10[a] is the apparatus equivalent of 1[a].

c. 10[b]

Fu discloses or suggests 10[b] for the same reasons as 1[b]. Section VIII.A.5.c; Ex-1003, ¶455. As discussed in 10[pre], 10[b] is the apparatus equivalent of 1[b].

d. 10[c]

Fu discloses or suggests 10[c] for the same reasons as 1[c]. Section VIII.A.5.d; Ex-1003, ¶456. As discussed in 10[pre], 10[c] is the apparatus equivalent of 1[c].

13. Claim 11

a. 11[a]

Fu discloses or suggests 11[a] for the same reasons as 2[a]. Section VIII.A.6.a; Ex-1003, ¶458. As discussed in 10[pre], 11[a] is the apparatus equivalent of 2[a].

b. 11[b]

Fu discloses or suggests 11[b] for the same reasons as 2[b]. Section VIII.A.6.b; Ex-1003, ¶459. As discussed in 10[pre], 11[b] is the apparatus equivalent of 2[b].

14. Claim 12

a. 12[a]

Fu discloses or suggests 12[a] for the same reasons as 3[a]. Section VIII.A.7.a; Ex-1003, ¶461. As discussed in 10[pre], 12[a] is the apparatus equivalent of 3[a].

b. 12[b]

Fu discloses or suggests 12[b] for the same reasons as 3[b]. Section VIII.A.7.b; Ex-1003, ¶462. As discussed in 10[pre], 12[b] is the apparatus equivalent of 3[b].

B. Ground 2: Obviousness over Bjontegaard in view of Bjontegaard's Code and a POSITA's understanding of the art, as evidenced by List, Fu, JCTVC-B205, and B118

1. Bjontegaard

Bjontegaard is a proposal submitted as part of the ITU Video Coding Experts Group (Question 15), Study Group 16. Bjontegaard was published on May 9, 2000, and constitutes prior art under §102(b).¹²

Bjontegaard discloses a “coding model” as part of what became H.264 (H.26L), Bjontegaard, 1, 4; Ex-1003, ¶¶193-98, which includes a “deblocking filter

¹² Bjontegaard was publicly accessible. Ex-1005, ¶¶51-70, and those interested knew where to find it Ex-1113, 8; Ex-1114, 4; Ex-1115 ¶2; Ex-1116 ¶6.

process.” Bjontegaard, 18. Bjontegaard describes the deblocking filter using pixels a-h, spanning two blocks:



Id., 19; Ex-1003, ¶¶199-200.

Bjontegaard performs a series of calculations used to decide how many pixels to filter in each block before calculating an initial value of the “activity” (“Act”) for each block, beginning with block 1 (Act₁) and continuing with block 2 (Act₂). Act₁ and Act₂ take on a value of 1 to 3, where a higher value means more filtering can be performed. Bjontegaard, 19; Ex-1003, ¶¶201-04.

Act₁ and Act₂ are then compared to a measure of overall activity across blocks 1 and 2 to calculate Act_{overall}, which can take a value of 0 to 3. Bjontegaard, 19; Ex-1003, ¶202-04. Whichever value of Act_{overall} compared to Act₁ or Act₂ is lower is used as the final activity value of each block (Act₁₁ and Act₂₂, respectively). Bjontegaard, 19; Ex-1003, ¶205.

Bjontegaard discloses modifying pixels d and e—the two pixels closest to either side of the block boundary—based on Act₁₁ and Act₂₂. Bjontegaard, 20 (§4.5.5); Ex-1003, ¶206.

$$\text{Act}_{\text{edge}} = (\text{Act}_{11} + \text{Act}_{22}) / 2$$

If Act_{edge} equals 1 or 2: $Diff = (3(c - f) - 8(d - e))/16$

If Act_{edge} equals 3: $Diff = (b + c - 8(d - e) - f - g)/16$

$d_{modified} = d + Diff$ (clipped to stay in the range 0-255)

$e_{modified} = e - Diff$ (clipped to stay in the range 0-255)

Bjontegaard, 20; Ex-1003, ¶206.

After filtering pixels d/e, Bjontegaard discloses making a decision to filter a pixel second closest to the boundary (c) in block 1. Bjontegaard, 20 (§4.5.6.1); Ex-1003, ¶207. If Act_{11} equals two or three, pixel c is filtered:

If Act_{11} equals 2: $Diff = 5(b - 2c + d)/16$

If Act_{11} equals 3: $Diff = 3(a + b - 4c + d + e)/16$

$c_{modified} = c + Diff$ (clipped to stay in the range 0-255)

Bjontegaard, 20; Ex-1003, ¶207. This same process (using Act_{22} and pixels from block 2) is then repeated to decide whether to filter pixel f. Bjontegaard, 20 (§4.5.6.2); Ex-1003, ¶208.

Bjontegaard was accompanied by computer-executable code (“Bjontegaard’s Code”) incorporating Bjontegaard’s deblocking filter into an encoder and decoder. Exs-1010-1015. Bjontegaard’s Code also constitutes prior art under §102(b).¹³ *Id.*

¹³ Bjontegaard’s Code was publicly accessible. Ex-1005, ¶¶65-70.

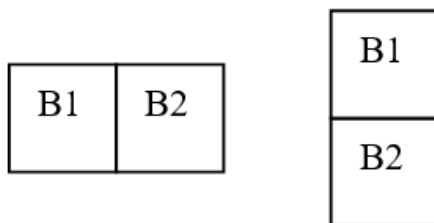
Because they were published at the same time, by the same person, as part of one standards proposal, a POSITA would have understood that Bjontegaard and Bjontegaard's Code were intended to be read together., Ex-1003, ¶¶209-11; *e.g.*, *Nvidia Corp. v. Advanced Cluster Sys., Inc.*, IPR2021-00075, Paper 9, 21, 26, 39-42 (May 5, 2021) (endorsing reliance on accompanying code to support paper disclosures).

2. Claim 1

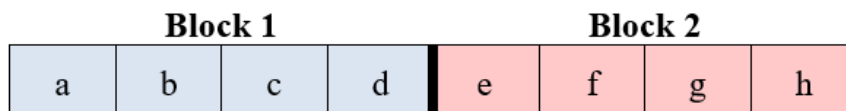
a. 1[pre]

If limiting, Bjontegaard discloses 1[pre]. Ex-1003, ¶¶464-68.

Bjontegaard discloses a method of “[f]iltering of pixels on both sides of a 4x4 block boundary,” in a video frame, below. Bjontegaard, 4, 19; Ex-1003, ¶¶465-67.



Bjontegaard, 18. Bjontegaard explains that “pixels [a-h] belong to two neighbouring [sic] blocks (1 and 2). There is a block boundary between pixels d [and] e.” Bjontegaard, 19.



Ex-1003, ¶468. Bjontegaard discloses equations that operate on the pixels to reduce blocking artifacts at the block boundary. Bjontegaard, 20.

b. 1[a]

Bjontegaard in view of a POSITA's understanding of the art discloses or suggests 1[a]. Ex-1003, ¶¶469-90.

As discussed in Section VIII.B.1 and below, Bjontegaard teaches or suggests a process to reduce blocking artifacts at a block boundary. First, Bjontegaard performs a series of calculations to determine how many pixels to filter. Bjontegaard, 19. Second, Bjontegaard calculates an “activity value” to determine how much filtering to perform. Bjontegaard, 19-20. If the activity value is high enough, then a first offset will be calculated for pixels d/e (the pixels closest to the block boundary). Bjontegaard, 20.



Ex-1003, ¶¶470-476; Bjontegaard, 19 (describing neighboring blocks 1 and 2 with a block boundary between pixels d and e). As understood by a POSITA, pixel d (i.e., p0) represents the pixel value of a pixel closest to the block boundary line, where the line of pixels a, b, c, and d is perpendicular to the block boundary. Ex-1003, ¶¶477-

78.¹⁴ A POSITA would have similarly understood that pixel e (i.e., q0) represents a pixel value of a pixel closest to the block boundary line in a neighboring block of pixels, where the line of pixels e, f, g, and h is perpendicular to the block boundary. *Id.*.

Bjontegaard also discloses a process for filtering pixels on both sides of the block boundary. If Act_{edge} equals 1 or 2, Bjontegaard teaches filtering pixels d/e according to the following:

$$Diff = (3(c - f) - 8(d - e))/16$$

$$Diff = \max(-Clip_{edge}, \min(Clip_{edge}, Diff))$$

$$d_{modified} = d + Diff \text{ (clipped to stay in the range 0-255)}$$

$$e_{modified} = e - Diff \text{ (clipped to stay in the range 0-255)}$$

Bjontegaard, 20; Ex-1003, ¶¶479-80, 482. A POSITA would have recognized that Bjontegaard's first offset equation can be reorganized, with the '659 Patent's pixel nomenclature adopted:

¹⁴ Bjontegaard has a typo in its S0₁ equation, where it points to a, b, and c as the three closest pixels to the block boundary rather than pixels b, c, and d. A POSITA would recognize that pixel d is the closest pixel to the boundary, followed by c and b. Ex-1003, ¶474.

$$Diff = (8 \times (q_0 - p_0) - 3 \times (q_1 - p_1))/16$$

Ex-1003, ¶481.

While Bjontegaard does not explicitly disclose a right shift operation and adding 8 as an offset (to round to the nearest integer), a POSITA would have known that a right shift operation is a computationally efficient hardware alternative to division. Ex-1003, ¶483. As discussed in Section VIII.A.5.b, Fu, B118, List, and B205 teach a right shift operation with a rounding offset. A POSITA would have further understood that adding an offset is a well-known technique to round up right-shifted values to the nearest integer. Ex-1003, ¶484. If a right shift of 4 ($\gg 4$) is used, a POSITA would have understood that an offset of 8 is needed. Ex-1003, ¶¶79-84. Doing so would have involved a simple substitution of one known method (division) with another well-known method (right shift with a numerical offset) to obtain predictable results. MPEP §2143; Ex-1003, ¶¶79-84. It follows that Bjontegaard's first offset equation would be rewritten as:

$$Diff = (8 \times (q_0 - p_0) - 3 \times (q_1 - p_1) + 8) \gg 4$$

Ex-1003, ¶485.

Bjontegaard teaches that its first offset equation is clipped. As discussed in Section VIII.A.5.b, a POSITA would have understood that Bjontegaard's clipping function constrains the range of pixel values but does not otherwise alter the modified pixel value. Ex-1003, ¶¶212-218, 486.

A comparison of Bjontegaard's first offset (without the clipping function) and the first offset recited in 1[a] is below:

Reference	First Offset Expression
'659 Patent	$(9 \times (q_0 - p_0) - 3 \times (q_1 - p_1) + 8) \gg 4$
Bjontegaard	$(8 \times (q_0 - p_0) - 3 \times (q_1 - p_1) + 8) \gg 4$

The only difference between the first offset expression in Bjontegaard and the first offset expression of the '659 Patent is the coefficient applied to the first set of pixels ($q_0 - p_0$). But as discussed above, modifying such a result-effective variable would have been well within the routine skill of a POSITA. Section VIII.A.5.b; Ex-1003, ¶¶488-90.

c. 1[b]

Bjontegaard in view of a POSITA's understanding of the art discloses or suggests 1[b]. Ex-1003, ¶¶491-97.

As discussed above in Section VIII.B.1, Bjontegaard discloses a process to reduce blocking artifacts. Bjontegaard teaches or suggests that after Diff (first offset) is calculated, it is added to pixel value d (p_0) to arrive at modified pixel value d_{modified} (p_0'). Ex-1003, ¶¶492-94. Bjontegaard discloses the following equation to filter pixel d :

$$d_{\text{modified}} = d + \text{Diff (clipped to stay in the range 0-255)}$$

Bjontegaard, 20.

As discussed in Section VIII.A.5.b, a POSITA would have understood that the clipping function constrains the range of pixel values but otherwise does not alter the modified pixel value. Ex-1003, ¶¶495-97.

d. 1[c]

Bjontegaard in view of a POSITA's understanding of the art discloses or suggests 1[c]. Ex-1003, ¶¶498-504.

Bjontegaard teaches or suggests that after the first offset is calculated, it is subtracted from pixel value e (q_0) to arrive at modified pixel value e_{modified} (q_0'). Ex-1003, ¶¶499-501. Specifically, Bjontegaard discloses the following equation to filter pixel e :

$$e_{\text{modified}} = e - \text{Diff} \text{ (clipped to stay in the range 0-255)}$$

Bjontegaard, 20.

As discussed in Section VIII.A.5.b, a POSITA would have understood that the clipping function constrains the range of pixel values but otherwise does not alter the modified pixel value. Ex-1003, ¶¶502-04.

3. Claim 2

a. 2[a]

Bjontegaard discloses or suggests 2[a]. Ex-1003, ¶¶506-16.

As discussed in Section VIII.B.2, Bjontegaard in view of the knowledge of a POSITA renders claim 1 obvious. Bjontegaard further teaches that its first offset is clipped using in the following equations:

$$Diff = (3(c - f) - 8(d - e))/16$$

$$Diff = \max(-Clip_{edge}, \min(Clip_{edge}, Diff))$$

$$Clip_{edge} = (Clip(qp, Strength_1) + Clip(qp, Strength_2) + Act_1 + Act_2 - 2)/2$$

Bjontegaard, 19-20. $Clip_{edge}$ is a value that is used as the upper and lower bound to clip the result of the first offset value, Diff. The value of $Clip_{edge}$ depends on five variables that are summed and divided by two: (1) its Clip function for the value of $strength_1$, (2) its Clip function for the value of $strength_2$, (3) Act_1 , (4) Act_2 , and (5) negative 2. Ex-1003, ¶¶507-09. Bjontegaard discloses the following table of values for the Clip(qp, Strength) function:

QP	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	29	30	31
Clip(qp,1)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3
Clip(qp,2)	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	3	3	3	4	5	5
Clip(qp,3)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	3	3	3	3	4	4	5	5	5	7	8	9

Bjontegaard, 19-20. Taking the values of Bjontegaard's Clip function, Act_1 , Act_2 , and -2 (and dividing that sum by 2), results in a value $Clip_{edge}$. *Id.* That value is used as the upper bound ($Clip_{edge}$) and lower bound ($-Clip_{edge}$) within which the first offset value is constrained. Ex-1003, ¶¶510-16.

b. 2[b]

Bjontegaard discloses or suggests 2[b]. Ex-1003, ¶¶517-21.

Bjontegaard teaches a quantization parameter value, qp, for its deblocking filter, where “qp” means the maximum qp for the two neighboring blocks. Bjontegaard, 18. The qp assigned to each block is used to derive the value $\text{Lim}(\text{qp})$, which is used to determine the value of Act_1 and Act_2 , from which $\text{Clip}_{\text{edge}}$ depends. Bjontegaard, 19. Bjontegaard’s activity calculations depend on the quantization parameter, where:

If $S0_1 < \text{Lim}(\text{qp})$, Act_1 is incremented by 1

If $S1_1 < \text{Lim}(\text{qp})$, Act_1 is incremented by 1

Bjontegaard, 19.

Clipping function, $\text{Clip}_{\text{edge}}$, depends on the values of $\text{Clip}(\text{qp}, \text{Strength}_1)$, $\text{Clip}(\text{qp}, \text{Strength}_2)$, Act_1 and Act_2 . Bjontegaard, 19-20. A POSITA, considering the teachings of Bjontegaard, would have understood that the threshold, $\text{Clip}_{\text{edge}}$, for its clipping function is dependent on the quantization parameter value assigned to block 1 when greater than block 2’s qp value. Ex-1003, ¶¶518-21.

4. Claim 3

a. 3[a]

Bjontegaard in view of a POSITA’s understanding of the art discloses or suggests 3[a]. Ex-1003, ¶¶523-28.

As discussed in Section VIII.B.2, Bjontegaard, in view of the knowledge of a POSITA, renders claim 1 obvious. Bjontegaard further teaches that the modified value of pixel *d* (*p*₀) is derived from the following equation, which is clipped from 0-255:

$$d_{modified} = d + Diff \text{ (clipped to stay in the range 0-255)}$$

Bjontegaard, 20. A POSITA would understand that the phrase “clipped to stay in the range 255” applies to *d*_{modified} because the first offset is already clipped. Ex-1003, ¶¶524-26.

As discussed above in Section VIII.A.7.a, a POSITA would have understood that pixels are typically represented as 8-bit values, such that the maximum value for a clipping function is 255. Ex-1003, ¶¶527-28.

b. 3[b]

Bjontegaard in view of a POSITA’s understanding of the art discloses or suggests 3[b]. Ex-1003, ¶¶529-34.

Bjontegaard teaches that the modified value of pixel *e* (*q*₀) is derived from the following equation, which is clipped from 0-255:

$$e_{modified} = e - Diff \text{ (clipped to stay in the range 0-255)}$$

Bjontegaard, 20.

As discussed above in Section VIII.A.7.a, a POSITA would have understood that pixels are typically represented as 8-bit values, such that the maximum value for a clipping function is 255. Ex-1003, ¶¶533-34.

5. Claim 4

a. 4[a]

Bjontegaard in view of Bjontegaard's Code and a POSITA's understanding of the art discloses or suggests 4[a]. Ex-1003, ¶¶536-57.

As discussed in Section VIII.B.2, Bjontegaard, in view of the knowledge of a POSITA, renders claim 1 obvious. Bjontegaard further teaches calculating a second offset based on pixels b, c, and d (p2, p1, and p0). Specifically, Bjontegaard discloses that if Act_{11} equals 2, the offset for pixel c (p1) is calculated with the following equation:

$$Diff = 5(b - 2c + d)/16$$

Bjontegaard, 20. Bjontegaard's second offset equation includes pixel b (p2), which is the value of the pixel second next closest to the block boundary. Ex-1003, ¶¶539-40; Bjontegaard, 19.



A POSITA would have found it obvious that Bjontegaard's equation should read as: $Diff = 5(b - 2c + d_{\text{modified}})/16$, or $Diff = 5(b - 2c + d + \Delta)/16$ (since $d_{\text{modified}} = d + \Delta$),

because Bjontegaard and Bjontegaard's Code disclose a step-by-step procedure that modifies pixel *d* *before* filtering other pixels. Ex-1012, 11 (modifying *d* before calculating offset for *c*); Bjontegaard, 20; Ex-1003, ¶¶541-43. Alternatively, a POSITA would have been motivated to use d_{modified} to ensure the second offset is related to the first offset and avoid inducing a discontinuity into the filtered block. Ex-1003, ¶544. Many prior-art deblocking filters used the first offset in the second offset to ensure a smooth transition at the block boundary. H.241, 29 (applying $\Delta/2$ for second offset); B205, 130 (same); Ex-1039, 215 (applying $\Delta/2$, $\Delta/4$, $\Delta/8$ when moving further from boundary).

Accordingly, Bjontegaard's second offset equation would be rewritten (using *p*):

$$\Delta_{p1} = \frac{5(p2 - 2p1 + p0)}{16} + \frac{5\Delta_{p0}}{16}$$

Ex-1003, ¶545. A POSITA would have understood that Bjontegaard's equation has two components, just like the claimed equation: (1) a high-pass filter component ($\frac{5(p2-2p1+p0)}{16}$); and (2) a first-offset component ($\frac{5\Delta}{16}$). Ex-1003, ¶546. The only difference between Bjontegaard and the second offset claimed is the coefficient assigned to each component (red):

Claimed Equation	Bjontegaard's Equation
$\Delta = \frac{1(p_2 - 2p_1 + p_0)}{4} + \frac{1\Delta}{2}$	$\Delta = \frac{5(p_2 - 2p_1 + p_0)}{16} + \frac{5\Delta}{16}$

Id.

A POSITA would have understood that, like the first-offset equation, these coefficients were known result-effective variables that controlled the frequency response of the filter, and thus how much pixel p_1 would be modified. Ex-1003, ¶547. Weighting the high-pass component—intended to target high-frequencies for additional filtering—by $\frac{1}{4}$ (or $4/16$) instead of $5/16$ would mean *slightly* less of the high-frequency blurring would be factored into the second offset. Ex-1003, ¶¶551-53. Weighting the first-offset component—intended to blur the second pixel as a function of the first offset—by $\frac{1}{2}$ (or $8/16$) instead of $5/16$ would mean *slightly* more blurring consistent with the first offset would be factored into the second offset. Ex-1003, ¶554.

A POSITA would have understood that these coefficients were subject to routine experimentation and optimization because others had similarly combined these two components and applied different coefficients. Ex-1003, ¶¶548-52; *e.g.*, B118, 48 ($\Delta_{p1} = \frac{1(p_2 - 2p_1 + p_0)}{2} + \frac{1\Delta}{2}$); Fu, 8:17 ($\Delta_{p1} = \frac{1(p_2 - 3p_1 + 3p_0 - q_0)}{8} + \frac{1\Delta}{2}$); Section VIII.A.8.

For these reasons, a POSITA would have found through routine experimentation that modifying Bjontegaard's coefficients to apply $\frac{1}{4}$ to the high-pass component, and $\frac{1}{2}$ to the first-offset component was obvious. *Friskit*, 306 F. App'x at 615; *see* Ex-1012, 11 (computer code for calculator); Ex-1003, ¶¶555-57.

b. 4[b]

Bjontegaard in view of Bjontegaard's Code and a POSITA's understanding of the art discloses or suggests 4[b]. Ex-1003, ¶¶558-68.

Bjontegaard, in view of the knowledge of a POSITA, further teaches calculating a third offset based on pixels q2, q1, q0, and the first offset. Like the second offset equation, Bjontegaard teaches that, when Act₂₂ equals two, the offset for pixel f (q1) is calculated with an offset equation as follows:

$$Diff = 5(e - 2f + g)/16$$

Bjontegaard, 20. Bjontegaard's third offset equation includes pixel g (i.e., q2), which is the pixel second next closest to the block boundary. Ex-1003, ¶¶561-62; Bjontegaard, 19.



Like the second offset, a POSITA would have found it obvious that Bjontegaard's third offset should read $Diff=5(e_{\text{modified}}-2f+g)/16$, and the only

difference to the third-offset equation claimed is the coefficients applied to each component:

Claimed Equation	Bjontegaard's Equation
$\Delta = \frac{1(q_2 - 2q_1 + q_0)}{4} - \frac{1\Delta}{2}$	$\Delta = \frac{5(q_2 - 2q_1 + q_0)}{16} - \frac{5\Delta}{16}$

Ex-1003, ¶¶563-65; Section VIII.B.5.a. For the same reasons as block 1, a POSITA would have experimented with coefficient applied to each component and found it obvious to weigh the high-pass component by ¼ instead of 5/16, and the first-offset component by ½ instead of 5/16. Ex-1003, ¶¶566-68; Section VIII.B.5.a.

c. 4[c]

Bjontegaard in view of Bjontegaard's Code and a POSITA's understanding of the art discloses or suggests 4[c]. Ex-1003, ¶¶569-75.

Bjontegaard teaches or suggests that after the second offset is calculated, it is added to pixel value c (p1) to arrive at a modified pixel value c_{modified} (p1') using the following equation:

$$c_{\text{modified}} = c + \text{Diff} \text{ (clipped to stay in the range 0-255)}$$

$$\text{Diff} = 5(b - 2c + d)/16$$

Ex-1003, ¶¶570-71 Bjontegaard, 20. The equation above adds the second offset equation with pixel value c (p1) to derive modified value, c_{modified} , where pixel c is the next closest pixel to the block boundary. Bjontegaard, 19; Ex-1003, ¶571.



As discussed in Section VIII.A.5.b, a POSITA would have understood that the clipping function constrains the range of pixel values but otherwise does not alter the modified pixel value. Ex-1003, ¶¶572-75.

d. 4[d]

Bjontegaard in view of Bjontegaard's Code and a POSITA's understanding of the art discloses or suggests 4[d]. Ex-1003, ¶¶576-82.

Bjontegaard teaches or suggests that after the third offset is calculated, it is added to pixel value $f(q_1)$ to arrive at a modified pixel value $f_{\text{modified}}(q_1')$ using the following equation:

$$f_{\text{modified}} = f + \text{Diff} \text{ (clipped to stay in the range 0-255)}$$

$$\text{Diff} = 5(e - 2f + g)/16$$

Ex-1003, ¶578; Bjontegaard, 20. The equation above adds the third offset with pixel value $f(q_1)$ to derive modified value, f_{modified} , where pixel f is the next closest pixel to the block boundary. Bjontegaard, 19; Ex-1003, ¶577.



As discussed in Section VIII.A.5.b, a POSITA would have understood that the clipping function constrains the range of pixel values but otherwise does not alter the modified pixel value. Ex-1003, ¶¶579-82.

6. Claim 5

a. 5[a]

Bjontegaard in view of a POSITA's understanding of the art discloses or suggests 5[a]. Ex-1003, ¶¶584-93.

For the reasons explained in Section VIII.B.5.a, Bjontegaard renders the second offset equation from 4[a] obvious. The second offset equation in 5[a] uses right shifts instead of division in 4[a]. A mathematical equivalent to the second offset equation in 4[a] is below, where the entire expression is divided by 2:

$$= \left[\left(\frac{1}{2}p_2 + \frac{1}{2}p_0 - p_1 + \Delta \right) \right] / 2$$

Ex-1003, ¶¶586-87. If the $\frac{1}{2}$ terms are combined, that results in the following expression:

$$= \left[\left(\frac{1}{2}(p_2 + p_0) - p_1 + \Delta \right) \right] / 2$$

Ex-1003, ¶588. If right shifts are substituted for the divisions, that results in:

$$= \left(((p_2 + p_0) \gg 1) - p_1 + \Delta \right) \gg 1$$

A POSITA would have understood that a right shift operation truncates the value of the result obtained after the division function to an integer, even if a decimal

would be the true result of a division by 2. Ex-1003, ¶590. As a design choice, to reduce the resulting inaccuracies, a POSITA would have recognized that a rounding value could be added, which is half of the value of the denominator (i.e., if you have a right shift of 2, the rounding value would be +2). Ex-1003, ¶¶590-92. Here, a rounding value of 1 is added to $p_2 + p_0$ to compensate for the inaccuracies introduced by the right shift operation, which would result in:

$$= ((p_2 + p_0 + 1) \gg 1) - p_1 + \Delta \gg 1$$

Ex-1003, ¶591. Applying the mathematical equivalents above to the second offset equation of 4[a], a POSITA would arrive at the second offset equation of 5[a]. *See* Section VIII.B.5.a.

b. 5[b]

Bjontegaard in view of a POSITA's understanding of the art discloses or suggests 5[b]. Ex-1003, ¶¶594-602.

As in Section VIII.B.5.b, Bjontegaard renders the third offset equation from 4[b] obvious. The third offset equation in 5[b] uses right shifts instead of division in 4[b]. A mathematical equivalent to the third offset equation in 4[b] is below, where the entire expression is divided by 2:

$$= \left[\left(\frac{1}{2}q_2 + \frac{1}{2}q_0 - q_1 - \Delta \right) \right] / 2$$

Ex-1003, ¶¶595-96. If the $\frac{1}{2}$ terms are combined, that results in the following expression:

$$= \left[\left(\frac{1}{2} (q_2 + q_0) - q_1 - \Delta \right) \right] / 2$$

Ex-1003, ¶597. If right shifts are substituted for the divisions, that results in:

$$= \left(((q_2 + q_0) \gg 1) - q_1 - \Delta \right) \gg 1$$

A POSITA would have understood that a right shift operation truncates the value of the result obtained after the division function to an integer, even if a decimal would be the true result of a division by 2. Ex-1003, ¶¶598-99. As a design choice, to reduce the resulting inaccuracies, a rounding value could be added, which is half of the value of the denominator (i.e., if you have a right shift of 2, the rounding value would be +2). Ex-1003, ¶599-601. Here, a rounding value of 1 is added to $q_2 + q_0$ to compensate for the inaccuracies introduced by the right shift operation, which would result in:

$$= \left(((q_2 + q_0 + 1) \gg 1) - q_1 - \Delta \right) \gg 1$$

Ex-1003, ¶600. Applying the mathematical equivalents above to the second offset equation of 4[b], a POSITA would arrive at the second offset equation of 5[b]. *See* Section VIII.B.5.b.

7. Claim 6

a. 6[a]

Bjontegaard discloses or suggests 6[a]. Ex-1003, ¶¶604-08.

As discussed in Section VIII.B.5, Bjontegaard, in view of the knowledge of a POSITA, renders claim 4 obvious. Bjontegaard further teaches that its second offset is clipped, shown in the following equation:

$$Diff = \max(-Clip(qp, Strength_1), \min(Clip(qp, Strength_1), Diff))$$

Bjontegaard, 20; *see* Section VIII.B.3.a (explaining Bjontegaard's Clip operation).

b. 6[b]

Bjontegaard discloses or suggests 6[b]. Ex-1003, ¶¶609-11.

Bjontegaard teaches a quantization parameter value, qp, for its deblocking filter, where "qp" means the maximum qp assigned to Block 1 and Block 2. Bjontegaard, 19. Bjontegaard teaches that its function $Clip(qp, Strength_1)$ is dependent on the quantization parameter "qp." *Id.*, 19-20. The threshold value $-Clip(qp, Strength_1)$ is therefore dependent on the qp assigned to Block 1 when greater than the qp value assigned to Block 2.

c. 6[c]

Bjontegaard in view of a POSITA's understanding of the art discloses or suggests 6[c]. Ex-1003, ¶¶612-23.

Bjontegaard teaches that its third offset is clipped, shown in the following equation:

$$Diff = \max(-Clip(qp, Strength_2), \min(Clip(qp, Strength_2), Diff))$$

Bjontegaard, 20; *see* Section VIII.B.3.a (explaining Bjontegaard's Clip operation). Bjontegaard uses Strength 1 for its clipping function of the second offset and Strength 2 for its clipping function of the third offset. Bjontegaard, 19-20. The clipped values are similar, as shown in the table for the values of $Clip(qp, Strength)$, where they result in the same threshold values in many instances. Ex-1003, ¶¶617-19.

qp	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	29	30	31
$Clip(qp, 1)$	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3
$Clip(qp, 2)$	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3	3	3	3	4	5	5
$Clip(qp, 3)$	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	3	3	3	4	4	5	5	5	7	8	9

It would have been obvious to a POSITA to use the same values for clipping the second and third offsets. For example, Fu, B118 and B205 teach clipping the second and third offsets by the same values. Ex-1003, ¶¶620-22. Doing so would have involved a simple substitution of one known element (clipping using the same threshold values) to obtain a predicable result (a natural ramp of modified and clipped pixel values). MPEP §2143. A POSITA would have understood that clipping these offsets using the same values would help remove blocking artifacts, while preserving the sharpness in the frame. Ex-1003, ¶¶623; Ex-1039, 214, Fig. 4.

8. Claim 7

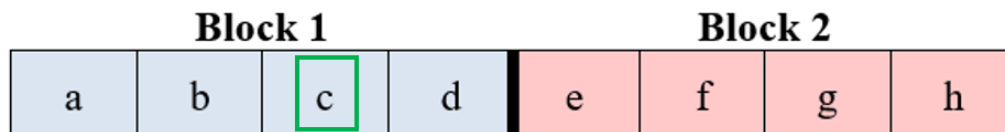
a. 7[a]

Bjontegaard discloses or suggests 7[a]. Ex-1003, ¶¶625-30.

As discussed in Section VIII.B.5, Bjontegaard, in view of the knowledge of a POSITA, renders claim 4 obvious. Bjontegaard further teaches that the filtered (modified) value of pixel c (p1) is clipped using the following equation:

$$c_{modified} = c + Diff \text{ (clipped to stay in the range 0-255)}$$

Bjontegaard, 20; see Section VIII.B.4.a (explaining Bjontegaard's clipping operation). Bjontegaard teaches that pixel c is the next closest pixel to the block boundary. Bjontegaard, 19; Ex-1003, ¶626.



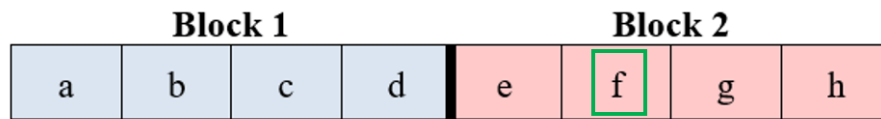
b. 7[b]

Bjontegaard discloses or suggests 7[b]. Ex-1003, ¶¶631-36.

Bjontegaard teaches that the filtered (modified) value of pixel f (q1) is clipped using the following equation:

$$f_{modified} = f + Diff \text{ (clipped to stay in the range 0-255)}$$

Bjontegaard, 20; see Section VIII.B.4.a (explaining Bjontegaard's clipping operation). Bjontegaard teaches that pixel f is the next closest pixel to the block boundary. Bjontegaard, 19; Ex-1003, ¶632.



9. Claim 10

a. 10[pre]

As discussed in Section VII, Ericsson argues that 10[pre] is limiting in its entirety, while Lenovo argues that “a user equipment comprising” is not limiting. Ex-1026, 7. Bjontegaard, in view of Bjontegaard’s Code and the knowledge of a POSITA discloses or suggests 10[pre] under either construction. Ex-1003, ¶¶637-41.

Although Bjontegaard does not describe the exact device that operates its deblocking filter, a POSITA would have understood that it would be run on user equipment, such as a computer or other processing device, because video codecs are conventionally run on such devices. Ex-1003, ¶638; *e.g.*, Ex-1040, 1-5 (describing importance of video codecs to various consumer electronics). Bjontegaard separately provides the source code to run its coding model on a computer. Ex-1003, ¶639; Exs. 1010-1015.

Similarly, the ’659 Patent describes that the offset calculators, clipping units, and pixel value modifiers can be implemented “as computer program modules running on a general purpose processor.” Ex-1001, 20:50-59; *see id.*, 21:37-42 (stating that the deblocking filter unit of a video decoder “can be implemented

preferably in hardware but also in software”). A POSITA would have understood that Bjontegaard discloses a deblocking filter process meant to be performed on user equipment comprising a deblocking filter unit. Ex-1003, ¶¶640-41.

b. 10[a]

Bjontegaard discloses or suggests 10[a] for the same reasons as 1[a]. Section VIII.B.2.b; Ex-1003, ¶642. As discussed in 10[pre], 10[a] is the apparatus equivalent of 1[a].

c. 10[b]

Bjontegaard discloses or suggests 10[b] for the same reasons as 1[b]. Section VIII.B.2.c; Ex-1003, ¶643. As discussed in 10[pre], 10[b] is the apparatus equivalent of 1[b].

d. 10[c]

Bjontegaard discloses or suggests 10[c] for the same reasons as 1[c]. Section VIII.B.2.d; Ex-1003, ¶644. As discussed in 10[pre], 10[c] is the apparatus equivalent of 1[c].

10. Claim 11

a. 11[a]

Bjontegaard discloses or suggests 11[a] for the same reasons as 2[a]. Section VIII.B.3.a; Ex-1003, ¶646. As discussed in 10[pre], 11[a] is the apparatus equivalent of 2[a].

b. 11[b]

Bjontegaard discloses or suggests 11[b] for the same reasons as 2[b]. Section VIII.B.3.b; Ex-1003, ¶647. As discussed in 10[pre], 11[b] is the apparatus equivalent of 2[b].

11. Claim 12

a. 12[a]

Bjontegaard discloses or suggests 12[a] for the same reasons as 3[a]. Section VIII.B.4.a; Ex-1003, ¶649. As discussed in 10[pre], 12[a] is the apparatus equivalent of 3[a].

b. 12[b]

Bjontegaard discloses or suggests 12[b] for the same reasons as 3[b]. Section VIII.B.4.b; Ex-1003, ¶650. As discussed in 10[pre], 12[b] is the apparatus equivalent of 3[b].

IX. Discretionary Factors Favor Institution

A. *Fintiv*

The Board should not deny institution on the basis of *Fintiv*.

The '659 Patent is being litigated before the district court and ITC. *Fintiv* does not apply to ITC proceedings. K. Vidal, Memorandum, U.S. PAT. AND TRADEMARK OFFICE, 2-3 (June 21, 2022).

For the district court, the relevant *Fintiv* factors weigh heavily against a discretionary denial. The case was initiated in December 2023, *Telefonaktiebolaget LM Ericsson v. Lenovo (United States), Inc.*, No. 5-23-cv-00714, ECF No. 1 (EDNC Dec. 12, 2023), no schedule has been entered, and it has been stayed pending resolution of the ITC proceedings. ECF No. 40 (EDNC Feb. 16, 2024). Any trial would therefore be expected well after the FWD deadline (likely December 2025). Further, it is unclear whether any overlap yet exists between this Petition and any district court issues. Discretionary denial under *Fintiv* is unwarranted.

B. 325(d)

The Board should not exercise its discretion under §325(d) to deny institution. *See Becton, Dickinson & Co. v. B. Braun Melsungen AG*, IPR2017-01586, Paper 8, 17-18 (Dec. 15, 2017) (precedential); *Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH*, IPR2019-01469, Paper 6, 9-11 (Feb. 13, 2020) (precedential).

Considering *Advanced Bionics* part one (*Becton, Dickinson* factors (a), (b), (d)), apart from B205 and List, which are relied upon in the Petition to show the knowledge of a POSITA as of the priority date, no other references presented here were previously before the Office. Moreover, the Examiner never considered a basis of invalidity that relied primarily upon either Fu or Bjontegaard. A different Bjontegaard reference (Bjontegaard '048) is listed on the face of the '659 Patent but

its teachings are different than the Bjontegaard reference relied on here. For example, Bjontegaard '048 did not disclose the first, second, or third offset disclosed in Bjontegaard. Nor is either reference cumulative of what was before the Examiner. Thus, the same or substantially same art or arguments were not previously presented to or considered by the Office; the Board need not reach *Advanced Bionics* part two.

X. Mandatory Notices

A. Real Party in Interest

In addition to itself, Petitioner identifies Lenovo (United States) Inc., Lenovo (Shanghai) Electronics Technology Co. Ltd., Lenovo Beijing, Ltd., Lenovo PC HK Limited, Lenovo Group, Ltd., and Lenovo Information Products (Shenzhen) Co., Ltd. as real parties in interest.

B. Related Matters

To the best of Petitioner's knowledge, the '659 Patent has been involved in the following matters:

- *Telefonaktiebolaget LM Ericsson v. Lenovo (United States), Inc.*, No. 5-23-cv-00714 (EDNC);
- Certain Electronic Computing Devices, and Components and Modules Thereof; Inv. No. 337-TA-1387 (ITC).

C. Notice of Counsel and Service Information

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D. Service Information

Please address all correspondence to lead and back-up counsel at the addresses shown above, and as follows. Petitioners consent to electronic service by e-mail.

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XI. Conclusion

Inter Partes Review of the challenged claims is respectfully requested.

Respectfully submitted,

/ Jessica Kaiser /

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Date: June 14, 2024

CERTIFICATE OF WORD COUNT UNDER 37 CFR §42.24(d)

Pursuant to 37 C.F.R. §42.24(a), Petitioner hereby certifies that portions of the above-captioned Petition for *Inter Partes* Review of U.S. Patent 10,142,659, in accordance with and reliance on the word count provided by the word-processing system used to prepare this Petition, that the number of words in this paper is 12,887. Pursuant to 37 C.F.R. §42.24(a), this word count is in compliance and excludes the table of contents, table of authorities, mandatory notices under §42.8, certificate of service, certificate of word count, appendix of exhibits, and any claim listing. This word count was prepared using Microsoft Word.

Respectfully submitted,

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CERTIFICATE OF SERVICE

The undersigned hereby certifies that true copies of the Petition for *Inter Partes* Review of U.S. Patent No. 10,142,659 and supporting materials (Exhibits and Power of Attorney) were served via overnight delivery on the Patent Owner at the correspondence address of record as listed on PAIR:

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A courtesy copy was also sent via electronic mail to Patent Owner's litigation counsel listed below:

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