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| *Title:* | Non-CE12 Subtest 5: Transform Dependent Deblocking Filter Parameter Adjustment in Slice Level | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes to adjust the Tc and Beta parameters of the deblocking filter by enabling signaling of control data in the slice header. It is proposed to adjust Tc depending on the transform size and on intra or inter type of the blocks. The deblocking\_filter\_control\_present\_flag is proposed in the SPS to control the presence of the deblocking filter adjustment parameters in the slice header. The benefit is to allow control over the psycho-visual characteristics of the deblocking filter for different block sizes. There are average BD-rate gains of -0.3% for all-intra HE and -0.1% for random access (HE) test conditions.

# Introduction

The HM4 deblocking loop filter specified in Working Draft version 4 (WD4) of HEVC [1] filters certain TU and PU edges based on the result from the boundary strength computation and deblocking decisions (on/off, weak/strong filter, weak filter strength) that are dependent on threshold variables tC and β. The tC and β thresholds are looked up in a table using the parameter Q, which is derived from the quantization parameter (QP) and the boundary strength (Bs), as follows:

* + TcOffset = ( Bs > 2 ) ? DEFAULT\_INTRA\_TC\_OFFSET(=2) : 0
  + **tC:** Q = Clip3(0, MAX\_QP+4, QP + TcOffset ) (luma and chroma deblocking)
  + **β:** Q = Clip3(0, MAX\_QP, QP ) (luma deblocking only)

The TcOffset value modifies the QP value to lookup the tC threshold variable, depending on the boundary strength value. Assume that the current edge to be deblocked is situated in between blocks P and Q, with P on the left or above Q. If Bs>2, then the current block Q or the neighboring block P is intra coded. Hence, the DEFAULT\_INTRA\_TC\_OFFSET(=2) will increase the QP value by 2.

In WD4 no signaling is supported to modify the QP value to lookup the tC or the β threshold. Therefore, the deblocking filter behavior cannot be influenced by an encoder in order to improve subjective quality or improve bit rate efficiency. To mitigate this restriction, in [2] the slice-level signaling of a slice\_tc\_offset and slice\_beta\_offset was proposed during the 6th JCT-VC meeting in July 2011 (Torino, Italy).

Because of significantly different psycho-visual importance of quantized transform blocks with widely varying sizes (4x4, 8x8, 16x16, 32x32), the effect of applying one single offset to the QP value for tC or β lookup has a different subjective and also BD-rate impact for each transform size. In addition, the effects of an offset on the BD-rate are experimentally also significantly different for intra and inter coded blocks. Therefore, this contribution proposes to signal deblocking adjustment parameters in the slice header that allow adapting the deblocking filter for different transform sizes and the intra/inter case.

# Transform Dependent Deblocking Parameter Adjustment

The following pseudo-code specifies a linear relationship to determine the offsets to be applied to the QP value based on the following slice-level syntax units: slice\_tc\_offset\_intra, slice\_tc\_offset\_intra\_delta, slice\_tc\_offset\_inter, slice\_tc\_offset\_inter\_delta, slice\_beta\_offset:

* transform\_type = NxN (= 4x4 or 8x8 or 16x16 or 32x32)
  + INTRA\_TC\_OFFSET = slice\_tc\_offset\_intra + tc\_offset\_NxN\_intra\_delta
  + INTER\_TC\_OFFSET = slice\_tc\_offset\_inter + tc\_offset\_NxN\_inter\_delta
  + BETA\_OFFSET = slice\_beta\_offset
* Tc\_offset\_NxN\_intra\_delta = slice\_tc\_offset\_intra\_delta \* factor\_NxN
* Tc\_offset\_NxN\_inter\_delta = slice\_tc\_offset\_inter\_delta \* factor\_NxN
* Constant values used in the computation (not signaled):
  + Factor\_4x4 = 3
  + Factor\_8x8 = 2
  + Factor\_16x16 = 1
  + Factor\_32x32 = 0
* TcOffset = ( Bs > 2 ) ? INTRA\_TC\_OFFSET : INTER\_TC\_OFFSET
* BetaOffset = BETA\_OFFSET
* **tC:** Q = Clip3(0, MAX\_QP+4, QP + TcOffset ) (luma and chroma de-blocking)
* **β:** Q = Clip3(0, MAX\_QP+4, QP + BetaOffset ) (luma de-blocking only)

Note that in case of rectangular transform types (NSQT: non-square quadtree transform), the equivalent square transform type is used (32x8: 16x16; 16x4: 8x8).

In addition to the slice-level syntax units above, the deblocking\_filter\_control\_present\_flag is signaled in the Sequence Parameter Set (SPS). The deblocking\_filter\_control\_present\_flag equal to 1 specifies that a set of syntax elements controlling the characteristics of the deblocking filter is present in the slice header. If equal to 0, then this flag specifies that the set of syntax elements controlling the characteristics of the deblocking filter is not present in the slice header and their inferred values are in effect.

Table Sequence Parameter Set syntax including deblocking\_filter\_control\_present\_flag

|  |
| --- |
| seq\_parameter\_set\_rbsp( ) { |
| **...** |
| **chroma\_pred\_from\_luma\_enabled\_flag** |
| **deblocking\_filter\_control\_present\_flag** |
| **loop\_filter\_across\_slice\_flag** |
| **sample\_adaptive\_offset\_enabled\_flag** |
| **adaptive\_loop\_filter\_enabled\_flag** |
| **pcm\_loop\_filter\_disable\_flag** |
| ... |
| } |

Signaling of the slice header syntax units slice\_tc\_offset\_intra, slice\_tc\_offset\_intra\_delta, slice\_tc\_offset\_inter, slice\_tc\_offset\_inter\_delta, slice\_beta\_offset is illustrated in Table 2.

Table Modified slice header syntax

|  |
| --- |
| slice\_header( ) { |
| ... |
| if( deblocking\_filter\_control\_present\_flag ) { |
| **disable\_deblocking\_filter\_idc** |
| if( disable\_deblocking\_filter\_idc != 1 ) { |
| **slice\_beta\_offset** |
| **slice\_tc\_offset\_intra** |
| **slice\_tc\_offset\_intra\_delta** |
| if ( slice\_type != I) { |
| **slice\_tc\_offset\_inter** |
| **slice\_tc\_offset\_inter\_delta** |
| } |
| } |
| } |
| } |

# Objective Results

The following are the changes to the configuration files and the parameter values used to generate the objective test results:

LoopFilterDisable : 0

LoopFilterBetaOffset : 0

slice\_tc\_offset\_intra : 0

slice\_tc\_offset\_inter : -2

slice\_tc\_offset\_intra\_delta : -1

slice\_tc\_offset\_inter\_delta : 1

The other configuration file parameters follow the common test conditions for the HM4.0 anchor. The encoding execution times are measured in a variable computing environment, while the decoding times are measured on a single CPU.

Table 3 BD-rate results compared with the HM4.0 anchor for QP values 22, 27, 32, 27

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.3% | -0.4% | -0.3% | 0.0% | -0.4% | -0.3% |
| Class B | -0.3% | -0.5% | -0.4% | -0.1% | -0.4% | -0.3% |
| Class C | -0.2% | -0.6% | -0.5% | -0.1% | -0.4% | -0.3% |
| Class D | -0.2% | -0.5% | -0.5% | -0.1% | -0.3% | -0.2% |
| Class E | -0.2% | 0.0% | 0.0% | 0.0% | 0.2% | 0.3% |
| **Overall** | -0.3% | -0.4% | -0.4% | -0.1% | -0.3% | -0.2% |
|  | -0.3% | -0.4% | -0.3% | -0.1% | -0.3% | -0.2% |
| Enc Time[%] | 103% | | | 99% | | |
| Dec Time[%] | 99% | | | 102% | | |
|  |  |  |  |  |  |  |
|  | **Random Access HE** | | | **Random Access LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.2% | -0.4% | -0.4% | 0.0% | -0.3% | -0.4% |
| Class B | -0.1% | -0.4% | -0.3% | 0.0% | -0.4% | -0.3% |
| Class C | 0.0% | -0.3% | -0.3% | 0.0% | -0.6% | -0.4% |
| Class D | 0.1% | -0.3% | -0.2% | 0.1% | -0.5% | -0.4% |
| Class E |  |  |  |  |  |  |
| **Overall** | -0.1% | -0.4% | -0.3% | 0.0% | -0.4% | -0.4% |
|  | 0.0% | -0.4% | -0.3% | 0.0% | -0.4% | -0.4% |
| Enc Time[%] | 100% | | | 101% | | |
| Dec Time[%] | 101% | | | 101% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B HE** | | | **Low delay B LC** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | 0.0% | 0.0% | 0.1% | 0.1% | 0.0% | -0.1% |
| Class C | 0.0% | -0.1% | 0.1% | 0.1% | 0.1% | -0.2% |
| Class D | 0.2% | 0.2% | 0.6% | 0.1% | 0.4% | 0.0% |
| Class E | 0.1% | 0.4% | 0.8% | 0.0% | 0.5% | 0.2% |
| **Overall** | 0.1% | 0.1% | 0.3% | 0.1% | 0.2% | 0.0% |
|  | 0.1% | 0.1% | 0.3% | 0.1% | 0.2% | 0.0% |
| Enc Time[%] | 100% | | | 99% | | |
| Dec Time[%] | 100% | | | 101% | | |

Table 4 BD-rate results compared with the HM4.0 anchor for high QP values 32, 37, 42, 47

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.3% | -0.3% | -0.2% | 0.1% | -0.3% | -0.1% |
| Class B | -0.2% | -0.1% | -0.1% | 0.1% | -0.1% | 0.1% |
| Class C | -0.2% | -0.3% | -0.2% | -0.1% | -0.1% | 0.1% |
| Class D | -0.2% | -0.3% | -0.2% | -0.1% | 0.0% | 0.2% |
| Class E | -0.2% | 0.0% | 0.0% | 0.1% | 0.1% | 0.3% |
| **Overall** | -0.2% | -0.2% | -0.2% | 0.0% | -0.1% | 0.1% |
|  | -0.2% | -0.3% | -0.2% | 0.0% | -0.1% | 0.1% |
| Enc Time[%] | 98% | | | 97% | | |
| Dec Time[%] | 101% | | | 101% | | |
|  |  |  |  |  |  |  |
|  | **Random Access HE** | | | **Random Access LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.1% | -0.3% | 0.0% | 0.2% | 0.2% | -0.3% |
| Class B | 0.0% | -0.1% | 0.0% | 0.1% | -0.2% | 0.0% |
| Class C | 0.2% | 0.1% | 0.1% | 0.1% | -0.2% | 0.3% |
| Class D | 0.7% | 0.3% | 0.5% | 0.6% | 0.0% | 0.3% |
| Class E |  |  |  |  |  |  |
| **Overall** | 0.2% | 0.0% | 0.1% | 0.2% | -0.1% | 0.1% |
|  | 0.2% | 0.0% | 0.1% | 0.2% | 0.0% | 0.1% |
| Enc Time[%] | 99% | | | 99% | | |
| Dec Time[%] | 98% | | | 101% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B HE** | | | **Low delay B LC** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | 0.2% | 0.7% | -0.1% | 0.1% | 0.1% | 0.0% |
| Class C | 0.2% | 0.1% | 0.6% | 0.3% | 0.3% | -0.3% |
| Class D | 1.0% | 1.9% | 1.2% | 0.7% | 0.6% | 0.4% |
| Class E | 0.7% | 1.3% | 1.2% | 0.4% | -0.1% | 0.4% |
| **Overall** | 0.5% | 1.0% | 0.7% | 0.4% | 0.2% | 0.1% |
|  | 0.5% | 0.9% | 0.5% | 0.4% | 0.2% | 0.1% |
| Enc Time[%] | 99% | | | 98% | | |
| Dec Time[%] | 101% | | | 99% | | |

# Subjective Results

Figures 1 and 2 illustrate examples of the subjective quality enhancements of the proposal with suggested offset parameter values compared with the HM4.0 anchor.

|  |  |
| --- | --- |
| 1. HM4.0 | 1. Proposal |

Figure 1 Frame 181 from the class B “Kimono” sequence (Low delay B LC, QP=32). Roof area contains more details on the right.

|  |  |
| --- | --- |
| 1. HM4 | 1. Proposal |

Figure 2 Frame 220 from class C “BQMall” sequence (Low delay B LC, QP=32). The HM4 frame contains trailing edges.

Figure 3 illustrates the tuning of subjective quality using the proposed transform block size dependent tC offset parameters. In this example, the class C “RaceHorses” sequence is coded using the “All Intra LC” test conditions and QP = 37. It is expected that the grassy areas are covered with small transform block sizes, while the horses are covered with large transform sizes. For subjective quality, it is recommended to apply weaker deblocking to the grassy areas in order to preserve texture and reduce blurriness, while the horses require stronger deblocking. This effect can be achieved by adjusting the slice\_tc\_offset\_intra\_delta parameter to -5, which means that the tC offset for the 4×4 transform blocks is as large as -15, while the offset remains 0 for the 32×32 transform blocks.

|  |
| --- |
| 1. HM4 |
| 1. Adjusted tC offset |

Figure 3 First frame from the class C sequence “RaceHorces” (All Intra LC; QP=37). Top: HM4 deblocked. Bottom: Deblocked with adjusted tC offset parameters to preserve texture details in grassy areas.

# Source Code

NSQT transform index lookup code is additionally implemented, because of the way the NSQT transform index is mapped onto a regular square quadtree partitioning in HM4.

# Conclusion

This contribution proposed to adjust the tC and β parameters of the deblocking filter by signaling the deblocking\_filter\_control\_present\_flag in the SPS and if enabled, then signal deblocking adjustment parameters in the slice header that allow to adjust the psycho-visual effect of the deblocking filter for different block sizes (transform sizes) and for intra or inter blocks. Hence, there are subjective quality benefits and also BD-rate gains of -0.3% for all-intra HE and -0.1% for random access HE test conditions.

# References

[1] B. Bross, W.-J. Han, J.-R. Ohm, G. J. Sullivan, T. Wiegand, “WD4: Working Draft 4 of High-Efficiency Video Coding,” 6th JCT-VC Meeting, Turin, Italy, July 2011, Doc. JCTVC-F803

[2] T. Yamakage, S. Asaka, T. Chujoh (Toshiba), M. Karczewicz, I. S. Chong (Qualcomm), “CE12: Deblocking Filter Parameter Adjustment in Slice Level,” 6th JCT-VC Meeting, Turin, Italy, July 2011, Doc. JCTVC-F143

# Working Draft

The following working draft changes are based on WD4\_d5 (JCTVC-F803).

“**7.3.2.1 Sequence parameter set RBSP syntax**”

|  |  |
| --- | --- |
| seq\_parameter\_set\_rbsp( ) { |  |
| **...** |  |
| **chroma\_pred\_from\_luma\_enabled\_flag** |  |
| **deblocking\_filter\_control\_present\_flag** | u(1) |
| **loop\_filter\_across\_slice\_flag** |  |
| **sample\_adaptive\_offset\_enabled\_flag** |  |
| **adaptive\_loop\_filter\_enabled\_flag** |  |
| **pcm\_loop\_filter\_disable\_flag** |  |
| ... |  |
| } |  |

“**7.3.3 Slice header syntax**”

|  |  |
| --- | --- |
| slice\_header( ) { |  |
| ... |  |
| if( deblocking\_filter\_control\_present\_flag ) { |  |
| **disable\_deblocking\_filter\_idc** | u(1) |
| if( disable\_deblocking\_filter\_idc != 1 ) { |  |
| **slice\_beta\_offset** /\* equal to 0 \*/ | se(v) |
| **slice\_tc\_offset\_intra** /\* equal to 0 \*/ | se(v) |
| **slice\_tc\_offset\_intra\_delta** /\* equal to -1 \*/ | se(v) |
| if ( slice\_type != I) { |  |
| **slice\_tc\_offset\_inter** /\* equal to -2 \*/ | se(v) |
| **slice\_tc\_offset\_inter\_delta** /\* equal to 1 \*/ | se(v) |
| } |  |
| } |  |
| } |  |
| } |  |

“**8.6.1.4.1 Decision process for luma block edge**

Inputs of this process are:

– a luma location ( xC, yC ) specifying the top-left luma sample of the current coding unit relative to the top left luma sample of the current picture,

– a luma location ( xB, yB ) specifying the top-left luma sample of the current block relative to the top left luma sample of the current coding unit,

– a variable verticalEdgeFlag,

– a variable bS specifying the boundary filtering strength,

– variables log2TrafoWidth and log2TrafoHeight specifying the width and height of the transform unit that includes the luma location ( xB, yB ) within the current coding unit,

Output of this process is:

– variables dE, dEp1 and dEq1 containing decisions,

– one-dimensional array of size (8), dS containing decisions.

Let s’ represent the luma sample array recPictureL of the current picture.

A variable β is specified as Table 8-15 with quantization parameter Clip3(0, 55, qPL + slice\_beta\_offset) as input.

A variable tC is specified as follows:

– variable log2TrafoSize is derived as ( log2TrafoWidth + log2TrafoHeight ) / 2,

– If bS is greater than 2, the variable tC is specified as Table 8-15 with quantization parameter Clip3(0, 55, qPL + slice\_tc\_offset\_intra + (5 – log2TrafoSize) \* slice\_tc\_offset\_intra\_delta ) as input,

– Otherwise (bS is equal or less than 2), the variable tC is specified specified as Table 8-15 with quantization parameter Clip3(0, 55, qPL + slice\_tc\_offset\_inter + (5 – log2TrafoSize) \* slice\_tc\_offset\_inter\_delta ) as input.

…”

**“8.6.1.4.2 Filtering process for luma block edge**

Inputs of this process are:

– a luma location ( xC, yC ) specifying the top-left luma sample of the current coding unit relative to the top left luma sample of the current picture,

– a luma location ( xB, yB ) specifying the top-left luma sample of the current block relative to the top left luma sample of the current coding unit,

– a variable verticalEdgeFlag,

– a variable bS specifying the boundary filtering strength,

– variables dE, dEp1 and dEq1 containing decisions,

– one-dimensional array of size (8), dS containing decisions,

– a variable bSL,

– a variable tCL,

– variables log2TrafoWidth and log2TrafoHeight specifying the width and height of the transform unit that includes the luma location ( xB, yB ) within the current coding unit,

Output of this process is:

– modified reconstruction of the picture.

Let s’ represent the luma sample array recPictureL of the current picture.

Depending on pcm\_flag, a variable β is specified as follows:

– If pcm\_flag is equal to 1, the variable β is specified as Table 8-15 with luma quantization parameter 0 as input.

– Otherwise, a variable β is specified as Table 8-15 with quantization parameter Clip3(0, 55, qPL + slice\_beta\_offset) as input.

A variable tC is specified as follows:

– variable log2TrafoSize is derived as ( log2TrafoWidth + log2TrafoHeight ) / 2,

– If bS is greater than 2, the variable tC is specified as Table 8-15 with quantization parameter Clip3(0, 55, qPL + slice\_tc\_offset\_intra + (5 – log2TrafoSize) \* slice\_tc\_offset\_intra\_delta ) as input,

– Otherwise (bS is equal or less than 2), the variable tC is specified specified as Table 8-15 with quantization parameter Clip3(0, 55, qPL + slice\_tc\_offset\_inter + (5 – log2TrafoSize) \* slice\_tc\_offset\_inter\_delta ) as input.

…”

**“8.6.1.4.3 Filtering process for chroma block edge**

...

Inputs of this process are:

– a luma location ( xC, yC ) specifying the top-left chroma sample of the current coding unit relative to the top left chroma sample of the current picture,

– a luma location ( xB, yB ) specifying the top-left chroma sample of the current block relative to the top left chroma sample of the current coding unit,

– a variable verticalEdgeFlag,

– a variable bS specifying the boundary filtering strength,

– a variable cIdx specifying the chroma component index.

– a variable xPOS,

– a variable bSL,

– a variable tCL,

– variables log2TrafoWidth and log2TrafoHeight specifying the width and height of the transform unit that includes the luma location ( xB, yB ) within the current coding unit,

Output of this process is:

– modified reconstruction of the picture.

Let s’ be a variable specifying chroma sample array which is derived as follows.

– If cIdx is equal to 1, s’ represents the chroma sample array recPictureCb of the current picture.

– Otherwise (cIdx is equal to 2), s’ represents the chroma sample array recPictureCr of the current picture.

A variable tC is specified as follows:

– variable log2TrafoSize is derived as ( log2TrafoWidth + log2TrafoHeight ) / 2,

– If bS is greater than 2, the variable tC is specified as Table 8-15 with quantization parameter Clip3(0, 55, qPL + slice\_tc\_offset\_intra + (5 – log2TrafoSize) \* slice\_tc\_offset\_intra\_delta ) as input,

– Otherwise (bS is equal or less than 2), the variable tC is specified specified as Table 8-15 with quantization parameter Clip3(0, 55, qPL + slice\_tc\_offset\_inter + (5 – log2TrafoSize) \* slice\_tc\_offset\_inter\_delta ) as input.

...”

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