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| *Title:* | **Deblocking of IPCM Blocks Containing Reconstructed Samples** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes a modification to the HM4 deblocking loop filter in case of IPCM blocks containing reconstructed samples. The HM4 deblocking filter always assigns quantization parameter value zero to the IPCM blocks, which results in disabling deblocking filtering for the left and top edges of the IPCM blocks. The proposal is to assign a quantization parameter value to the IPCM block, which is predicted from the neighboring quantization group.

# Introduction

The present HEVC version specified in Working Draft version 4 (WD4) [1] supports the IPCM intra mode, which allows the encoder to represent luma and chroma CU samples directly into the bitstream as uncompressed data. There are several possible usages for IPCM coding [2]:

* As a means for the encoder to ensure that the size in bits of a coded representation of a CU does not exceed the bits required to send the uncompressed CU data. In this case the encoder may code the CU data as IPCM.
* Another usage of IPCM is to avoid encoder pipeline stalls [2]. In this case, the encoder may decide to represent non-original samples, e.g., reconstructed samples, as IPCM.

The WD4 also signals the pcm\_loop\_filter\_disable\_flag in the sequence parameter set (SPS). This flag specifies whether the loop filter processes are disabled or enabled on samples of IPCM blocks. If the pcm\_loop\_filter\_disable\_flag value is equal to 1, then deblocking, SAO, and ALF processes are disabled on the samples of IPCM blocks; otherwise, if the pcm\_loop\_filter\_disable\_flag value is equal to 0, the loop filters are enabled.

Original uncompressed samples that are coded as IPCM samples are distortion free. Therefore, in-loop filtering, such as deblocking, can be skipped for these IPCM samples. Conversely, the encoder implementations that represent non-original reconstructed samples as IPCM may need to perform in-loop deblocking along both sides of the IPCM CU boundaries.

The HEVC deblocking filter processes certain TU and PU edges based on the result from the boundary strength computation and deblocking decisions (on/off, weak/strong, weak filter strength) that are dependent on thresholds variables β and tC. In order to lookup these thresholds in a table, the quantization parameter (QP) of the CU is required. The deblocking filter obtains the QP value from the CU that contains the current edge to be deblocked (luma-QP for luma edge; chroma-QP for chroma edge). The problem is that WD4 specifies that QP always equals 0 for IPCM type CUs (pcm\_flag=true), which effectively disables the deblocking filter for the left and top edges of the IPCM CU, while the right and bottom edge may be deblocking filtered depending on neighboring CU types and QPs. This contribution proposes a solution to properly support the deblocking process for IPCM blocks containing reconstructed samples.

The following briefly describes the sub-LCU-level delta quantization parameter (dQP) method [3], which will be referred to in the next section. This method allows dQP signaling for CUs smaller than the LCU size. The purpose is to allow finer granularity rate and visual quality control. The dQpMinCuSize parameter is defined as the minimum CU quantization group size that can signal dQP. All leaf CUs within a dQpMinCuSize quantization group share the same dQP. A dQP is also signaled for a leaf CU of the LCU quadtree, if the leaf CU is larger than or equal to the dQpMinCuSize. dQP is sent only when at least one nonzero coefficient exists (CBF=true). The dQP value is added to the predicted QPY,PREV value from the neighboring quantization group (on the left or last in decoding order if unavailable) to produce the QP value for the present CU.

# Deblocking of IPCM Blocks Containing Reconstructed Samples

Figure 1(a) illustrates the HM4 deblocking filter behavior in case the deblocking loop filter is disabled (pcm\_loop\_filter\_disable\_flag = 1) for IPCM blocks versus enabled. Figure 1(b) illustrates the proposed behavior. In the figures, the middle CU is the IPCM block and in HM4 the QP is assigned value 0 for deblocking. This contribution proposes to assign a meaningful QP value to the IPCM block in order to obtain the deblocking behavior in Figure 1(b).

QPB Non-IPCM

QPB Non-IPCM

QPB Non-IPCM

QPR Non- IPCM

QP=0

IPCM

HM4:

Proposal:

Deblocking filtered samples

Loop filters OFF for IPCM

QPR Non-IPCM

QP=0

IPCM

Loop filters ON for IPCM

No deblocking for this edge

No deblocking for this edge

QPB Non-IPCM

QPR Non-IPCM

QPPREV

IPCM

Loop filters OFF for IPCM

QPR Non-IPCM

QPPREV

IPCM

Loop filters ON for IPCM

(a)

(b)

Figure Current HM4 situation for deblocking of IPCM block samples (a) versus proposed deblocking (b) in case deblocking is enabled or disabled for IPCM blocks.

WD4 specifies the following for luma block edge filtering in case of IPCM:

“8.6.1.4.2 Filtering process for luma block edge

...

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, the variable β is specified as Table 8-15 with luma quantization parameter qPL as input.

…”

And:

“8.6.1.4.5 Filtering process for a luma sample

…

Each of the filtered sample values, pi’ with i = 0..nDp-1, is substituted by the corresponding input sample value pi if all of the following conditions are true.

–    pi is a sample of an I\_PCM block.

–    pcm\_loop\_filter\_disable\_flag value is equal to 1.

Similarly, each of the filtered sample values, qj’ with j = 0..nDq-1, is substituted by the corresponding input sample value qj if all of the following conditions are true.

–    qj is a sample of an I\_PCM block.

–    pcm\_loop\_filter\_disable\_flag value is equal to 1.

…”

This means that in case the pcm\_flag equals 1 (IPCM block), the quantization parameter for luma deblocking is always 0. Therefore, independent of the value of pcm\_loop\_filter\_disable\_flag (loop filters are enabled or disabled for IPCM), the deblocking filter will use the value 0 for the threshold variable β, which disables luma deblocking for the left and top edges of the IPCM block (on both sides of the edges) as illustrated in Figure 1(a). Furthermore, in case the blocks on the right and bottom of the IPCM block are not IPCM blocks, then the right and bottom edges of the IPCM block will be deblocking filtered on both sides of the edge (in case the deblocking filter is enabled for IPCM blocks) using the threshold variable β based on the QP value of the neighboring blocks. In case the deblocking filter is disabled for IPCM blocks, the right and bottom edges will only be filtered on a single side.

This contribution proposes the deblocking behavior in Figure 1(b). In case the deblocking filter is enabled for IPCM blocks, all four edges of the IPCM block are filtered on both sides of the edges, while only on a single side in case the deblocking filter is disabled for IPCM blocks.

The problem is that IPCM blocks do not have a QP value in WD4 that can be used to lookup deblocking variable β (and also tC). The idea is to assign the QPY,PREV value (dQP method) to the IPCM block instead of value 0. The working draft specifies that the QPY,PREV quantization parameter is the luma quantization parameter of the left neighboring quantization group of coding units in the current slice. If the left neighbor quantization group in the current slice is unavailable, QPY,PREV is the luma quantization parameter, of the previous quantization group in decoding order in the current slice.

# Results

To illustrate that there is no impact of the proposed changes to the deblocking filter in case of the common test conditions, the anchor was perfectly reproduced in the following results. The execution times were measured in a computing environment with variable capability.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class C | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class D | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class E | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
|  | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 100% | | | 100% | | |
| Dec Time[%] | 102% | | | 101% | | |
|  |  |  |  |  |  |  |
|  | **Random Access HE** | | | **Random Access LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class C | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class D | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class E |  |  |  |  |  |  |
| **Overall** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
|  | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 98% | | | 100% | | |
| Dec Time[%] | 99% | | | 102% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B HE** | | | **Low delay B LC** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class C | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class D | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Class E | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Overall** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
|  | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Enc Time[%] | 99% | | | 99% | | |
| Dec Time[%] | 102% | | | 101% | | |

# Working Draft

“8.6.1.4.2 Filtering process for luma block edge

...

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 quantization parameter QPY,PREV as input.

–    Otherwise, the variable β is specified as Table 8-15 with luma quantization parameter qPL as input.

Depending on bS and on pcm\_flag, a variable tC is specified as follows:

–    If bS is greater than 2 and pcm\_flag is equal to 0, the variable tC is specified as Table 8-15 with luma quantization parameter Clip3(0, 55, qPL + 2 ) as input.

–    If pcm\_flag is equal to 1, the variable tC is specified as Table 8-15 with quantization parameter Clip3(0, 55, QPY,PREV + 2 ) as input.

–    Otherwise (bS is equal or less than 2), the variable tC is specified as Table 8-15 with luma quantization parameter qPL as input.

…”

The substitution with unfiltered samples in case of pcm\_loop\_filter\_disable\_flag value is equal to 1 remains the same.

“8.6.1.4.3 Filtering process for chroma block edge

…

A variable tC is specified as follows:

– If bS is greater than 2 and pcm\_flag is equal to 0, the variable tC is specified as Table 8-15 with quantization parameter Clip3(0, 55, qPL + 2 ) as input.

– If pcm\_flag is equal to 1, the variable tC is specified as Table 8-15 with quantization parameter Clip3(0, 55, QPY,PREV + 2 ) as input.

– Otherwise (bS is equal or less than 2), the variable tC is specified as Table 8-15 with luma quantization parameter qPL as input.

…”

# Conclusion

This contribution proposed assigning the quantization parameter value predicted from the neighboring quantization group to the IPCM block in order to properly deblock the IPCM block containing non-original reconstructed samples.

# References

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3. T.-D. Chuang, C.-Y. Chen, Y.-L. Chang, Y.-W. Huang, S. Lei, “Quantization: Sub-LCU Delta QP,” 5th JCT-VC Meeting, Geneva, Switzerland, March 2011, Doc. JCTVC-E051

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