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| --- | --- | --- | --- |
| *Title:* | **Non-CE2: improved inter merge for unified IBC and inter framework** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposed an improved inter merge for the unified IBC and inter framework, which was tested in CE-2 Test-1. The inter merge is improved in three aspects: (1) checking MV and BV uniqueness and validation; (2) adding one temporal BV predictor; (3) adding default BVs. Compared to SCM-3.0 anchors, for 444 lossy coding, the proposed scheme reportedly achieves average {Y, U, V} BD rate gain of {-1.4%, -2.9%, -2.8%}, {-3.4%, -5.3%, -5.3%} and {-3.6%, -5.0%, -5.1%} for the category (RGB/YUV, text & graphics with motion, 1080p&720p) for AI, RA and LD, respectively. And the 444 lossless coding reportedly achieves total bit-rate saving of 0.5%, -1.2% and -1.3% for the category (RGB/YUV, text & graphics with motion, 1080p&720p) for AI, RA and LD, respectively. Additionally, non-normative encoder-only improvements proposed in JCTVC-T0116 were tested together with the proposed inter merge modifications in this unified framework. Compared to SCM-3.0 anchors, for 444 lossy coding, the proposed scheme reportedly achieves average {Y, U, V} BD rate gain of {-2.9%, -4.3%, -4.2%}, {-4.4%, -6.3%, -6.3%} and {-4.7%, -6.3%, -6.2%} for the category (RGB/YUV, text & graphics with motion, 1080p&720p) for AI, RA and LD, respectively. And the 444 lossless coding reportedly achieves total bit-rate saving of -0.1%, -1.3% and -1.3% for the category (RGB/YUV, text & graphics with motion, 1080p&720p) for AI, RA and LD, respectively.

# Introduction

In unified IBC and inter framework tested in CE-2 Test-1 [2], IBC is treated as inter mode by adding the current reconstructed picture without deblocking and SAO in the reference picture list. IBC will share the same merge process with traditional inter mode. Figure 1 shows an example of reference picture lists in this unified framework. Current partially reconstructed picture Pic'(t) is added as a long term reference picture in the reference list-0. This contribution proposed a number of modifications to the existing inter merge process in the unified framework.



Figure 1. IBC mode is signaled as inter mode

## Modified inter merge

The inter merge process is proposed to be modified in the following ways:

1. Only valid BV merge candidates are added in the merge candidate list. BVs are considered invalid if any of the following is true:

* If the BV makes reference to any unreconstructed samples or any samples within the same CU;
* If the BV makes references to any samples outside of the picture boundary;
* If the BV makes reference to samples inside a region which is not allowed for IBC (for parallel decoding implementation consideration).

1. One BV from the temporal collocated blocks in collocated reference picture if it is available. This is achieved using the existing TMVP process by setting the target reference picture to the current partially reconstructed picture Pic’(t) (i.e., the last reference picture of list-0);

For example, if collocated PU C5 is IBC coded shown in Figure 2, then its BV will be used as merge candidate.

1. After checking spatial merge candidates, temporal merge candidates, bi-prediction merge candidates, if the list is still not full, then traditional default MVs and five default BVs are appended in an interleaving order starting from MV first until the list is full. The five default BVs are defined as follows in order:

(-PUx - PUw, 0), (-PUx – 2\*PUw, 0), (0, -PUy - PUh), (0, -PUy – 2\*PUh), (-PUx - PUw, -PUy - PUh).

Where (PUx, PUy) is the coordinates of the top left luma sample in the PU relative to the top left luma sample in the CU, and PUw and PUh are the PU width and PU height, respectively.



Figure 2. The BV from collocated block in collocated reference picture is added as one merge candidate

## Encoder optimizations

The encoder-only improvements proposed in JCTVC-T0116 [3] are tested together with the proposed inter merge modifications. The additional Nx2N and 2NxN partitions of IBC mode for large CU size (32x32, 16x16) is not incorporated in this framework because it is already included in BV and MV mixed mode checking in CE-2 Test-1. The BV and MV bi-prediction search, which is allowed under the unified framework, is added for 2Nx2N partitions if CU size is no greater than 32x32. The BV and MV bi-prediction search is only performed when the MV resolution in the current slice is not integer MV only (i.e., use\_integer\_mv\_flag = 0) in order to reduce the encoding complexity.

# Simulation results

The compression performance of the proposed method is compared with SCM-3.0 anchors, using the CE-2 test conditions [2]. There are two tests based on CE-2 Test-1 software:

Test-A: modified inter merge method

Test-B: Test-A + encoder improvements in JCTVC-T0116

The results of Test-A are reported from Table 1 to Table 4. The results of Test-B are reported from Table 5 to Table 8. The accompanying spreadsheets are provided for further details.

As shown in Table 1 compared with SCM-3.0 anchors, for 444 lossy coding, the proposed modified inter merge achieves average {Y, U, V} BD rate gain of {-1.6%, -3.0%, -3.1%}, {-3.6%, -5.3%, -5.4%} and {-3.8%, -5.1%, -5.4%} for the category (YUV, text & graphics with motion, 1080p&720p) for AI, RA and LD, respectively. As shown in Table 2, compared with SCM-3.0 anchors, for 420 lossy coding, the proposed IBC search achieves average {Y, U, V} BD rate gain of {-2.8%, -3.2%, -3.2%}, {-2.9%, -4.1%, -3.9%} and {-2.4%, -3.5%, -3.7%} for the category (Text & graphics with motion, 720p) for AI, RA and LD, respectively.

As shown in Table 5, compared with SCM-3.0 anchors, for 444 lossy coding, the proposed modified inter merge together with encoder optimizations in JCTVC-T0116 achieves average {Y, U, V} BD rate gain of {-3.1%, -4.3%, -4.3%}, {-4.5%, -6.3%, -6.5%} and {-4.9%, -6.3%, -6.3%} for the category (YUV, text & graphics with motion, 1080p&720p) for AI, RA and LD, respectively. As shown in Table 6, compared with SCM-3.0 anchors, for 420 lossy coding, the proposed IBC search achieves average {Y, U, V} BD rate gain of {-4.6%, -5.0%, -5.1%}, {-3.6%, -4.7%, -4.9%} and {-3.3%, -3.6%, -5.5%} for the category (Text & graphics with motion, 720p) for AI, RA and LD, respectively.

Table 9 and Table 10 report the 444 lossy results for Test-A and Test-B compared to CE-2 Test-1, respectively. Test-A achieves average Y BD rate gain of -0.9%, -1.3% and -1.4% for the category (YUV, text & graphics with motion, 1080p&720p) for AI, RA and LD, respectively. Test-B achieves average Y BD rate gain of -2.3%, -2.2% and -2.5% for the category (YUV, text & graphics with motion, 1080p&720p) for AI, RA and LD, respectively. The encoding complexity of Test-B is also lower compared to CE-2 Test-1 with encoder optimization.

Table 1. Average BD rate reduction for Test-A 444 lossy coding compared with SCM-3.0 anchors

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ` | **All Intra** | | | **Random Access** | | | **Low delay B** | | |
|  | G/Y | B/U | R/V | G/Y | B/U | R/V | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p & 720p | -1.2% | -2.7% | -2.6% | -3.2% | -5.2% | -5.1% | -3.4% | -4.9% | -4.8% |
| RGB, mixed content, 1440p & 1080p | -0.7% | -1.5% | -1.6% | -1.2% | -2.7% | -2.9% | -1.6% | -3.1% | -3.2% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | 0.0% | 0.0% | -0.2% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | -0.2% | -0.1% | -0.1% | 0.1% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p & 720p | -1.6% | -3.0% | -3.1% | -3.6% | -5.3% | -5.4% | -3.8% | -5.1% | -5.4% |
| YUV, mixed content, 1440p & 1080p | -1.1% | -2.1% | -2.2% | -1.6% | -3.5% | -3.6% | -2.1% | -4.7% | -5.1% |
| YUV, Animation, 720p | -0.1% | -0.3% | -0.4% | -0.2% | -0.8% | -0.3% | -0.1% | -0.1% | -0.1% |
| YUV, camera captured, 1080p | 0.0% | -0.1% | -0.1% | -0.2% | -0.2% | -0.3% | 0.0% | 0.1% | 0.1% |
| Enc Time[%] | 107% | | | 100% | | | 100% | | |
| Dec Time[%] | 95% | | | 95% | | | 97% | | |

Table 2. Average BD rate reduction for Test-A 420 lossy coding compared with SCM-3.0 anchors

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | **Random Access** | | | **Low delay B** | | |
|  | G/Y | B/U | R/V | G/Y | B/U | R/V | G/Y | B/U | R/V |
| Text & graphics with motion, 720p | -2.8% | -3.2% | -3.2% | -2.9% | -4.1% | -3.9% | -2.4% | -3.5% | -3.7% |
| Mixed content, 480p | -1.3% | -1.3% | -1.5% | -0.7% | -1.5% | -1.5% | 0.2% | 0.1% | -0.9% |
| Animation, 768p | -1.1% | -1.9% | -2.3% | -1.1% | -3.0% | -2.7% | -0.5% | -1.0% | -2.6% |
| Average of all sequences | -2.0% | -2.4% | -2.6% | -1.9% | -3.1% | -3.0% | -1.3% | -2.0% | -2.7% |
| Enc Time[%] | 92% | | | 100% | | | 99% | | |
| Dec Time[%] | 98% | | | 94% | | | 96% | | |

Table 3. Average BD rate reduction for Test-A 444 lossless coding compared with SCM-3.0 anchors

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | **Random Access** | | | | **Low Delay B** | | | |
|  | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) |
|  |
| RGB, text & graphics with motion, 1080p & 720p | 0.2% | 0.0% | -1.8% | 1.7% | -1.4% | -1.4% | -3.0% | 0.0% | -1.5% | -1.6% | -4.9% | -0.1% |
| RGB, mixed content, 1440p & 1080p | 0.1% | 0.1% | -0.2% | 0.3% | -0.2% | -0.2% | -0.4% | 0.0% | -0.2% | -0.2% | -0.4% | 0.0% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p & 720p | 0.9% | 0.8% | -0.6% | 2.6% | -1.0% | -0.9% | -2.6% | 0.2% | -1.1% | -1.2% | -4.6% | 0.1% |
| YUV, mixed content, 1440p & 1080p | 0.2% | 0.2% | -0.2% | 0.6% | -0.1% | -0.2% | -0.4% | 0.0% | -0.1% | -0.2% | -0.3% | 0.0% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 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% | | | | 96% | | | | 97% | | | |
| Dec Time[%] | 96% | | | | 102% | | | | 101% | | | |

Table 4. Average BD rate reduction for Test-A 420 lossless coding compared with SCM-3.0 anchors

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | **Random Access** | | | | **Low Delay B** | | | |
|  | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) |
|  |
| Text & graphics with motion, 720p | -0.7% | -0.7% | -0.8% | -0.5% | -1.2% | -2.2% | -4.0% | -0.4% | -0.4% | -0.8% | -1.4% | -0.2% |
| Mixed content, 480p | -0.1% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Animation, 768p | 0.1% | 0.1% | 0.1% | 0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| Average of all sequences | -0.2% | -0.3% | -0.8% | 0.1% | -0.1% | -1.1% | -4.0% | 0.0% | -0.1% | -0.4% | -1.4% | 0.0% |
| Enc Time[%] | 74% | | | | 94% | | | | 95% | | | |
| Dec Time[%] | 96% | | | | 97% | | | | 99% | | | |

Table 5. Average BD rate reduction for Test-B 444 lossy coding compared with SCM-3.0 anchors

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | **Random Access** | | | **Low delay B** | | |
|  | G/Y | B/U | R/V | G/Y | B/U | R/V | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p & 720p | -2.8% | -4.3% | -4.0% | -4.3% | -6.3% | -6.1% | -4.5% | -6.2% | -6.1% |
| RGB, mixed content, 1440p & 1080p | -1.5% | -2.3% | -2.4% | -1.4% | -3.1% | -3.2% | -2.1% | -3.6% | -3.8% |
| RGB, Animation, 720p | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.2% | -0.1% | -0.3% | -0.4% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | -0.2% | -0.2% | -0.3% | 0.0% | 0.0% | -0.1% |
| YUV, text & graphics with motion, 1080p & 720p | -3.1% | -4.3% | -4.3% | -4.5% | -6.3% | -6.5% | -4.9% | -6.3% | -6.3% |
| YUV, mixed content, 1440p & 1080p | -1.9% | -2.8% | -3.0% | -2.0% | -3.8% | -4.1% | -2.5% | -4.9% | -5.4% |
| YUV, Animation, 720p | -0.3% | -0.6% | -0.6% | -0.3% | -1.0% | -0.7% | -0.2% | -0.6% | -0.2% |
| YUV, camera captured, 1080p | 0.0% | -0.1% | -0.1% | -0.2% | -0.2% | -0.5% | 0.0% | 0.1% | -0.1% |
| Enc Time[%] | 105% | | | 99% | | | 99% | | |
| Dec Time[%] | 94% | | | 91% | | | 97% | | |

Table 6. Average BD rate reduction for Test-B 420 lossy coding compared with SCM-3.0 anchors

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | **Random Access** | | | **Low delay B** | | |
|  | G/Y | B/U | R/V | G/Y | B/U | R/V | G/Y | B/U | R/V |
| Text & graphics with motion, 720p | -4.6% | -5.0% | -5.1% | -3.6% | -4.7% | -4.9% | -3.3% | -3.6% | -5.5% |
| Mixed content, 480p | -1.6% | -1.7% | -2.0% | -0.9% | -1.6% | -1.9% | 0.0% | -0.5% | -0.4% |
| Animation, 768p | -1.4% | -2.2% | -2.5% | -1.2% | -3.2% | -3.0% | -0.7% | -1.6% | -2.8% |
| Average of all sequences | -3.1% | -3.5% | -3.7% | -2.3% | -3.6% | -3.7% | -1.8% | -2.3% | -3.6% |
| Enc Time[%] | 91% | | | 96% | | | 96% | | |
| Dec Time[%] | 98% | | | 92% | | | 93% | | |

Table 7. Average BD rate reduction for Test-B 444 lossless coding compared with SCM-3.0 anchors

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | **Random Access** | | | | **Low Delay B** | | | |
|  | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) |
|  |
| RGB, text & graphics with motion, 1080p & 720p | -0.5% | -0.8% | -2.7% | 0.2% | -1.5% | -1.7% | -3.7% | -0.3% | -1.5% | -1.9% | -6.1% | -0.2% |
| RGB, mixed content, 1440p & 1080p | -0.1% | -0.1% | -0.3% | 0.1% | -0.2% | -0.2% | -0.5% | 0.0% | -0.2% | -0.2% | -0.4% | 0.0% |
| RGB, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, text & graphics with motion, 1080p & 720p | 0.2% | 0.1% | -1.0% | 1.7% | -1.1% | -1.1% | -3.2% | 0.0% | -1.0% | -1.4% | -5.7% | 0.0% |
| YUV, mixed content, 1440p & 1080p | 0.0% | 0.0% | -0.4% | 0.3% | -0.2% | -0.2% | -0.4% | 0.0% | -0.2% | -0.2% | -0.4% | 0.0% |
| YUV, Animation, 720p | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| YUV, camera captured, 1080p | 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% | | | | 96% | | | | 96% | | | |
| Dec Time[%] | 96% | | | | 94% | | | | 96% | | | |

Table 8. Average BD rate reduction for Test-B 420 lossless coding compared with SCM-3.0 anchors

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | | **Random Access** | | | | **Low Delay B** | | | |
|  | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) | Bit-rate change (Total) | Bit-rate change (Avg.) | Bit-rate change (Min) | Bit-rate change (Max) |
|  |
| Text & graphics with motion, 720p | -2.3% | -2.3% | -3.9% | -0.7% | -1.3% | -2.4% | -4.3% | -0.5% | -0.4% | -0.7% | -1.1% | -0.3% |
| Mixed content, 480p | -0.1% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Animation, 768p | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| Average of all sequences | -0.7% | -1.1% | -3.9% | 0.0% | -0.1% | -1.2% | -4.3% | 0.0% | -0.1% | -0.4% | -1.1% | 0.0% |
| Enc Time[%] | 73% | | | | 94% | | | | 95% | | | |
| Dec Time[%] | 99% | | | | 95% | | | | 97% | | | |

Table 9. Average BD rate reduction for Test-A 444 lossy coding compared with CE-2 Test-1

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | **Random Access** | | | **Low delay B** | | |
|  | G/Y | B/U | R/V | G/Y | B/U | R/V | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p & 720p | -0.6% | -0.7% | -0.7% | -1.0% | -1.2% | -1.2% | -1.1% | -1.1% | -1.2% |
| RGB, mixed content, 1440p & 1080p | 0.0% | 0.0% | -0.1% | -0.5% | -0.5% | -0.5% | -0.7% | -0.6% | -0.7% |
| RGB, Animation, 720p | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.0% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% |
| YUV, text & graphics with motion, 1080p & 720p | -0.9% | -1.0% | -0.9% | -1.3% | -1.4% | -1.2% | -1.4% | -1.3% | -1.4% |
| YUV, mixed content, 1440p & 1080p | -0.6% | -0.4% | -0.5% | -0.7% | -0.8% | -0.9% | -0.7% | -0.8% | -0.9% |
| YUV, Animation, 720p | -0.1% | -0.3% | -0.3% | 0.0% | -0.4% | -0.3% | -0.1% | -0.3% | -0.3% |
| YUV, camera captured, 1080p | -0.1% | -0.2% | -0.2% | 0.0% | -0.1% | -0.2% | 0.0% | 0.1% | -0.1% |

Table 10. Average BD rate reduction for Test-B 444 lossy coding compared with CE-2 Test-1

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra** | | | **Random Access** | | | **Low delay B** | | |
|  | G/Y | B/U | R/V | G/Y | B/U | R/V | G/Y | B/U | R/V |
| RGB, text & graphics with motion, 1080p & 720p | -2.2% | -2.3% | -2.1% | -2.1% | -2.4% | -2.2% | -2.3% | -2.5% | -2.5% |
| RGB, mixed content, 1440p & 1080p | -0.8% | -0.8% | -0.9% | -0.7% | -0.9% | -0.8% | -1.2% | -1.2% | -1.3% |
| RGB, Animation, 720p | -0.1% | -0.1% | -0.1% | 0.0% | -0.1% | -0.1% | 0.0% | -0.2% | -0.1% |
| RGB, camera captured, 1080p | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | 0.0% | -0.1% |
| YUV, text & graphics with motion, 1080p & 720p | -2.3% | -2.3% | -2.2% | -2.2% | -2.5% | -2.4% | -2.5% | -2.5% | -2.4% |
| YUV, mixed content, 1440p & 1080p | -1.3% | -1.2% | -1.3% | -1.1% | -1.1% | -1.3% | -1.2% | -1.0% | -1.2% |
| YUV, Animation, 720p | -0.3% | -0.5% | -0.5% | -0.2% | -0.6% | -0.7% | -0.2% | -0.8% | -0.4% |
| YUV, camera captured, 1080p | -0.1% | -0.2% | -0.2% | 0.0% | -0.2% | -0.4% | 0.0% | 0.1% | -0.3% |

# Patent rights declaration(s)

**InterDigital Communications, Inc. may have IPR relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**

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