|  |  |
| --- | --- |
| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11**  7th Meeting: Geneva, 21-30 November, 2011 | Document: JCTVC-G558 |

|  |  |  |  |
| --- | --- | --- | --- |
| *Title:* | **CE6.c Report on Combination of SDIP and Its Improvements** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
| *Author(s) or Contact(s):* | X. Cao, Y. He (Tsinghua)  X. Peng (USTC)  C. Lai, L. Liu, J. Zheng (HiSilicon)  Jizheng Xu (Microsoft)  H. Yang, J. Song, H. Yu (Huawei)  J. Lim, B. Jeon (LGE)  [J. Sole](mailto:joels@qualcomm.com), R. Joshi, X. Wang, M. Karczewicz (Qualcomm)  J. Xu, E. Maani, A. Tabatabai (Sony). | Email: | laichangcai@huawei.com  jzxu@microsoft.com  jaehyun.lim@lge.com  [joels@qualcomm.com](https://imailcn.huawei.com/owa/?ae=Item&t=IPM.Note&a=New&to=joels%40qualcomm.com&nm='Sole+Rojals%2c+Joel')  haoping.yu@huawei.com  ali.tabatabai@am.sony.com |
| Source: | Tsinghua University, University of Science and Technology of China, HiSilicon, Microsoft, Huawei, LG Electronics, Qualcomm, Sony | | |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Abstract

This document summarizes the experimental results of CE6.c subset for three kinds of simplification of SDIP (short distance intra prediction), results of four improvements based on the simplified SDIP in CE6.c were also summarized which include LM mode position in chroma prediction mode, VLC improvement for SDIP partitioning flags, CABAC improvement for SDIP coefficients encoding and extension the SDIP to chroma prediction. By introducing these improvements, additional about 0.2% gain for luma and about 1.5% gain for chroma can be achieved compared with SDIP.

# Introduction

SDIP was adopted into HM3.0-sdip branch at Geneva in March of this year. Harmonization between SDIP and other intra tools in HM software were investigated and the harmonization effort was judged to be satisfactory at Turin meeting in July. This CE subset is to conduct further tests, based on the comments received in the discussions at Turin meeting, on the tradeoff of coding efficiency and encoding/decoding running time of the harmonized SDIP integrated on the HM4.0 software platform. The additional gain from improvements that firstly proposed in JCTVC-F505[1] (A chroma coding scheme for SDIP mode), JCTVC-F110[2] (LM mode harmonization), JCTVC-F111[3] (Intra prediction mode coding with CAVLC on SDIP) as well as the harmonization in HE residual coding described in JCTVC-F556[4] have also been tested. Additional improvements in MPM coding and CABAC from Sony (JCTVC-G354) have also been included and added to this report.

# Simplification of SDIP and results in CE6.c

The harmonized SDIP in Turin meeting introduced two types of PUs which were named as 2NxhN and hNx2N for CUs whose size is smaller than 64x64, where h means half or 0.5. Three cases of simplification were made for SDIP to find the best trade-off between coding efficiency and encoding complexity, both case\_1 and case\_2 are encoder only simplification and case\_3 need some change at decoder based on SDIP. The description of SDIP and its simplification can be found in JCTVC-G558[5].

## case\_1: early skip based simplification

In this case, the non square PU type maybe skipped according to the coding results of square PU,

Table 1&2 are the results with and without classF sequences for case\_1.

Table 1 Results of case\_1 without classF

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.5% | -1.5% | -1.9% | -1.2% | -1.9% | -2.5% |
| Class B | -1.2% | -2.4% | -2.6% | -2.3% | -2.4% | -3.0% |
| Class C | -1.5% | -1.4% | -1.7% | -2.3% | -2.4% | -2.9% |
| Class D | -1.5% | -1.2% | -1.1% | -2.1% | -2.1% | -2.1% |
| Class E | -2.2% | -5.3% | -4.9% | -3.8% | -7.1% | -5.6% |
| **Overall** | -1.35% | -2.22% | -2.34% | -2.28% | -2.95% | -3.10% |
|  | -1.35% | -2.21% | -2.32% | -2.28% | -2.93% | -3.07% |
| Enc Time[%] | 127% | | | 135% | | |
| Dec Time[%] | 101% | | | 102% | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access HE** | | | **Random Access LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.5% | -0.7% | -1.2% | -0.9% | -0.7% | -1.2% |
| Class B | -0.7% | -1.2% | -1.3% | -1.2% | -1.4% | -1.4% |
| Class C | -0.8% | -0.8% | -1.0% | -1.2% | -1.3% | -1.4% |
| Class D | -0.6% | -0.6% | -0.6% | -0.9% | -1.0% | -1.0% |
| Class E |  |  |  |  |  |  |
| **Overall** | -0.63% | -0.86% | -1.05% | -1.05% | -1.13% | -1.24% |
|  | -0.63% | -0.90% | -1.08% | -1.06% | -1.12% | -1.22% |
| Enc Time[%] | 105% | | | 104% | | |
| Dec Time[%] | 100% | | | 99% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B HE** | | | **Low delay B LC** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | -0.2% | -0.3% | -0.8% | -0.3% | -0.4% | -0.5% |
| Class C | -0.3% | -0.5% | -0.6% | -0.4% | -0.3% | -0.8% |
| Class D | -0.1% | -0.1% | -0.4% | -0.3% | -0.4% | -1.2% |
| Class E | -0.6% | -2.5% | -2.3% | -0.9% | -2.3% | -2.0% |
| **Overall** | -0.27% | -0.69% | -0.93% | -0.46% | -0.73% | -1.04% |
|  | -0.27% | -0.72% | -0.89% | -0.46% | -0.73% | -0.99% |
| Enc Time[%] | 104% | | | 103% | | |
| Dec Time[%] | 98% | | | 100% | | |

Table 2 Results of case\_1 with classF.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.5% | -1.5% | -1.9% | -1.2% | -1.9% | -2.5% |
| Class B | -1.2% | -2.4% | -2.6% | -2.3% | -2.4% | -3.0% |
| Class C | -1.5% | -1.4% | -1.7% | -2.3% | -2.4% | -2.9% |
| Class D | -1.5% | -1.2% | -1.1% | -2.1% | -2.1% | -2.1% |
| Class E | -2.2% | -5.3% | -4.9% | -3.8% | -7.1% | -5.6% |
| Class F | -6.1% | -5.0% | -5.1% | -6.7% | -5.1% | -5.2% |
| **Overall** | -2.1% | -2.7% | -2.8% | -3.0% | -3.3% | -3.4% |
|  | -2.1% | -2.7% | -2.8% | -3.0% | -3.3% | -3.4% |
| Enc Time[%] | 127% | | | 134% | | |
| Dec Time[%] | 101% | | | 101% | | |
|  |  |  |  |  |  |  |
|  | **Random Access HE** | | | **Random Access LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.5% | -0.7% | -1.2% | -0.9% | -0.7% | -1.2% |
| Class B | -0.7% | -1.2% | -1.3% | -1.2% | -1.4% | -1.4% |
| Class C | -0.8% | -0.8% | -1.0% | -1.2% | -1.3% | -1.4% |
| Class D | -0.6% | -0.6% | -0.6% | -0.9% | -1.0% | -1.0% |
| Class E |  |  |  |  |  |  |
| Class F | -4.4% | -3.7% | -4.0% | -4.9% | -3.9% | -4.1% |
| **Overall** | -1.4% | -1.4% | -1.6% | -1.8% | -1.7% | -1.8% |
|  | -1.3% | -1.4% | -1.6% | -1.8% | -1.7% | -1.8% |
| Enc Time[%] | 105% | | | 104% | | |
| Dec Time[%] | 100% | | | 99% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B HE** | | | **Low delay B LC** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | -0.2% | -0.3% | -0.8% | -0.3% | -0.4% | -0.5% |
| Class C | -0.3% | -0.5% | -0.6% | -0.4% | -0.3% | -0.8% |
| Class D | -0.1% | -0.1% | -0.4% | -0.3% | -0.4% | -1.2% |
| Class E | -0.6% | -2.5% | -2.3% | -0.9% | -2.3% | -2.0% |
| Class F | -2.9% | -2.9% | -2.6% | -2.9% | -2.5% | -2.7% |
| **Overall** | -0.8% | -1.1% | -1.3% | -0.9% | -1.1% | -1.4% |
|  | -0.8% | -1.1% | -1.2% | -1.0% | -1.1% | -1.3% |
| Enc Time[%] | 104% | | | 103% | | |
| Dec Time[%] | 98% | | | 100% | | |

## case\_2: fast non-square PU selection

In addition to the early skip method described in case\_1, a fast non-square PU selection method was used to further reduce the encoder complexity in this case. Table 3&4 are the results with and without classF sequences for case\_2.

Table 3 Results of case\_2 without classF

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.3% | -1.1% | -1.4% | -0.8% | -1.3% | -1.8% |
| Class B | -0.9% | -2.0% | -2.1% | -1.6% | -1.6% | -2.1% |
| Class C | -1.0% | -1.0% | -1.3% | -1.6% | -1.8% | -2.2% |
| Class D | -1.1% | -0.9% | -0.9% | -1.6% | -1.6% | -1.7% |
| Class E | -1.6% | -4.3% | -3.9% | -2.7% | -5.7% | -4.4% |
| **Overall** | -1.0% | -1.7% | -1.8% | -1.6% | -2.2% | -2.4% |
|  | -1.0% | -1.7% | -1.8% | -1.6% | -2.2% | -2.3% |
| Enc Time[%] | 113% | | | 118% | | |
| Dec Time[%] | 102% | | | 101% | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access HE** | | | **Random Access LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.2% | -0.3% | -0.6% | -0.6% | -0.4% | -0.6% |
| Class B | -0.4% | -0.9% | -1.2% | -0.8% | -0.9% | -1.1% |
| Class C | -0.5% | -0.8% | -0.8% | -0.8% | -1.0% | -1.1% |
| Class D | -0.5% | -0.5% | -0.8% | -0.7% | -1.0% | -0.8% |
| Class E |  |  |  |  |  |  |
| **Overall** | -0.41% | -0.67% | -0.87% | -0.71% | -0.84% | -0.90% |
|  | -0.41% | -0.67% | -0.89% | -0.71% | -0.81% | -0.89% |
| Enc Time[%] | 105% | | | 104% | | |
| Dec Time[%] | 99% | | | 99% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B HE** | | | **Low delay B LC** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | -0.1% | -0.4% | -0.3% | -0.2% | -0.2% | -0.6% |
| Class C | -0.2% | -0.2% | -0.4% | -0.3% | -0.3% | -0.8% |
| Class D | -0.1% | -0.2% | -0.7% | -0.2% | -0.2% | -0.7% |
| Class E | -0.4% | -1.1% | -1.4% | -0.7% | -3.2% | -2.3% |
| **Overall** | -0.18% | -0.43% | -0.66% | -0.32% | -0.77% | -1.00% |
|  | -0.18% | -0.41% | -0.66% | -0.32% | -0.82% | -0.99% |
| Enc Time[%] | 104% | | | 103% | | |
| Dec Time[%] | 98% | | | 99% | | |

Table 4 Results of case\_2 with classF

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.3% | -1.1% | -1.4% | -0.8% | -1.3% | -1.8% |
| Class B | -0.9% | -2.0% | -2.1% | -1.6% | -1.6% | -2.1% |
| Class C | -1.0% | -1.0% | -1.3% | -1.6% | -1.8% | -2.2% |
| Class D | -1.1% | -0.9% | -0.9% | -1.6% | -1.6% | -1.7% |
| Class E | -1.6% | -4.3% | -3.9% | -2.7% | -5.7% | -4.4% |
| Class F | -5.3% | -4.2% | -4.3% | -5.5% | -4.1% | -4.1% |
| **Overall** | -1.7% | -2.1% | -2.2% | -2.3% | -2.5% | -2.6% |
|  | -1.7% | -2.1% | -2.2% | -2.3% | -2.5% | -2.6% |
| Enc Time[%] | 113% | | | 118% | | |
| Dec Time[%] | 101% | | | 101% | | |
|  |  |  |  |  |  |  |
|  | **Random Access HE** | | | **Random Access LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.2% | -0.3% | -0.6% | -0.6% | -0.4% | -0.6% |
| Class B | -0.4% | -0.9% | -1.2% | -0.8% | -0.9% | -1.1% |
| Class C | -0.5% | -0.8% | -0.8% | -0.8% | -1.0% | -1.1% |
| Class D | -0.5% | -0.5% | -0.8% | -0.7% | -1.0% | -0.8% |
| Class E |  |  |  |  |  |  |
| Class F | -3.8% | -3.1% | -3.4% | -4.0% | -3.0% | -3.1% |
| **Overall** | -1.1% | -1.1% | -1.3% | -1.3% | -1.2% | -1.3% |
|  | -1.1% | -1.1% | -1.4% | -1.3% | -1.2% | -1.3% |
| Enc Time[%] | 105% | | | 105% | | |
| Dec Time[%] | 99% | | | 98% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B HE** | | | **Low delay B LC** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | -0.1% | -0.4% | -0.3% | -0.2% | -0.2% | -0.6% |
| Class C | -0.2% | -0.2% | -0.4% | -0.3% | -0.3% | -0.8% |
| Class D | -0.1% | -0.2% | -0.7% | -0.2% | -0.2% | -0.7% |
| Class E | -0.4% | -1.1% | -1.4% | -0.7% | -3.2% | -2.3% |
| Class F | -2.3% | -2.2% | -2.2% | -2.3% | -2.0% | -2.0% |
| **Overall** | -0.6% | -0.8% | -1.0% | -0.7% | -1.0% | -1.2% |
|  | -0.6% | -0.8% | -1.0% | -0.7% | -1.0% | -1.2% |
| Enc Time[%] | 104% | | | 103% | | |
| Dec Time[%] | 98% | | | 99% | | |

## case\_3: NSQT for intra

In this case, the NSQT\_INTRA introduces non-square quad-tree transform (NSQT) to intra CU to replace the non square PU for purpose of reducing the encoder complexity.

Table 5&6 are the results with and without classF sequences for case\_3.

Table 5 Results of case\_3 without classF

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.2% | -0.8% | -0.9% | -0.5% | -1.1% | -1.4% |
| Class B | -0.8% | -1.6% | -1.7% | -1.4% | -1.7% | -1.9% |
| Class C | -0.7% | -0.7% | -0.8% | -0.8% | -1.0% | -1.2% |
| Class D | -0.6% | -0.5% | -0.5% | -0.7% | -0.8% | -0.8% |
| Class E | -1.6% | -3.1% | -2.8% | -2.4% | -4.9% | -3.7% |
| **Overall** | -0.76% | -1.28% | -1.29% | -1.09% | -1.72% | -1.71% |
|  | -0.76% | -1.27% | -1.27% | -1.09% | -1.74% | -1.70% |
| Enc Time[%] | 114% | | | 115% | | |
| Dec Time[%] | 102% | | | 102% | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Random Access HE** | | | **Random Access LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.2% | -1.0% | -0.4% | -0.3% | -0.8% | -0.9% |
| Class B | -0.4% | -0.8% | -0.9% | -0.7% | -1.2% | -1.2% |
| Class C | -0.3% | -0.5% | -0.4% | -0.3% | -0.6% | -0.6% |
| Class D | -0.2% | -0.5% | -0.5% | -0.2% | -0.7% | -0.1% |
| Class E |  |  |  |  |  |  |
| **Overall** | -0.27% | -0.68% | -0.57% | -0.40% | -0.82% | -0.71% |
|  | -0.27% | -0.70% | -0.58% | -0.40% | -0.81% | -0.68% |
| Enc Time[%] | 102% | | | 100% | | |
| Dec Time[%] | 99% | | | 99% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B HE** | | | **Low delay B LC** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | -0.1% | -0.4% | -0.4% | -0.2% | -0.5% | -0.3% |
| Class C | -0.1% | -0.3% | -0.6% | -0.1% | -0.1% | -0.3% |
| Class D | -0.1% | -0.1% | 0.0% | 0.0% | 0.3% | -0.2% |
| Class E | -0.5% | -2.4% | -1.5% | -0.7% | -2.8% | -2.1% |
| **Overall** | -0.17% | -0.66% | -0.54% | -0.23% | -0.62% | -0.64% |
|  | -0.17% | -0.61% | -0.50% | -0.23% | -0.68% | -0.57% |
| Enc Time[%] | 102% | | | 101% | | |
| Dec Time[%] | 98% | | | 99% | | |

Table 6 Results of case\_3 without classF

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.2% | -0.8% | -0.9% | -0.5% | -1.1% | -1.4% |
| Class B | -0.8% | -1.6% | -1.7% | -1.4% | -1.7% | -1.9% |
| Class C | -0.7% | -0.7% | -0.8% | -0.8% | -1.0% | -1.2% |
| Class D | -0.6% | -0.5% | -0.5% | -0.7% | -0.8% | -0.8% |
| Class E | -1.6% | -3.1% | -2.8% | -2.4% | -4.9% | -3.7% |
| Class F | -3.1% | -2.5% | -2.2% | -3.4% | -2.5% | -2.5% |
| **Overall** | -1.1% | -1.5% | -1.4% | -1.5% | -1.9% | -1.8% |
|  | -1.1% | -1.5% | -1.4% | -1.5% | -1.9% | -1.8% |
| Enc Time[%] | 114% | | | 115% | | |
| Dec Time[%] | 101% | | | 102% | | |
|  |  |  |  |  |  |  |
|  | **Random Access HE** | | | **Random Access LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.2% | -1.0% | -0.4% | -0.3% | -0.8% | -0.9% |
| Class B | -0.4% | -0.8% | -0.9% | -0.7% | -1.2% | -1.2% |
| Class C | -0.3% | -0.5% | -0.4% | -0.3% | -0.6% | -0.6% |
| Class D | -0.2% | -0.5% | -0.5% | -0.2% | -0.7% | -0.1% |
| Class E |  |  |  |  |  |  |
| Class F | -2.1% | -1.7% | -1.8% | -2.4% | -1.9% | -1.9% |
| **Overall** | -0.6% | -0.9% | -0.8% | -0.8% | -1.0% | -0.9% |
|  | -0.6% | -0.9% | -0.8% | -0.8% | -1.0% | -0.9% |
| Enc Time[%] | 102% | | | 100% | | |
| Dec Time[%] | 99% | | | 98% | | |
|  |  |  |  |  |  |  |
|  | **Low delay B HE** | | | **Low delay B LC** | | |
|  | Y | U | V | Y | U | V |
| Class A |  |  |  |  |  |  |
| Class B | -0.1% | -0.4% | -0.4% | -0.2% | -0.5% | -0.3% |
| Class C | -0.1% | -0.3% | -0.6% | -0.1% | -0.1% | -0.3% |
| Class D | -0.1% | -0.1% | 0.0% | 0.0% | 0.3% | -0.2% |
| Class E | -0.5% | -2.4% | -1.5% | -0.7% | -2.8% | -2.1% |
| Class F | -1.4% | -1.1% | -1.1% | -1.4% | -1.0% | -1.0% |
| **Overall** | -0.4% | -0.7% | -0.6% | -0.5% | -0.7% | -0.7% |
|  | -0.4% | -0.7% | -0.6% | -0.5% | -0.7% | -0.7% |
| Enc Time[%] | 102% | | | 100% | | |
| Dec Time[%] | 98% | | | 99% | | |

# Results of improvements for SDIP in CE6.c

## LM mode position in chroma prediction mode

In the previous meeting, the first position of LM mode in the chroma mode coding in SDIP was agreed. In this test, the performance of LM mode position change is investigated again under the new SDIP anchor based on HM4. The detailed description of LM mode position in the chroma mode coding in SDIP can be found in JCTVC-G142[6]. Table 7&8 are the results of LM mode position change based on SDIP case1 with and without classF.

Table 7 Results of LM mode position change without class F

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | All Intra HE | | | All Intra LC | | |
|  | Y | U | V | Y | U | V |
| Class A | 0.0% | -0.5% | -0.2% | 0.0% | -1.0% | -0.4% |
| Class B | 0.0% | -0.2% | -0.2% | 0.0% | -0.4% | -0.3% |
| Class C | -0.1% | -0.4% | -0.3% | -0.1% | -0.4% | -0.4% |
| Class D | -0.1% | -0.3% | -0.2% | 0.0% | -0.4% | -0.3% |
| Class E | 0.0% | -1.0% | -0.7% | 0.0% | -0.7% | -0.6% |
| Overall | 0.0% | -0.4% | -0.3% | 0.0% | -0.6% | -0.4% |
| Enc Time[%] | 101% | | | 100% | | |
| Dec Time[%] | 100% | | | 100% | | |

Table 8 Results of LM mode position change with class F

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | All Intra HE | | | All Intra LC | | |
|  | Y | U | V | Y | U | V |
| Class A | 0.0% | -0.5% | -0.2% | 0.0% | -1.0% | -0.4% |
| Class B | 0.0% | -0.2% | -0.2% | 0.0% | -0.4% | -0.3% |
| Class C | -0.1% | -0.4% | -0.3% | -0.1% | -0.4% | -0.4% |
| Class D | -0.1% | -0.3% | -0.2% | 0.0% | -0.4% | -0.3% |
| Class E | 0.0% | -1.0% | -0.7% | 0.0% | -0.7% | -0.6% |
| Class F | -0.2% | -0.3% | -0.2% | -0.1% | -0.3% | -0.3% |
| Overall | -0.1% | -0.4% | -0.3% | 0.0% | -0.5% | -0.3% |
| Enc Time[%] | 101% | | | 100% | | |
| Dec Time[%] | 100% | | | 100% | | |

## VLC improvement for SDIP partitioning flags

When SDIP is enabled, intra prediction modes include split flag, 2Nx2N, NxN, 2NxhN and hNx2N. According to the current SDIP anchor software, intra mode information is sent with two types by the size of CU, in this improvement, split flag and partition flags are grouped and coded together as described in JCTVC-G143[7].

Table 9 is the results of VLC improvement for SDIP partitioning based on SDIP case1.

Table.9 Results of VLC improvement for SDIP partitioning

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | w/o class F | | | w/t class F | | |
|  | All Intra LC | | | All Intra LC | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| Class B | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| Class C | 0.0% | 0.1% | 0.1% | 0.0% | 0.1% | 0.1% |
| Class D | 0.0% | 0.1% | 0.0% | 0.0% | 0.1% | 0.0% |
| Class E | -0.2% | -0.4% | -0.3% | -0.2% | -0.4% | -0.3% |
| Class F |  |  |  | 0.0% | 0.0% | 0.0% |
| Overall | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| Enc Time[%] | 100% | | | 100% | | |
| Dec Time[%] | 100% | | | 100% | | |

Table 10 is the results of the combination test including the proposed VLC improvement for SDIP partitioning and chroma prediction extension as described in JCTVC-G267[8].

Table.10 Results of the combination test for VLC improvement and chroma prediction extension

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | w/o class F | | | w/t class F | | |
|  | All Intra LC | | | All Intra LC | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.1% | -2.1% | -1.6% | -0.1% | -2.1% | -1.6% |
| Class B | -0.1% | -2.5% | -2.5% | -0.1% | -2.5% | -2.5% |
| Class C | -0.1% | -1.0% | -1.1% | -0.1% | -1.0% | -1.1% |
| Class D | 0.0% | -1.2% | -1.0% | 0.0% | -1.2% | -1.0% |
| Class E | -0.2% | -2.6% | -2.3% | -0.2% | -2.6% | -2.3% |
| Class F |  |  |  | -0.3% | -1.8% | -1.8% |
| Overall | -0.1% | -1.9% | -1.7% | -0.2% | -1.9% | -1.7% |
| Enc Time[%] | 100% | | | 100% | | |
| Dec Time[%] | 102% | | | 102% | | |

## Chroma prediction extension

A chroma coding scheme for intra CUs with non-square PUs was proposed in last meeting. In this scheme, the chroma intra prediction mode set contains 6 modes. According to the mode distribution of the non-square luma PUs within a CU, the 6 modes in the mode set is selected from 9 candidate modes, i.e. LM, DM1, DM2, SDM, Planar, Vertical, Horizontal, DC and Vertical+8. DM1, DM2 and SDM are new modes for SDIP, and other modes are the same as those in HM4.0, the detailed description on chroma prediction extension for non square PU can be found in JCTVC-G267[8].

Table 11 is the results of SDIP chroma extension based on SDIP case1.

Table 11 Results of SDIP chroma extension based on SDIP case1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | 0.0% | -0.8% | -0.3% | 0.0% | -1.9% | -1.4% |
| Class B | 0.0% | -1.4% | -1.2% | 0.0% | -2.4% | -2.3% |
| Class C | -0.1% | -1.0% | -1.1% | -0.1% | -1.1% | -1.1% |
| Class D | 0.0% | -1.3% | -1.3% | -0.1% | -1.2% | -1.0% |
| Class E | 0.0% | -1.8% | -1.9% | 0.0% | -2.1% | -2.0% |
| Class F | -0.3% | -1.2% | -1.5% | -0.2% | -1.8% | -1.9% |
| **Overall** | -0.1% | -1.3% | -1.2% | -0.1% | -1.8% | -1.6% |
|  | -0.1% | -1.3% | -1.2% | -0.1% | -1.8% | -1.6% |
| Enc Time[%] | 100% | | | 100% | | |
| Dec Time[%] | 101% | | | 101% | | |

## CABAC improvement for non-square coefficients encoding

HE entropy coding has been modified in JCTVC-G322[9] to deal with non-square transform coefficients. HM4.0 uses a mapping applied to the non-square blocks to convert them to a square shape and then, apply the entropy coding. Instead, this contribution modifies the entropy coding in order to directly code the non-square block transform coefficients without the added complexity of the mapping. Modifications of CABAC are straightforward. The following parts are changed: scans, coding of the last significant coefficient, and significance map.

Similar to the square blocks, three scans for the non-square blocks: horizontal, vertical and diagonal scan. The scan depends on the intra mode for the SDIP case. The diagonal scan of HEVC starts from the long side of the block. For the signaling of the last significant coefficient, the context model depends on the length of the side of the coordinate being coded. The contexts models are the same as the square, adding an extra one for the 2-point transform. Finally, for the significance map of non-square blocks, blocks with the same number of coefficients share the same contexts. In this way, no additional contexts are introduced. Blocks with 64 coefficients or less use contexts for the significance map depending on the position. The other blocks use the neighbor based derivation equivalent to the larger blocks in HEVC. Table 12 shows the results based on case\_1 of SDIP.

Table 12 SDIP Harmonization with HE Residual Coding results

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.15% | -0.29% | -0.51% |  |  |  |
| Class B | -0.15% | -0.15% | -0.26% |  |  |  |
| Class C | 0.01% | -0.06% | -0.09% |  |  |  |
| Class D | 0.02% | 0.02% | -0.04% |  |  |  |
| Class E | -0.14% | -0.54% | -0.36% |  |  |  |
| **Overall** | -0.08% | -0.19% | -0.25% |  |  |  |
|  | -0.08% | -0.19% | -0.25% |  |  |  |
| Enc Time[%] | 99% | | |  | | |
| Dec Time[%] | 99% | | |  | | |

## MPMS in Intra mode coding and contexts in significance map in CABAC

### MPMs in Intra mode coding

Improvement of MPMs in Intra mode coding was proposed in JCTVC-G354 [10]. PM-0 is set to Planar. MPM-1 is set as the mode from longer side neighbor, i.e. if current CU is 2NxhN, above neighbor intra mode is selected; if current CU is hNx2N, left neighbor intra mode is selected. If selected neighbor intra mode is not available, set MPM-1 to DC. If MPM-1 is Planar, set MPM-1 to DC. A summary of results of proposed intra mode coding is listed in Table 13, where the anchor is SDIP case 1.

Table 13 Simulation results using proposed MPMS in intra mode coding

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.05% | 0.09% | 0.02% | -0.11% | 0.03% | 0.01% |
| Class B | 0.01% | 0.10% | 0.05% | -0.08% | 0.11% | 0.11% |
| Class C | -0.03% | 0.03% | 0.04% | -0.04% | 0.09% | 0.08% |
| Class D | -0.07% | 0.09% | 0.07% | -0.11% | 0.10% | 0.05% |
| Class E | -0.01% | 0.06% | 0.22% | -0.12% | 0.12% | 0.25% |
| **Overall** | -0.03% | 0.08% | 0.07% | -0.09% | 0.09% | 0.09% |
|  | -0.03% | 0.07% | 0.07% | -0.09% | 0.08% | 0.08% |

### Significance map contexts

To improve the coding efficiency, JCTVC-G354 [10] proposed to define the context in non-square layout before the mapping from non-square to square TU. Since in SDIP on top of HM4.0 all non-square blocks are transposed to 2N-by-xN, only one 1x4 sub-block pattern applies to all non-square blocks of 4x16/16x4 and 2x32/32x2 sizes in this contribution. A summary of results of proposed contexts for significant map is listed in Table 14 , where the anchor is SDIP case 1.

Table 14 Simulation results using proposed Significance map contexts

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE** | | |
|  | Y | U | V |
| Class A | -0.16% | -0.26% | -0.39% |
| Class B | -0.11% | -0.22% | -0.32% |
| Class C | -0.07% | -0.21% | -0.22% |
| Class D | -0.04% | -0.06% | -0.08% |
| Class E | -0.10% | -0.44% | -0.36% |
| **Overall** | -0.10% | -0.23% | -0.27% |
|  | -0.09% | -0.22% | -0.26% |

### Combination

A summary of results of proposed algorithms (MPMs + significance map contexts) is listed in Table 15, where the anchor is SDIP case 1.

Table 15 Simulation results using MPMs + significance map contexts

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE** | | |
|  | Y | U | V |
| Class A | -0.22% | -0.20% | -0.35% |
| Class B | -0.11% | -0.13% | -0.24% |
| Class C | -0.11% | -0.13% | -0.15% |
| Class D | -0.12% | -0.01% | -0.06% |
| Class E | -0.13% | -0.29% | -0.20% |
| **Overall** | -0.14% | -0.14% | -0.20% |
|  | -0.14% | -0.15% | -0.21% |

# Test Results of SDIP with all improvements

This test is to investigate the performance of SDIP when combined with all above mentioned improvements. Since the above mentioned improvements are not conflicted with each other, the combination is straight forward. In the test, LM mode position in chroma prediction mode, VLC improvement for SDIP partitioning flags, CABAC improvement for SDIP coefficients encoding and extension the SDIP to chroma prediction are all turned ON for case\_1 and case\_2, and only CABAC improvement is turned ON for case\_3 because no non square PU in this case. The following tables show the results of SDIP with above mentioned improvements for three cases, with and without classF.

## Results without classF

Table16.a SDIP+improvement vs HM4.0 for case\_1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.7% | -2.8% | -2.8% | -1.4% | -3.9% | -4.0% |
| Class B | -1.5% | -4.1% | -4.1% | -2.5% | -4.8% | -5.3% |
| Class C | -1.6% | -2.5% | -2.9% | -2.4% | -3.4% | -3.9% |
| Class D | -1.5% | -2.5% | -2.4% | -2.2% | -3.2% | -3.1% |
| Class E | -2.3% | -7.3% | -7.0% | -4.0% | -9.3% | -7.7% |
| **Overall** | -1.49% | -3.68% | -3.69% | -2.40% | -4.71% | -4.68% |
|  | -1.49% | -3.71% | -3.70% | -2.40% | -4.72% | -4.67% |
| Enc Time[%] | 129% | | | 136% | | |
| Dec Time[%] | 102% | | | 103% | | |

Table16.b SDIP+improvement vs HM4.0 for case\_2

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.4% | -2.1% | -2.1% | -0.9% | -2.8% | -3.0% |
| Class B | -1.0% | -3.6% | -3.5% | -1.8% | -3.7% | -4.2% |
| Class C | -1.1% | -2.0% | -2.3% | -1.6% | -2.6% | -3.0% |
| Class D | -1.1% | -2.2% | -2.1% | -1.6% | -2.5% | -2.5% |
| Class E | -1.7% | -6.1% | -5.7% | -2.9% | -7.7% | -6.3% |
| **Overall** | -1.01% | -3.07% | -3.03% | -1.72% | -3.67% | -3.69% |
|  | -1.01% | -3.08% | -3.04% | -1.72% | -3.67% | -3.69% |
| Enc Time[%] | 115% | | | 118% | | |
| Dec Time[%] | 101% | | | 99% | | |

Table16.c SDIP+improvement vs HM4.0 for case\_3

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.3% | -1.0% | -1.2% | -0.5% | -1.1% | -1.4% |
| Class B | -0.9% | -1.8% | -1.9% | -1.4% | -1.7% | -1.9% |
| Class C | -0.7% | -0.8% | -0.9% | -0.8% | -1.0% | -1.2% |
| Class D | -0.7% | -0.6% | -0.5% | -0.7% | -0.8% | -0.8% |
| Class E | -1.6% | -3.3% | -2.9% | -2.4% | -4.9% | -3.7% |
| **Overall** | -0.81% | -1.42% | -1.43% | -1.09% | -1.72% | -1.71% |
|  | -0.81% | -1.41% | -1.40% | -1.09% | -1.74% | -1.70% |
| Enc Time[%] | 115% | | | 114% | | |
| Dec Time[%] | 101% | | | 101% | | |

## Results with classF

Table17.a SDIP+improvement vs HM4.0 for case\_1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.7% | -2.9% | -2.8% | -1.4% | -3.9% | -4.0% |
| Class B | -1.5% | -4.2% | -4.2% | -2.5% | -4.8% | -5.3% |
| Class C | -1.6% | -2.6% | -2.9% | -2.4% | -3.4% | -3.9% |
| Class D | -1.5% | -2.6% | -2.5% | -2.2% | -3.2% | -3.1% |
| Class E | -2.3% | -7.4% | -7.0% | -4.0% | -9.3% | -7.7% |
| Class F | -6.1% | -6.2% | -6.4% | -6.9% | -6.8% | -6.8% |
| **Overall** | -2.25% | -4.16% | -4.18% | -3.16% | -5.07% | -5.04% |
|  | -2.25% | -4.18% | -4.19% | -3.16% | -5.07% | -5.04% |
| Enc Time[%] | 129% | | | 135% | | |
| Dec Time[%] | 103% | | | 103% | | |

Table17.b SDIP+improvement vs HM4.0 for case\_2

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.4% | -2.1% | -2.1% | -0.9% | -2.8% | -3.0% |
| Class B | -1.0% | -3.6% | -3.6% | -1.8% | -3.7% | -4.2% |
| Class C | -1.1% | -2.0% | -2.4% | -1.6% | -2.6% | -3.0% |
| Class D | -1.1% | -2.2% | -2.2% | -1.6% | -2.5% | -2.5% |
| Class E | -1.7% | -6.1% | -5.7% | -2.9% | -7.7% | -6.3% |
| Class F | -5.2% | -5.1% | -5.5% | -5.8% | -5.6% | -5.7% |
| **Overall** | -1.71% | -3.42% | -3.48% | -2.40% | -3.98% | -4.03% |
|  | -1.71% | -3.45% | -3.50% | -2.40% | -3.99% | -4.04% |
| Enc Time[%] | 116% | | | 120% | | |
| Dec Time[%] | 101% | | | 103% | | |

Table17.c SDIP+improvement vs HM4.0 for case\_3

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **All Intra HE** | | | **All Intra LC** | | |
|  | Y | U | V | Y | U | V |
| Class A | -0.3% | -1.0% | -1.2% | -0.5% | -1.1% | -1.4% |
| Class B | -0.9% | -1.8% | -1.9% | -1.4% | -1.7% | -1.9% |
| Class C | -0.7% | -0.8% | -0.9% | -0.8% | -1.0% | -1.2% |
| Class D | -0.7% | -0.6% | -0.5% | -0.7% | -0.8% | -0.8% |
| Class E | -1.6% | -3.3% | -2.9% | -2.4% | -4.9% | -3.7% |
| Class F | -3.1% | -2.4% | -2.0% | -3.4% | -2.5% | -2.5% |
| **Overall** | -1.19% | -1.58% | -1.53% | -1.46% | -1.85% | -1.84% |
|  | -1.19% | -1.56% | -1.51% | -1.46% | -1.86% | -1.83% |
| Enc Time[%] | 115% | | | 114% | | |
| Dec Time[%] | 101% | | | 100% | | |

## Results summary of SDIP and its combination

Table 18&19 summarized the average results of SDIP with and without classF for each case

Table 18 Summary results of SDIP without classF for each case

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test case** | | **BD-RATE** | | | | | | **Enc/Dec Time** | | | |
| **HE** | | | **LC** | | | **HE** | | **LC** | |
| **Y** | **U** | **V** | **Y** | **U** | **V** | **Enc time** | **Dec time** | **Enc time** | **Dec time** |
| **case\_1** | Intra | -1.35% | -2.22% | -2.34% | -2.28% | -2.95% | -3.10% | 127% | 101% | 135% | 102% |
| RA | -0.63% | -0.86% | -1.05% | -1.05% | -1.13% | -1.24% | 105% | 100% | 104% | 99% |
| LD | -0.27% | -0.69% | -0.93% | -0.46% | -0.73% | -1.04% | 104% | 98% | 103% | 100% |
|  | | | | | | | | | | | |
| **case\_2** | Intra | -0.96% | -1.74% | -1.82% | -1.60% | -2.20% | -2.35% | 113% | 102% | 118% | 101% |
| RA | -0.41% | -0.67% | -0.87% | -0.71% | -0.84% | -0.90% | 105% | 99% | 104% | 99% |
| LD | -0.18% | -0.43% | -0.66% | -0.32% | -0.77% | -1.00% | 104% | 98% | 103% | 99% |
|  | | | | | | | | | | | |
| **case\_3** | Intra | -0.76% | -1.28% | -1.29% | -1.09% | -1.72% | -1.71% | 114% | 102% | 115% | 102% |
| RA | -0.27% | -0.68% | -0.57% | -0.40% | -0.82% | -0.71% | 102% | 99% | 100% | 99% |
| LD | -0.17% | -0.66% | -0.54% | -0.23% | -0.62% | -0.64% | 102% | 98% | 101% | 99% |

Table 19 Summary of the average results with classF for each case

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test case** | | **BD-RATE** | | | | | | **Enc/Dec Time** | | | |
| **HE** | | | **LC** | | | **HE** | | **LC** | |
| **Y** | **U** | **V** | **Y** | **U** | **V** | **Enc time** | **Dec time** | **Enc time** | **Dec time** |
| **case\_1** | Intra | -2.14% | -2.69% | -2.80% | -3.01% | -3.31% | -3.44% | 127% | 101% | 134% | 101% |
| RA | -1.40% | -1.40% | -1.60% | -1.80% | -1.70% | -1.80% | 105% | 100% | 104% | 99% |
| LD | -0.80% | -1.10% | -1.30% | -0.90% | -1.10% | -1.40% | 104% | 98% | 103% | 100% |
|  | | | | | | | | | | | |
| **case\_2** | Intra | -1.70% | -2.10% | -2.20% | -2.30% | -2.50% | -2.60% | 113% | 101% | 118% | 101% |
| RA | -1.10% | -1.10% | -1.30% | -1.30% | -1.20% | -1.30% | 105% | 99% | 105% | 98% |
| LD | -0.60% | -0.80% | -1.00% | -0.70% | -1.00% | -1.20% | 104% | 98% | 103% | 99% |
|  | | | | | | | | | | | |
| **case\_3** | Intra | -1.10% | -1.50% | -1.40% | -1.50% | -1.90% | -1.80% | 114% | 101% | 115% | 102% |
| RA | -0.60% | -0.90% | -0.80% | -0.80% | -1.00% | -0.90% | 102% | 99% | 100% | 98% |
| LD | -0.40% | -0.70% | -0.60% | -0.50% | -0.70% | -0.70% | 102% | 98% | 100% | 99% |

The following Table 20 shows the summary results of SDIP with above mentioned improvements for three cases, with and without classF.

Table 20 Summary of SDIP+improvement vs HM4.0

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test case** | | **BD-RATE** | | | | | | **Enc/Dec Time** | | | |
| **Intra\_HE** | | | **Intra\_LC** | | | **HE** | | **LC** | |
| **Y** | **U** | **V** | **Y** | **U** | **V** | **Enc time** | **Dec time** | **Enc time** | **Dec time** |
| **Without**  **ClassF** | **case\_1** | **-1.49%** | **-3.68%** | **-3.69%** | **-2.40%** | **-4.71%** | **-4.68%** | **129%** | **102%** | **136%** | **103%** |
| **case\_2** | **-1.01%** | **-3.07%** | **-3.03%** | **-1.72%** | **-3.67%** | **-3.69%** | **115%** | **101%** | **118%** | **99%** |
| **case\_3** | **-0.81%** | **-1.42%** | **-1.43%** | **-1.09%** | **-1.72%** | **-1.71%** | **115%** | **101%** | **114%** | **101%** |
| **With**  **ClassF** | **case\_1** | **-2.25%** | **-4.16%** | **-4.18%** | **-3.16%** | **-5.07%** | **-5.04%** | **129%** | **103%** | **135%** | **103%** |
| **case\_2** | **-1.71%** | **-3.42%** | **-3.48%** | **-2.40%** | **-3.98%** | **-4.03%** | **116%** | **101%** | **120%** | **103%** |
| **case\_3** | **-1.19%** | **-1.58%** | **-1.53%** | **-1.46%** | **-1.85%** | **-1.84%** | **115%** | **101%** | **114%** | **100%** |

# Conclusion

Compared with Turin meeting, the encoding time increase was greatly reduced while the gain was retained. In addition, the straight forward combination of LM mode position in chroma prediction mode, VLC improvement for SDIP partitioning flags, modification to MPM coding, CABAC improvements for SDIP coefficients encoding and extension the SDIP to chroma prediction can achieve additional about 0.2% gain for luma and about 1.5% gain for chroma compared with SDIP. Based on the significant gain and drastically reduced complexity, we recommend adopt the SDIP with above improvements into HM.

# References

1. Jin Song, Haitao Yang, etc. “A chroma coding scheme for SDIP mode”, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-F505, 6th Meeting: Torino, IT, 14-22 July, 2011.
2. Jaehyun Lim, Byeongmoon Jeon, “CE6.b Test 4: LM mode harmonization on SDIP”, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-F110, 6th Meeting: Torino, IT, 14-22 July, 2011.
3. Jaehyun Lim, Byeongmoon Jeon, “Intra prediction mode coding with CAVLC on SDIP”, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-F111, 6th Meeting: Torino, IT, 14-22 July, 2011.
4. Geert Van der Auwera, Joel Sole, etc. “CE6.b: SDIP Harmonization with Deblocking, MDIS and HE Residual Coding”, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-F556, 6th Meeting: Torino, IT, 14-22 July, 2011.
5. Xiaoran Cao, Xiulian Peng, Changcai Lai, etc. “CE6.c Report on Simplification of Short Distance Intra Prediction Method”, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-G556, 7th Meeting: Geneva, CH, 21-30 November, 2011.
6. Jaehyun Lim, Byeongmoon Jeon, “CE6: LM mode harmonization on SDIP” , Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-G142, 7th Meeting: Geneva, CH, 21-30 November, 2011.
7. Jaehyun Lim, Byeongmoon Jeon, “CE6: VLC improvement for intra partitioning on SDIP” , Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-G143, 7th Meeting: Geneva, CH, 21-30 November, 2011.
8. Jin Song, Haitao Yang, etc., “CE6.c Report on SDIP chroma extension scheme” , Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-G267, 7th Meeting: Geneva, CH, 21-30 November, 2011.
9. [J. Sole](mailto:joels@qualcomm.com), R. Joshi, X. Wang, M. Karczewicz, “CE6.c: Harmonization of HE residual coding with non-square block transforms”, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-G322, 7th Meeting: Geneva, CH, 21-30 November, 2011.
10. Jun Xu, Ehsan Maani and Ali Tabatabai, “Further improvements of SDIP”, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-G354, 7th Meeting: Geneva, CH, 21-30 November, 2011.

# Patent rights declaration(s)

**Huawei, Microsoft, HiSilicon, Tsinghua, USTC, LEG and Qualcomm 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).**