|  |  |
| --- | --- |
| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  10th Meeting: Stockholm, Sweden, 11– 20 July 2012 | Document: JCTVC-J0045 |

|  |  |  |  |
| --- | --- | --- | --- |
| *Title:* | **AhG6: On SAO type sharing between U and V components** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
| *Author(s) or Contact(s):* | E. Alshina, A. Alshin, J.H. Park #416 Matean 3-dong, Yeongtong-gu, Suwon-si, Gyeonggi-do, 443-742, Korea  Guillaume Laroche  Christophe Gisquet  Patrice Onno  Canon Research Centre France Rue de la Touche Lambert  35510 CESSON-SEVIGNE, FRANCE | Tel: Email: | +82 10 3026 1305 {elena\_a.alshina, alexander\_b.alshin, [jeonghoon}@samsung.com](mailto:jeonghoon%7d@samsung.com)  +33(0)299876800 [guillaume.laroche@crf.canon.fr](mailto:guillaume.laroche@crf.canon.fr)  [christophe.gisquet@crf.canon.fr](mailto:christophe.gisquet@crf.canon.fr)  [patrice.onno@crf.canon.fr](mailto:patrice.onno@crf.canon.fr) |
| *Source:* | Samsung Electronics Ltd. and Canon Research Centre France | | |

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

# Abstract

This contribution proposes to share SAO type, merging left and merging up flags between U and V color components. The number of context coded bins for SAO syntax is reportedly reduced by 36% with suggested modifications (which is 1.2% total amount of context coded bins reduction). In addition, this simplification respectively provides 0.2%, 0.2% and 0.3% Luma BD-rate gain with LCU sizes of 64x64, 32x32 and 16x16. It is asserted that proposed change simplifies memory access during simultaneous processing of U and V components and helps for efficient SAO implementation.

# Introduction

In the current HEVC specifications, the following parameters are the same for U and V color components in HEVC:

* Intra prediction mode,
* Motion vector,
* ALF filter shape,
* Interpolation filter.

Memory access is uniform for U and V in all these cases and this is reasonable to keep them interleaved in a memory and process simultaneously. The only one tool in HEVC which allows different processing for U and V is SAO. SAO can be enabled or disabled at slice level separately for U and V. When looking at the LCU level, SAO type can be different for U and V components.

U and V components are stored in an interleaved way in a memory. A de-interleaving process is needed before SAO followed by a re-interleaving process after SAO. This introduces undesirable latency.

This contribution provides performance impact by simplifying the SAO design by sharing the same SAO type for U and V component at LCU level. Sharing SAO type between U and V components were initially proposed in [1] in HM6.0. In this contribution the same experiment is provided in HM7.0 According to the attached results, the performance impact of this change is positive since even better results can be obtained with this simplification compared to HM7.0 where distinct SAO types for each component are coded.

# Implementation details.

Our goal is to guarantee the same SAO type for U and V. However due to the particular way the SAO type is coded by using the merge flag form the top or from the left LCU, our modification forces SAO merge left/up flags to be the same for U and V. This has some physical meaning. Merging of two blocks is reasonable if they both are parts of the same object. So the same merging for both color components is natural.

# DIS text

This section presents DIS text changes related to the modification proposed by the contribution.

## Reduction of one SAO flag for SAO chroma signaling

|  |  |
| --- | --- |
| slice\_header( ) { | Descriptor |
| … |  |
| if( sample\_adaptive\_offset\_enabled\_flag ) { |  |
| **slice\_sample\_adaptive\_offset\_flag[ 0 ]** | u(1) |
| if( slice\_sample\_adaptive\_offset\_flag[ 0 ] ) { |  |
| **slice\_sample\_adaptive\_offset\_flag[ 1 ]** | u(1) |
| **~~slice\_sample\_adaptive\_offset\_flag[ 2 ]~~** | ~~u(1)~~ |
| } |  |
| } |  |
| ….. |  |
| } |  |

In slice header slice\_sample\_adaptive\_offset\_flag[2] is not decoded, but set equal to slice\_sample\_adaptive\_offset\_flag[1]:

slice\_sample\_adaptive\_offset\_flag[2]= slice\_sample\_adaptive\_offset\_flag[1]

## Removal of the merge flag and type index for Chroma.

|  |  |
| --- | --- |
| sao\_param( rx, ry, cIdx ){ | Descriptor |
| if( rx > 0 && cIdx <2) { |  |
| leftCtbInSlice = CtbAddrInSlice > 0 |  |
| leftCtbInTile = TileId[ CtbAddrTS ] = = TileId[ CtbAddrRStoTS[ CtbAddrRS − 1 ] ] |  |
| if( leftCtbInSlice && leftCtbInTile ) |  |
| **sao\_merge\_left\_flag** | ae(v) |
| } |  |
| if( ry > 0 && !sao\_merge\_left\_flag && cIdx <2 ) { |  |
| upCtbInSlice = (CtbAddrTS – CtbAddrRStoTS[CtbAddrRS − PicWidthInCtbs]) <= CtbAddrInSlice |  |
| upCtbInTile = TileId[ CtbAddrTS ] = = TileId[ CtbAddrRStoTS[ CtbAddrRS − PicWidthInCtbs ] ] |  |
| if( upCtbInSlice && upCtbInTile ) |  |
| **sao\_merge\_up\_flag** | ae(v) |
| } |  |
| if( !sao\_merge\_up\_flag && !sao\_merge\_left\_flag ) { |  |
| if ( cIdx <2 ) |  |
| **sao\_type\_idx**[ cIdx ][ rx ][ ry ] | ae(v) |
| if( sao\_type\_idx[ cIdx ][ rx ][ ry ] = =5 ) |  |
| **sao\_band\_position**[ cIdx ][ rx ][ ry ] | ae(v) |
| if( sao\_type\_idx[ cIdx ][ rx ][ ry ] != 0 ) |  |
| for( i = 0; i < 4; i++ ) |  |
| **sao\_offset\_abs**[ cIdx ][ rx][ ry ][ i ] | ae(v) |
| if( sao\_type\_idx[ cIdx ][ rx ][ ry ] = = 5 ) { |  |
| for( i = 0; i < 4; i++ ) { |  |
| if( sao\_offset\_abs[ cIdx ][ rx ][ ry ] != 0 ) |  |
| **sao\_offset\_sign**[ cIdx ][ rx ][ ry ][ i ] | ae(v) |
| } |  |
| } |  |
| } |  |
| } |  |

For each LCU, **sao\_type\_idx** [2] [rx][ry] is not decoded but set equal to **sao\_type\_idx** [1][rx][ry] so that the same SAO type is shared between the two color components.

## Context model reduction for SAO merge left flag

SAO merge left flag in HEVC draft 7.0 are encoded by using 3 different context models (one per each color component) while the merge up flag is using a single context for the 3 components. Since merge left flag is shared between U and V in the current HEVC draft 7.0, the 3rd context for merge left flag is not needed anymore.

| Table 9‑34 – Syntax elements and associated types of binarization, maxBinIdxCtx, ctxIdxTable, and ctxIdxOffset | | | | | |
| --- | --- | --- | --- | --- | --- |
| **Syntax element** | **initType** | **Type of binarization** | **maxBinIdxCtx** | **ctxIdxTable** | **ctxIdxOffset** |
| sao\_merge\_left\_flag | 0 | FL, cMax = 1 | 0 | Table 9‑5 | 0 |
| 1 | 0 | Table 9‑5 | ~~3~~2 |
| 2 | 0 | Table 9‑5 | ~~6~~4 |

Table 9‑5 – Values of variable initValue for sao\_merge\_left\_flag ctxIdx

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Initialization variable** | **sao\_merge\_left\_flag ctxIdx** | | | | | | | | |
| **0** | **1** | **~~2~~** | **~~3~~2** | **~~4~~3** | **~~5~~** | **~~6~~4** | **~~7~~5** | **~~8~~** |
| **initValue** | 118 | 118 | ~~118~~ | 102 | 102 | ~~102~~ | 102 | 102 | ~~102~~ |

SAO magnitudes, signs and left band positions are allowed to be different for U and V. There is therefore no change of SAO design on this aspect.

# Test results

This section presents the results on HM7.0 with the above modifications (sharing of SAO type and merge flags between V and U color) and tested according to the common test conditions [2]. Test results are summarized in Table 1.

In average suggested modification provides 0.2% BD-rate Luma gain. Encoding-decoding time variations are under noise level.

**Table 1.** SAO parameters sharing between U and V color components.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **All Intra Main** | | | | | | **All Intra HE10** | | | | | |
|  | Y | | U | | V | | Y | | U | | V | |
| Class A | -0,1% | | 0,2% | | 0,2% | | 0,0% | | 0,2% | | 0,3% | |
| Class B | -0,1% | | 0,3% | | 0,4% | | 0,0% | | 0,1% | | 0,3% | |
| Class C | -0,1% | | 0,3% | | 0,4% | | 0,0% | | 0,1% | | 0,3% | |
| Class D | -0,1% | | 0,0% | | 0,2% | | 0,0% | | 0,0% | | 0,1% | |
| Class E | -0,1% | | 0,2% | | 0,1% | | 0,0% | | 0,1% | | 0,1% | |
| **Overall** | -0,1% | | 0,2% | | 0,3% | | 0,0% | | 0,1% | | 0,2% | |
|  | -0,1% | | 0,2% | | 0,3% | | 0,0% | | 0,1% | | 0,2% | |
| Class F | -0,1% | | 0,3% | | 0,4% | | -0,1% | | 0,2% | | 0,3% | |
| Enc Time[%] | 100% | | | | | | 100% | | | | | |
| Dec Time[%] | 101% | | | | | | 101% | | | | | |
|  |  | |  | |  | |  | |  | |  | |
|  | **Random Access Main** | | | | | | **Random Access HE10** | | | | | |
|  | Y | | U | | V | | Y | | U | | V | |
| Class A | -0,2% | | 0,6% | | 0,2% | | -0,1% | | 0,3% | | 0,2% | |
| Class B | -0,2% | | 0,8% | | 0,5% | | -0,1% | | 0,2% | | 0,2% | |
| Class C | -0,2% | | 0,5% | | 0,5% | | -0,1% | | 0,2% | | 0,2% | |
| Class D | -0,3% | | 0,4% | | 0,4% | | -0,2% | | 0,1% | | 0,1% | |
| Class E |  | |  | |  | |  | |  | |  | |
| **Overall** | -0,2% | | 0,6% | | 0,4% | | -0,1% | | 0,2% | | 0,2% | |
|  | -0,2% | | 0,6% | | 0,4% | | -0,1% | | 0,2% | | 0,2% | |
| Class F | -0,2% | | 0,4% | | 0,5% | | -0,1% | | 0,1% | | 0,3% | |
| Enc Time[%] | 99% | | | | | | 100% | | | | | |
| Dec Time[%] | 99% | | | | | | 101% | | | | | |
|  |  | |  | |  | |  | |  | |  | |
|  | **Low delay B Main** | | | | | | **Low delay B HE10** | | | | | |
|  | Y | | U | | V | | Y | | U | | V | |
| Class A |  | |  | |  | |  | |  | |  | |
| Class B | -0,2% | | 0,6% | | 0,1% | | -0,1% | | 0,1% | | 0,4% | |
| Class C | -0,1% | | 0,5% | | 0,4% | | -0,1% | | 0,0% | | 0,4% | |
| Class D | -0,2% | | 0,5% | | 0,8% | | -0,2% | | 0,4% | | 0,5% | |
| Class E | -0,3% | | -0,2% | | -1,0% | | -0,1% | | -0,5% | | -0,1% | |
| **Overall** | -0,2% | | 0,4% | | 0,1% | | -0,1% | | 0,0% | | 0,3% | |
|  | -0,2% | | 0,4% | | 0,2% | | -0,1% | | 0,1% | | 0,4% | |
| Class F | -0,4% | | 0,0% | | 0,4% | | -0,1% | | -0,4% | | 0,3% | |
| Enc Time[%] | 100% | | | | | | 101% | | | | | |
| Dec Time[%] | 100% | | | | | | 102% | | | | | |
|  |  | |  | |  | |  | |  | |  | |
|  | **Low delay P Main** | | | | | | **Low delay P HE10** | | | | | |
|  | Y | | U | | V | | Y | | U | | V | |
| Class A |  | |  | |  | |  | |  | |  | |
| Class B | -0,6% | | 0,6% | | -0,4% | | -0,2% | | 0,4% | | -0,2% | |
| Class C | -0,3% | | 0,1% | | 0,2% | | -0,1% | | -0,2% | | 0,0% | |
| Class D | -0,3% | | 0,6% | | 0,8% | | -0,2% | | 0,2% | | 0,1% | |
| Class E | -0,5% | | 0,0% | | -0,8% | | -0,4% | | -0,3% | | -0,5% | |
| **Overall** | -0,4% | | 0,2% | | -0,1% | | -0,2% | | 0,0% | | -0,2% | |
|  | -0,4% | | 0,2% | | 0,0% | | -0,2% | | 0,0% | | -0,1% | |
| Class F | -0,5% | | -0,3% | | -0,1% | | -0,4% | | -0,2% | | -0,6% | |
| Enc Time[%] | 100% | | | | | | 101% | | | | | |
| Dec Time[%] | 101% | | | | | | 102% | | | | | |
|  | |  | |  | |  | |  | |  | |  | |
| Average: | | Y:-0.2% | | U:0.2% | | V:0.2% | |  | |  | |  | |

# Analysis of coded bins

Additionally statistics for total number of context coded bins was collected using AhG5 s/w. All SAO syntax elements together use 3% of total number of ctx coded bins in HEVC.

Suggested modification reduces 36% of SAO context coded bins, which is 1.2% of total context coded bins in HEVC. Statistics of context coded and by-pass bins relatively to HM7.0 is presented in Table 2.

**Table 2.** Statistics of ctx coded and by-pass bins relatively to HM7.0.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Total | | SAO | |
| ctx | Bp | ctx | bp |
| AI Main | 99.73% | 99.99% | 75.80% | 82.19% |
| RA Main | 98.39% | 99.99% | 59.76% | 92.72% |
| LB Main | 98.33% | 99.89% | 64.03% | 98.89% |
| LP Main | 98.22% | 99.81% | 65.87% | 96.77% |
| **Average** | **98.67%** | **99.92%** | **66.37%** | **92.64%** |
|  |  |  |  |  |
|  | Total | | SAO | |
| ctx | bp | ctx | bp |
| AI HE10 | 74.21% | 83.99% | 74.21% | 83.99% |
| RA HE10 | 55.29% | 88.34% | 55.29% | 88.34% |
| LB HE10 | 59.00% | 96.28% | 59.00% | 96.28% |
| LP HE10 | 60.59% | 93.69% | 60.59% | 93.69% |
| **Average** | **62.27%** | **90.58%** | **62.27%** | **90.58%** |

There is no reduction for context coded bins in theoretical worst case.

Detailed test results are included into excel spreadsheets attached to this contribution. We would like to thank experts from DOCOMO for cross-check.

# Smaller LCU sizes

Since SAO type, merge left/up flags are encoded for each LCU we also have studied performance impact of SAO parameters sharing in test with LCU size 32x32 and 16x16.

**Table 2.** Average BD-rate is test with different LCU sizes.

|  |  |  |  |
| --- | --- | --- | --- |
| **LCU size** | **Y BD-rate,%** | **U BD-rate,%** | **V BD-rate,%** |
| 64x64 | -0.18% | 0.22% | 0.16% |
| 32x32 | -0.21% | 0.05% | 0.00% |
| 16x16 | -0.34% | -0.25% | -0.29% |

As it is expected gain is higher when LCU size goes down since several SAO parameters are not encoded. This test proves that the freedom to have different SAO types for U and V component is not needed.

# Conclusions

* Based on reported results:36% reduction of SAO context coded bins (1.2% of total amount context bins) reduction.
* 1 context model is removed from HEVC design.
* 0.2% average Luma BD-rate gain under HM7.0 conditions.

Samsung and Canon recommend adoption of SAO type and merge flags sharing between U and V components to DIS text and next version of HM reference s/w.

# References

1. G. Laroche, C. Gisquet, P. Onno, E. Alshina, A. Alshin, J.H. Park “On SAO type sharing between color components,” Document of Joint Collaborative Team on Video Coding, JCTVC-I0590, April 2012.
2. F. Bossen, “Common HM test conditions and software reference configurations,” Document of Joint Collaborative Team on Video Coding, JCTVC-I1100, April 2012.

# Patent rights declaration(s)

**Samsung Electronics Ltd may have current or pending patent rights 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).**

**Canon Research Centre France may have current or pending patent rights 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).**