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| *Title:* | **HDR CE2: CE6-4.6b report on usage of SEI for Test Model** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This document reports results from experiment HDR CE6-4.6b. The experiment aims at replacing the SPS/PPS signalling used in ETM to convey the reshaper metadata, by an SEI container. The tests are made in reshape setting mode 1 focused on SDR backward compatibility, with same algorithm as in CE2.b-1. It is reported that same performance are obtained as CE2.b-1.

# Introduction

The principle of the Exploratory Test Model [1,2] for HDR video coding is to apply prior to the encoding a pre-processing step, named reshaping, that converts the input HDR content into a reshaped version aiming at improving the compression performance and/or providing an SDR backward compatible content. The reshaper also generates reshaping metadata. After decoding, the video has to be post-processed (by the inverse reshaper) using the reshaping metadata to reconstruct the HDR video. The reshaper can work in two main modes, HDR-only mode targeting improved compression performance, and SDR backward compatible mode targeting the compatibility with legacy SDR devices while maintaining high compression performance.

The reshaping metadata can be conveyed in SPS/PPS or in an SEI container. In ETM, SPS/PPS is used. SPS/PPS changes may raise some issues, in particular regarding conformance. The SEI option is a solution to address this point. As the SEI is in principle not mandatory (the decision to make it mandatory or not is usually rather up to the application standards), there may be risks that it is not properly conveyed. In case of HDR-only mode, the loss of reshaping metadata is highly prejudicial since the reshaped signal is not supposed to be viewable as is on an HDR display (and even less on an SDR display). There is a high risk that the decoded signal cannot be correctly rendered. In case of SDR backward compatible mode, the signal can still be rendered, without reshaping, on an SDR and even on an HDR device, as soon as it understands the SDR format signalled in the VUI.

The purpose of this experiment is to move the reshaping data into a new SEI message, for the SDR backward compatible mode. The experiments are performed for reshape mode 1, using the tuning algorithm delivered in CE2.b-1.

# ETM\_RC\_r1 process overview for reshapeSetting 1 configuration

Reshaper setting 1 configuration applies cross-plane mode for chroma reshaping, using two piece-wise-linear (PWL) modelled look-up-tables (LUTs) to control the chroma components. The luma component is reshaped using an intra-plane piece-wise-polynomial (PWP) modelled LUT. In the current ETM settings, 8 pieces are used both for luma PWP and for chroma PWL models.

The reshaping process works in four main steps, as shown in Figure 1:

1. Conversion of input HDR signal into Y’CbCr 10b 4:2:0 with inverse ST.2084 (PQ) EOTF;
2. Reshaping of 10b luma PQ to get an SDR-like 10b luma;
3. Automatic generation of an intermediate SDR 4:2:0 Y’CbCr picture;
4. Derivation of cross-plane chroma PWL models parameters to fit as much as possible the chroma components of the intermediate 4:2:0 Y’CbCr SDR picture.

In the following sub-sections, short description of these processes is provided. More details on the reshaping algorithms in ETM\_RC\_r1 are provided in document JCTVC-W0031 [1].



Figure 1: simplified block diagram of ETM\_RC\_r1 process in reshapeSetting 1 configuration.

## Y reshaping

Y reshaping is achieved using the following function

F(L) = log( 1. + (L / Ba)g ) / log( 1. + (P / Ba)g )

controlled by two adaptive tuning parameters Ba, g, and by the peak luminance P. In ETM\_RC\_r1, g is set to 2.8, and Ba varies depending on the content. The resulting function is modeled by a PWP 8 pieces model. Y is then scaled to and quantized in Full or Standard Range signal.

## Intermediate SDR generation

To generate the intermediate SDR (YintermUintermVinterm), the following steps apply:

1. Generate HDR luminance Lhdr from input linear-light HDR R,G,B samples
2. Convert Yreshape to linear-light Lreshape as follows

Lreshape = ( (Yreshape – off) / scale ) (1 / 0.45)

where off and scale are the parameters for Full or Standard Range normalization of Yreshape

1. Scale linear-light HDR R,G,B samples by ratio w = Lreshape / Lhdr
2. Convert scaled R,G,B to SDR R’,G’,B’ as follows

R’ = 1023 \* (Rscaled)0.45 G’ = 1023 \* (Gscaled)0.45 B’ = 1023 \* (Bscaled)0.45

1. Convert SDR R’,G’,B’ to 10b Y’CbCr then downsample chroma to get 10b 4:2:0 signal YintermUintermVinterm

## Chroma LUTs fitting

The chroma LUTs fitting computes the two LUTs LUTcb and LUTcr in order to fit as much as possible the chroma components of the intermediate SDR picture. The LUTs are derived by least mean squares optimization, with minimization of the following functions:

with OC equal to 512 (29) for 10 bits content.

More details on the cross-plane LUT optimization for reshape setting 1 are provided in document JCTVC-W0031 [1].

# Proposed modifications

## Reshaper for reshapeSetting 1 configuration

The main changes are shown in shown in Figure 2. First modification is the addition of a fitting process for the luma component, in order to fit as much as possible the intermediate SDR luma. This re-tuning of luma aims at improving the perceived saturation of the output SDR version resulting from the reshaping.



Figure 2: simplified block diagram of CE2.b-1 (and CE6-4.6b) reshaping algorithm.

The luma LUT is derived as follows:

with a weighting function defined as

The function intends to favour or not the low luma levels from the reshaping. When A is small (we use 0.01 by default), the weight will favour low luma values (and therefore more intense colors).

In addition, the following changes have been made:

* In the Y reshaping block, to get more contrasted pictures, the parameter g is set to 2.4 instead of 2.8.
* In the Intermediate SDR generation block, a smooth clipping applies once the R,G,B samples are scaled (after step 3 in process described in section **Error! Reference source not found.**).
* In the PWL modelling of chroma LUTs, 32 pieces are used instead of 8. This allows finer matching to the intermediate SDR colors and results in a noticeable impact on the SDR rendering.

## Changes in the HM

The HM has been modified to move all the ETM SPS/PPS reshaper-related syntax into a new SEI.

This corresponds to the following syntax changes:

|  |  |
| --- | --- |
| sei\_payload( payloadType, payloadSize ) { | **Descriptor** |
| if( nal\_unit\_type = = PREFIX\_SEI\_NUT ) |  |
| ... |  |
| else if( payloadType = = 148 ) |  |
| hdr\_reconstruction\_info( payloadSize ) |  |
| ... |  |
| } |  |

|  |  |
| --- | --- |
| hdr\_reconstruction\_info( payloadSize ) { | Descriptor |
| **reshape\_present\_flag** | ue(v) |
| if( reshape\_present\_flag ) { |  |
| **reshape\_chroma\_crosschannel\_flag** | u(1) |
| **reshape\_input\_luma\_bit\_depth\_minus8** | ue(v) |
| **reshape\_input\_chroma\_bit\_depth\_minus8** | ue(v) |
| **reshape\_output\_luma\_bit\_depth\_minus8** | ue(v) |
| **reshape\_output\_chroma\_bit\_depth\_minus8** | ue(v) |
| **reshape\_default\_flag** | u(1) |
| if( !reshape\_default\_flag ) { |  |
| **reshape\_scale\_int\_bit\_depth** | u(4) |
| **reshape\_offset\_int\_bit\_depth** | u(4) |
| **reshape\_scale\_frac\_bit\_depth** | u(4) |
| **reshape\_offset\_frac\_bit\_depth** | u(4) |
| **reshape\_negative\_scales\_present\_flag** | u(1) |
| } |  |
| **reshape\_num\_comps\_minus2** | ue(v) |
| for( c = 0; c < reshape\_num\_comps\_minus2 + 2; c++ ) { |  |
| **reshape\_num\_ranges\_minus1**[ c ] | ue(v) |
| **reshape\_equal\_ranges\_flag**[ c ] | u(1) |
| **reshape\_global\_offset\_val**[ c ] | u(v) |
| if( !reshape\_equal\_ranges\_flag[ c ] ) |  |
| for ( i = 0; i < reshape\_num\_ranges\_minus1[ c ] + 1; i++ ) |  |
| **reshape\_range\_val**[ c ][ i ] | u(v) |
| if ( c = = 0 ) { |  |
| **coeff\_log2\_offset\_minus2** | ue(v) |
| **reshape\_continuity\_flag** | u(1) |
| for( i = 0; i < reshape\_num\_ranges\_minus1[ c ] + 2; i++ ) { |  |
| **poly\_coef\_int**[ i ][ 0 ] | ue(v) |
| **poly\_coef\_frac**[ i ][ 0 ] | u(v) |
| } |  |
| if( reshape\_continuity\_flag = = 1 ) { |  |
| **poly\_coef\_int**[ 0 ][ 1 ] | se(v) |
| **poly\_coef\_frac**[ 0 ][ 1 ] | u(v) |
| } |  |
| } else { |  |
| for( i = 0; i < reshape\_num\_ranges\_minus1[ c ] + 1; i++ ) { |  |
| **reshape\_scale\_int\_val**[ c – 1 ][ i ] | u(v) |
| **reshape\_scale\_fract\_val**[ c – 1 ][ i ] | u(v) |
| } |  |
| if ( reshape\_chroma\_crosschannel\_flag ) { |  |
| **reshape\_offset1**[ c – 1 ] | u(16) |
| **reshape\_offset2**[ c – 1 ] | u(16) |
| } |  |
| } |  |
| } |  |
| } |  |
| } |  |

The semantics and reconstruction process are the same as for the ETM [1].

# Objective metrics

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | X | Y | Z | XYZ | tOSNR-XYZ | DE100 | MD100 | PSNRL100 |
| FireEaterClip4000r1 | 28.7% | 17.5% | 70.2% | 35.0% | 77.2% | 45.9% | -44.4% | 14.6% |
| Market3Clip4000r2 | 10.1% | 5.2% | 12.4% | 9.4% | 8.7% | 34.7% | -94.7% | -3.5% |
| SunRise | 13.2% | 10.4% | 10.5% | 11.4% | 9.2% | 43.7% | -44.4% | -1.5% |
| BikeSparklers cut 1 | 3.6% | 1.1% | 10.1% | 5.1% | 8.5% | 22.4% | -29.2% | 5.6% |
| BikeSparklers cut 2 | 4.8% | 3.0% | 8.4% | 5.3% | 9.8% | 21.3% | -47.7% | 7.9% |
| GarageExit | 8.2% | 4.1% | 8.9% | 6.9% | 7.7% | 29.0% | -56.7% | 2.1% |
| ShowGirl2Teaser | 24.0% | 17.9% | 45.3% | 29.3% | 71.0% | 16.8% | -82.3% | 8.2% |
| StEM\_MagicHour cut 1 | -1.2% | 1.4% | 5.6% | 2.8% | 2.1% | -12.3% | -41.1% | -1.1% |
| StEM\_MagicHour cut 2 | 4.4% | 4.4% | 9.0% | 6.6% | 6.3% | -5.5% | -29.9% | 1.9% |
| StEM\_MagicHour cut 3 | 7.8% | 5.5% | 25.6% | 16.3% | 17.3% | 11.2% | -7.3% | 0.5% |
| StEM\_WarmNight cut 1 | 2.3% | 3.2% | 1.2% | 2.0% | 3.1% | -13.5% | -20.0% | -1.2% |
| StEM\_WarmNight cut 2 | 9.0% | 4.5% | 11.4% | 8.9% | 17.6% | -4.0% | -74.7% | -2.5% |
| BalloonFestival | 11.0% | 8.4% | 16.7% | 12.9% | 17.6% | 39.5% | -64.3% | -6.3% |
| EBU\_04\_Hurdles | 7.0% | -1.8% | -0.9% | 0.7% | -1.3% | 22.6% | 27.8% | -8.2% |
| EBU\_06\_Start | 13.9% | -2.0% | 14.3% | 8.7% | 8.2% | 56.0% | -8.5% | -10.4% |
| **Overall** | 9.8% | 5.5% | 16.6% | 10.8% | 17.5% | 20.5% | -41.2% | 0.4% |

The results are close the results provided in CE2.b-1. The differences are due to slightly different bitrates of the metadata.

# References

1. “Proposed initial Test Model for HEVC HDR extension,” R. Brondijk, R. Goris, R. van der Vleuten, L. van de Kerkhof, D. Rusanovskyy, A. Ramasubramonian, D. Bugdayci, S. Lee, J. Sole, M. Karczewicz, F. Galpin, S. Lasserre, F. Le Leannec, T. Poirier, E. François, MPEG document M37285, Geneva, Switzerland, Oct. 2015.
2. “Description of the reshaper parameters derivation process in ETM reference software,” K. Minoo, T. Lu, P. Yin, L. Kerofsky, D. Rusanovskyy, E. François, JCTVC-W0031/MPEG M37536, San Diego, USA, Feb. 2016.
3. “HDR CE2: report of experiment CE2.b-1 on SDR-backward compatible configuration (reshape setting 1),” E. François, Y. Olivier, C. Chevance, JCTVC-W0033/MPEG M37691, San Diego, USA, Feb. 2016.

# Patent rights declaration(s)

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