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| *Title:* | **HDR CE5 test 3: Constant Luminance results** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This document reports results of the CE6 test 3 on a Constant Luminance (CL) approach discussed in the MPEG contributions m36256 and m37067. The standard NCL chroma weights and another set of weights are tested. There is no sequence or frame level optimization of the proposed CL approach: identical CL coefficients are applied throughout all the test sequences.

# Introduction

The ITU-R BT.2020 standard specifies two different ways of conversion process from R’G’B’ to Y’CbCr: Constant-luminance (CL) and Non-constant luminance (NCL) [1]. Figure 1 shows an example of NCL approach that applies the conversion from R’G’B’ to Y’CbCr after gamma OETF. The conversion is done as below.

* + Y’ = 0.2627 \* R’ + 0.6780 \* G’ + 0.0593 \* B’

where signal components R, G, and B are in linear light and the signal components R’, G’, and B’ are the output of a given OETF, TF(.), for each corresponding component, i.e. R’ = TF(R), G’ = TF(G), and B’ = TF(B).

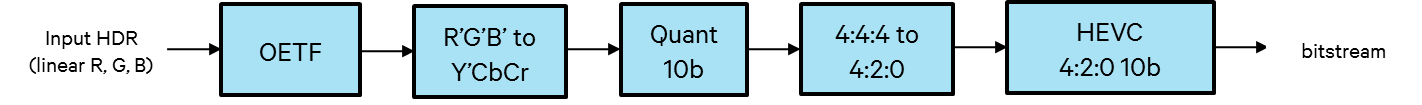


Figure 1 Block diagram for the Non-Constant Luminance

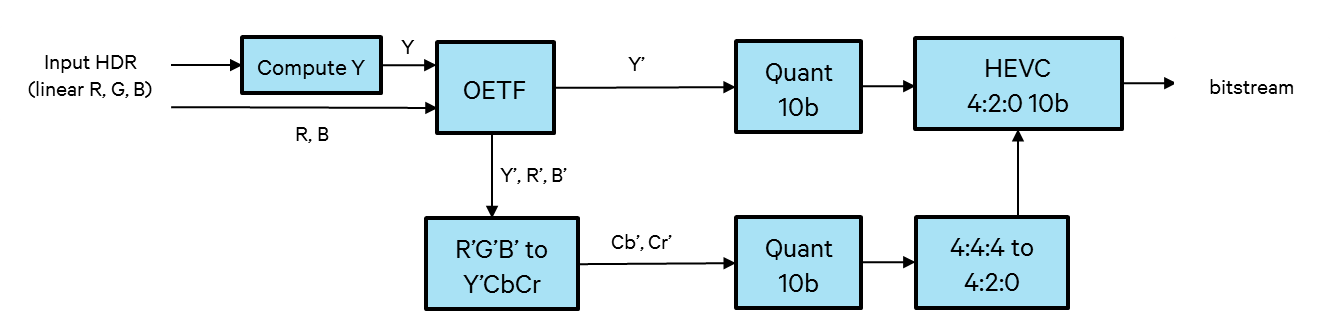


Figure 2 Block diagram for the Constant Luminance

On the other hand, the CL approach generates Y’CbCr as illustrated in Figure 2. To generate Y’, luminance, Y is first computed from R, G, and B in linear light, and then Y’ is obtained by applying the gamma OETF to Y. The two chroma components, Cb and Cr, are computed using Y’, R’, and B’, where R’ and B’ are obtained by applying the gamma OETF to R and B:

* + Y’ = TF(0.2627 \* R + 0.6780 \* G + 0.0593 \* B)
  + (1)
  + (2)

Note that Equation (1) and (2) were derived using gamma OETF [1]. For other OETFs, the four denominators (Nb, Pb, Nr, and Pr) in Equation (3) and (4) should be properly derived.

* + Y’ = TF( 0.2627 \* R + 0.6780 \* G + 0.0593 \* B )
  + (3)
  + (4)

Given an OETF, the four denominators in (3) and (4) are derived as follows for a given set of color primaries such that Y = CR \* R + CG \* G + CB \* B, where CR, Cb and Cg are parameters of color transform:

For BT. 2020 color primaries and PQ TF [2], the denominators are derived as

(Nb, Pb, Nr, Pr) = (1.9872, 0.6100, 1.9358, 0.2858).

However, these mathematically derived denominators exhibit severe color artifacts, which motives a new set of coefficients as in m36256.

# Test

CE6 tests the following set of coefficients in the CL framework:

1. BT.2020 NCL weights: (Nb, Pb, Nr, Pr) = (1.8814, 1.8814, 1.4746, 1.4746).
2. Weights in m37067: (Nb, Pb, Nr, Pr) = (1.4904, 1.0736, 0.6452, 0.4764).

Figure 3 shows how the codewords of Cb and Cr are distributed in test 2 in the 10-bit quantized domain. Compared to BT.2020 CL with PQ TF, the proposed Cb and Cr provide more evenly-distributed precision of the chromaticity information, i.e. uniform distribution of chromaticity information in the Cr, Cb representation, which leads to better results.

Result are generated without any adaptive scheme such as sequence or frame level optimization on the proposed CL approach; identical CL coefficients are applied to all the sequences.

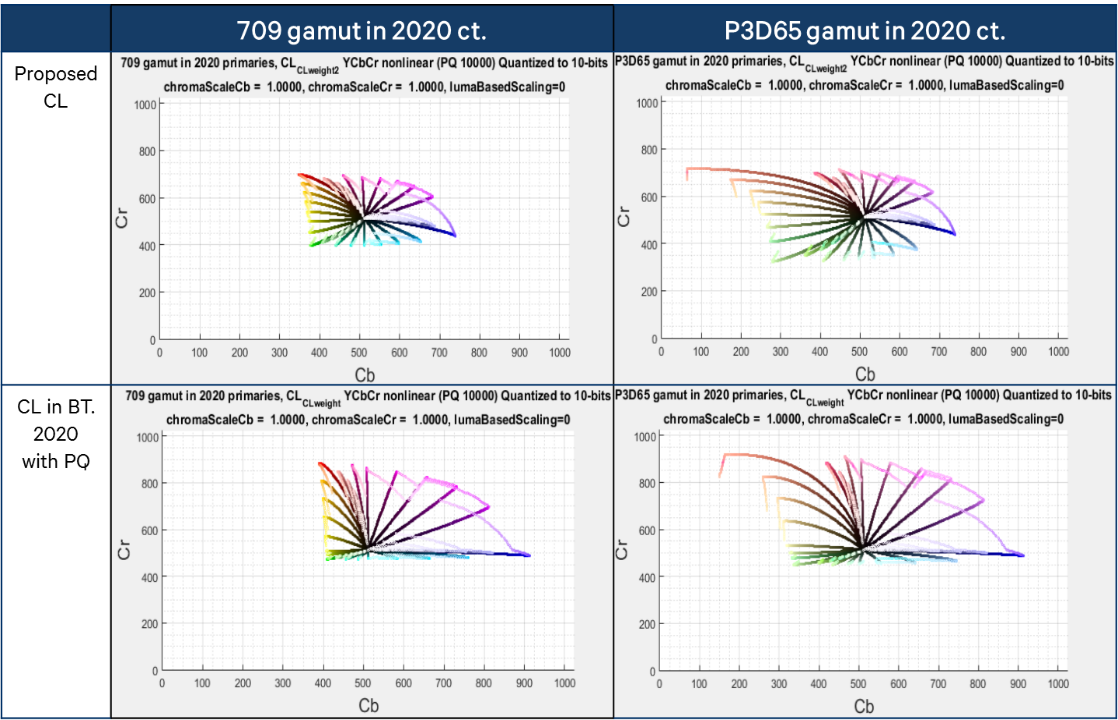


Figure 3 Chromaticity information in Cb/Cr representation: proposed CL vs. BT. 2020 CL with PQ OETF.

# Results

CL is tested on the top of the anchor 3.2 [3]. Objective results are in table 1 for test 1. Objective results for test 2 are shown in table 2. Table 3 shows the results of test 3 with the chroma QP offsets of the anchor set to 0 in order to align the luma-chroma balance as in the anchor. Results in all the tables are obtained with the rate-matched bitstreams.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | X | Y | Z | XYZ | tOSNR-XYZ | DE100 | MD100 | PSNRL100 |
| class A | FireEaterClip4000r1 | -9.3% | -7.8% | 26.7% | -0.1% | 1.1% | 28.6% | 10.3% | -8.9% |
|  | Market3Clip4000r2 | -1.2% | -0.5% | 0.6% | -0.3% | -0.3% | 3.3% | -91.0% | -0.3% |
|  | SunRise | -1.7% | -0.6% | 2.0% | 0.0% | -0.4% | 10.4% | -23.7% | -1.4% |
| class B | BikeSparklers cut 1 | -1.7% | -0.5% | 3.3% | 0.4% | 0.5% | 6.9% | -30.5% | -0.3% |
|  | BikeSparklers cut 2 | -1.5% | -0.4% | 4.1% | 0.5% | 0.9% | 6.8% | -25.8% | 0.1% |
|  | GarageExit | -2.7% | -1.1% | -0.1% | -1.2% | -1.3% | 4.8% | 4.1% | -1.3% |
| class C | ShowGirl2Teaser | -2.6% | -0.8% | 1.5% | -0.6% | 1.5% | 7.3% | -3.8% | -1.1% |
| class D | StEM\_MagicHour cut 1 | -4.3% | -1.7% | 1.0% | -1.0% | -1.2% | 9.1% | -10.4% | -1.9% |
|  | StEM\_MagicHour cut 2 | -2.7% | -1.0% | 1.0% | -0.5% | -0.4% | 7.0% | 2.7% | -1.0% |
|  | StEM\_MagicHour cut 3 | -2.2% | -1.3% | 1.2% | -0.2% | -0.2% | 7.9% | 5.5% | -1.3% |
|  | StEM\_WarmNight cut 1 | -3.4% | -0.8% | 3.6% | 0.3% | -0.1% | 8.1% | 14.8% | -0.9% |
|  | StEM\_WarmNight cut 2 | -6.1% | -1.9% | 5.0% | 0.1% | -0.1% | 13.3% | 809.4% | -1.4% |
| class G | BalloonFestival | 0.1% | -0.5% | 1.9% | 0.7% | 0.2% | 5.4% | 11.0% | -1.2% |
| class H | EBU\_04\_Hurdles | -4.2% | -1.2% | 2.7% | -0.3% | -0.4% | 8.5% | -6.4% | -0.9% |
|  | EBU\_06\_Start | -3.5% | -1.9% | 0.8% | -1.3% | -1.4% | 4.4% | -21.5% | -2.0% |
|  | **Overall** | -3.1% | -1.5% | 3.7% | -0.2% | -0.1% | 8.8% | 43.0% | -1.6% |

Table 1 Objective results for test 1.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | X | Y | Z | XYZ | tOSNR-XYZ | DE100 | MD100 | PSNRL100 |
| class A | FireEaterClip4000r1 | -13.0% | 0.1% | -0.9% | -5.6% | -14.7% | -25.0% | -24.2% | -1.0% |
|  | Market3Clip4000r2 | 6.4% | 9.8% | 1.9% | 5.7% | 3.1% | -49.6% | 0.0% | 10.0% |
|  | SunRise | 2.0% | 9.8% | -3.5% | 2.2% | -5.8% | -76.7% | -61.6% | 8.7% |
| class B | BikeSparklers cut 1 | 20.0% | 27.3% | 13.0% | 20.0% | 17.4% | -36.6% | -33.0% | 27.3% |
|  | BikeSparklers cut 2 | 17.2% | 25.4% | 9.9% | 17.7% | 14.5% | -40.2% | -47.0% | 25.6% |
|  | GarageExit | 6.5% | 14.9% | -4.4% | 4.6% | 1.1% | -47.8% | -69.3% | 14.6% |
| class C | ShowGirl2Teaser | 0.0% | 8.4% | -6.0% | 0.7% | -5.6% | -51.3% | -59.7% | 7.7% |
| class D | StEM\_MagicHour cut 1 | -1.6% | 11.2% | -7.2% | -1.0% | -3.8% | -48.5% | -41.3% | 10.7% |
|  | StEM\_MagicHour cut 2 | 2.6% | 10.6% | -8.4% | -0.6% | -3.3% | -43.0% | -16.8% | 10.3% |
|  | StEM\_MagicHour cut 3 | 2.2% | 10.4% | -8.6% | -1.2% | -3.7% | -39.4% | 1.0% | 10.3% |
|  | StEM\_WarmNight cut 1 | -2.0% | 7.5% | -1.8% | 1.0% | -1.6% | -45.3% | -9.4% | 7.5% |
|  | StEM\_WarmNight cut 2 | -4.4% | 8.8% | -2.3% | 0.2% | -2.6% | -38.2% | 0.0% | 9.5% |
| class G | BalloonFestival | 8.0% | 16.0% | 3.2% | 7.9% | 1.3% | -40.2% | 0.0% | 15.1% |
| class H | EBU\_04\_Hurdles | 10.2% | 18.1% | 11.2% | 13.1% | 9.8% | -39.5% | -44.8% | 18.3% |
|  | EBU\_06\_Start | 26.7% | 36.9% | 22.2% | 28.2% | 24.7% | -33.3% | -77.1% | 37.1% |
|  | **Overall** | 5.4% | 14.4% | 1.2% | 6.2% | 2.0% | -43.6% | -32.2% | 14.1% |

Table 2 Objective results for test 2.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | X | Y | Z | XYZ | tOSNR-XYZ | DE100 | MD100 | PSNRL100 |
| class A | FireEaterClip4000r1 | -14.6% | -4.9% | 14.5% | -3.3% | -6.4% | -13.8% | -21.4% | -6.0% |
|  | Market3Clip4000r2 | -2.0% | 0.0% | 3.1% | 0.5% | 0.9% | -5.3% | -63.7% | 0.2% |
|  | SunRise | -3.4% | 2.8% | -0.7% | -0.5% | -4.5% | -43.3% | -56.9% | 1.7% |
| class B | BikeSparklers cut 1 | -2.4% | 2.0% | 8.5% | 2.6% | 2.2% | -17.9% | -44.3% | 2.4% |
|  | BikeSparklers cut 2 | -2.0% | 2.7% | 9.5% | 3.0% | 2.3% | -17.4% | -45.1% | 3.3% |
|  | GarageExit | -3.4% | 2.5% | 2.9% | 0.4% | -0.2% | -19.3% | -33.2% | 2.3% |
| class C | ShowGirl2Teaser | -4.2% | 2.3% | -0.1% | -0.8% | -2.6% | -26.0% | -29.5% | 1.8% |
| class D | StEM\_MagicHour cut 1 | -7.2% | 3.4% | -2.3% | -2.3% | -3.9% | -29.5% | -23.2% | 2.9% |
|  | StEM\_MagicHour cut 2 | -2.6% | 3.9% | -4.8% | -2.2% | -3.6% | -27.6% | -17.9% | 3.7% |
|  | StEM\_MagicHour cut 3 | -2.9% | 3.4% | -4.0% | -2.1% | -3.4% | -24.1% | -1.0% | 3.4% |
|  | StEM\_WarmNight cut 1 | -5.8% | 2.3% | 1.8% | -0.3% | -1.8% | -28.8% | -9.9% | 2.3% |
|  | StEM\_WarmNight cut 2 | -9.6% | 1.8% | 3.0% | -0.9% | -2.5% | -24.1% | -66.3% | 2.4% |
| class G | BalloonFestival | -2.1% | 1.0% | 7.2% | 2.7% | 1.3% | -10.4% | -26.2% | 0.2% |
| class H | EBU\_04\_Hurdles | -6.6% | -1.6% | 11.4% | 2.7% | 4.1% | 15.2% | -0.6% | -1.1% |
|  | EBU\_06\_Start | -6.0% | -1.4% | 10.3% | 1.6% | 3.1% | 11.3% | -13.2% | -1.4% |
|  | **Overall** | -5.0% | 1.3% | 4.0% | 0.1% | -1.0% | -17.4% | -30.2% | 1.2% |

Table 3 Objective results for test 2 with anchor chroma QP offsets disabled.

# References

[1] Recommendation ITU-R BT. 2020, “Parameter values for ultra-high definition television systems for production and international programme exchange” (2012).

[2] SMPTE ST 2084:2014, “High Dynamic Range Electro-Optical Transfer Function of Mastering Reference Displays”, 2014.

[3] J. Strom, J. Sole, Y. He, “HDR CE1: Optimization without HEVC Specification Change”, m37501, Geneva, CH, Oct. 2015.

# Patent rights declaration(s)

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