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| *Title:* | **HDR CE7: Comments on visual quality and compression performance of HLG for SDR backward compatible HDR coding system** | | |
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# Abstract

This document reports the visual tests performed by Technicolor on the HLG-based HDR coding system in context of SDR backward compatibility. The evaluation aims at evaluating the performance of HLG for different settings. The tests are done both on the quality of SDR obtained after applying HLG to the input HDR content and on the HDR obtained after compression and reconstruction. They have been performed on a sub-set of CTCs HDR test sequences, with different settings (parameter system gamma), and using either BT.709 or BT.2020 as a container. One of the main reported observations is that it seems the system gamma value has to be adjusted per content, and not only based on the grading monitor peak luminance. It is reported that for some of the considered test sequences, some color shift is observed between HDR and SDR, this shift being much more noticeable when using a BT.709 than a BT.2020 container. The shift mostly appears in saturated red/orange and green colors. It is also reported that the optimal system gamma for HDR compression performance also seems to be content dependent.

# Introduction

HDR CE7 [1] relates to Hybrid Log Gamma (HLG) [2] experiments. HLG transfer function is proposed to address the SDR backward compatible feature in HDR coding. In this document, a number of visual tests, performed by Technicolor, are reported. The visual tests aimed at evaluating the quality of the SDR produced by HLG, with different settings (parameter system gamma). Compression performance evaluation with different settings has also been made.

# Test conditions

The viewing conditions are the following:

* SDR viewing using two different BT.709 SDR monitors:
  + professional SDR monitor TVlogic XVM 245W
  + Sony consumer TV KDL 47W805A, tuned to disable the TV processing
* HDR viewing using Sim2 monitor
* The Sim2 monitor is placed in one side of the viewing room, and the SDR monitors on the other side, in order to limit the double stimuli issue

The viewing sessions were done with 5 experts (non-naïve) viewers.

Two types of tests have been performed:

* **First tests** consist in assessing the SDR quality of the uncompressed version, relatively to the HDR rendering. The goal is to evaluate the consistency of SDR compared to HDR. This evaluation has been made in two configurations:
  + BT.709 Container, Standard range: the EXR BT.2020 content is first converted to EXR BT.709, then processed by the HLG conversion, and finally rendered on SDR BT.709 monitors.
  + BT.2020 Container, Standard range: the EXR BT.2020 content is processed by the HLG process, then converted to Y’CbCr 4:2:0 BT.709 (based on the process shown in Figure 1), and finally rendered on SDR BT.709 monitors.
* **Second tests** evaluate the HDR compression performance of HLG for different system gamma values. Due to time constraints, the evaluation was mostly made on rates 2, 3 and 4. The tests have been performed only in BT.2020 container, with final conversion to BT.709 for viewing on the SDR and HDR BT.709 monitors.



Figure : conversion process from BT.2020 SDR to BT.709SDR.

The considered test sequences are the following:

* First tests (HLG in BT.709)
  + BT.709/4000nits - Seine, Market, FireEater, SunRise
  + BT.709/3000nits - Hurdles, Starting
* Second tests (HLG in BT.2020)
  + BT.709/4000nits - BalloonFestival, Market
  + BT.709/3000nits - Starting
  + P3D65/4000nits – ShowGirl – the final conversion to BT.709 is done with hard clipping

The HLG conversion has been made according to the process described in [1]. The evaluations have been done using three system gamma values: 1.2 / 1.4 / 1.6.

# Visual tests report

## HLG in BT.709

For this case, only the SDR rendering is considered (no evaluation of the HDR compression performance).

The observations from the viewing session are summarized in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Sequence | System gamma 1.2 | System gamma 1.4 | System gamma 1.6 |
| Sunrise | Too dark on trees | Best trade-off, sun is yellow instead of light orange, a bit dark on trees | Too bright around sun and in sky |
| Fire | Too dark | A bit dark, but roughly ok | More details visible, but a bit too reddish and bright |
| Hurdles | Too bright; colors not enough saturated (e.g. ground not enough red/orange) | Too bright | Far too bright |
| Market | A bit dark, better colors than with 1.4 (purple umbrella) | Very bright but could be ok, wrong color on red umbrella, loss of details on flaps and wall, orange label very saturated, weird sky color (very pale) | Far too bright |
| Seine | Too dark | Looks ok, good contrast, details preserved | Looks pale |
| Starting | Sky very clear, cable and light panel structures on ground disappear in sky  Wrong colors (not enough intense) | Too bright | Far too bright |

The table below summarizes the preferred system gamma selected by the viewers.

|  |  |
| --- | --- |
| Sequence | Comments |
| Sunrise | 1.4 better |
| Fire | 1.4 or 1.6 – 1.4 darker, 1.6 has more details |
| Hurdles | 1.2 better but still too bright with not enough saturated colors |
| Market | 1.4 better, then 1.2 – but wrong color on purple umbrella and wall too yellow |
| Seine | 1.4 better |
| Starting | 1.2 better but not enough saturated wrong colors |

## HLG in BT.2020

For this case, the SDR quality and the HDR compression performance have been assessed.

### SDR quality

The observations from the viewing session are summarized in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Sequence | System gamma 1.2 | System gamma 1.4 | System gamma 1.6 |
| BalloonFest | Has good contrast / HDR, but still a bit washed compared to HDR – limited hue changes (some colors not enough saturated) | Too bright, washed colors | Far too bright |
| Market | Has good contrast / HDR – color purple umbrella ok, sky not enough saturated, same on wall – globally ok, maybe a bit dark | Red umbrella hue change, wall too bright, globally too washed – gives a more “sunny” mood than 1.2 | Far too bright |
| Starting | Has good contrast / HDR, still a bit washed – red ground in HDR becomes orange, grass less saturated than HDR | Too bright, washed colors | Far too bright |
| ShowGirl 1st part | Better for background (more conform to HDR) but too dark for rest of the picture | Best contrast / HDR – too redish/orange – flowers are ok | Less good than 2 others |
| ShowGirl 2nd part | Best contrast / HDR | Dark background a bit better than 1.2, but too bright for rest of the picture | Too bright |

The table below summarizes the preferred system gamma selected by the viewers.

|  |  |
| --- | --- |
| Sequence | Comments |
| BalloonFest | 1.2 definitely preferred |
| Market | 1.2 preferred |
| Starting | 1.2 preferred |
| ShowGirl 1st part | 1.4 preferred |
| ShowGirl 2nd part | 1.2 preferred |

### HDR compression performance

In this test, only HDR is considered. The observations from the viewing session are summarized in the table below.

|  |  |
| --- | --- |
| Sequence | Comments |
| BalloonFest | System gamma 1.2 clearly gives the best result – e.g. more detailed on rope |
| Market | 1.2 is better for wall and ground texture, but degrades the foliage. Inversely, foliage is much better with 1.6, but this degrades noticeable the wall. |
| Starting | 1.2 is better for details (cables in sky, lines in the field, grass) |
| ShowGirl 1st part | 1.4 is better than 1.2 on flowers and face – 1.4 and 1.6 are very close |
| ShowGirl 2nd part | 1.2 is a bit more details on feather clothes and face than the 2 others |

# Concluding remarks

From these tests, the following observations are made:

* It seems that the optimal system gamma value for reaching a good SDR rendering with acceptable conformity with HDR rendering, depends on the content, not on the peak luminance.
* A system gamma of 1.4 does not necessary look to be optimal, especially for bright content, where 1.2 seems to be more adapted for a good SDR rendering. System gamma 1.4 seems to be rather adapted to mid-bright and dark content.
* Even SDRs with system gamma 1.2 are considered by viewers as a bit washed for brightest tested content. Possibly lower values could even be preferable.
* Hue changes are generally observed in the SDR version compared to the HDR version, mostly in red/orange and sometimes green areas. This shift is particularly observed when the process applies in BT.709; when operating in BT.2020 container, the problem is noticeably reduced, but still remains on specific areas with saturated colors.
* For HDR compression, 1.2 is also preferable for bright content, while 1.4 seems to be a good trade-off for less bright to dark content.

# References

1. A. Luthra, E. Francois, L. van de Kerkhof, “Core Experiment 7 on investigating how to generate compressed HDR/SDR video using HLG and HEVC”, ISO/IEC JTC1/SC29/WG11 N15800, October 2015, Geneva, Switzerland.
2. “Hybrid Log-Gamma HDR,” A. Cotton, M. Naccari, JCTVC-W0037/MPEG M37535, San Diego, USA, Feb. 2016.
3. “Recommended conversion processes of YCbCr 4:2:0 and RGB SDR content in and between BT.709 and BT.2020 color gamut,” E. Francois, K. Minoo, R. van der Vleuten, A. Tourapis, JCTVC-W0046/MPEG M37680, San Diego, USA, Feb. 2016.

# Patent rights declaration(s)

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