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# Abstract

The authors of this information document report that High Dynamic Range / Wide Color Gamut video content can, or has been exchanged between single-layer HEVC Main10 products. A description of the metadata and example settings for open source software encoders is provided. Examples of detailed bitstream parameters can be found at: http://www.blu-raydisc.com/en/Technical/TechnicalWhitePapers/

# Introduction

The following metadata is used to signal “HDR-10” [1] through decoder-receiver side systems. All metadata below is static, and should remain constant throughout the CLVS. Depending upon application, the values for MaxFALL and MaxCLL may be measured explicitly on content a priori, or for example, be set by the content author or broadcast service operator as a fixed number.

Table 1 Essential HDR/WCG metadata

|  |  |  |
| --- | --- | --- |
| Metadata | HEVC bitstream elements | HDMI metadata elements |
| Range | VUI video\_full\_range\_flag = 0 | AVI InfoFrame (CEA 861-F) Data Byte 3,  Q (quantization range) bits = 0 |
| Transfer function | VUI transfer\_characteristics=16 (SMPTE ST 2084 [2]) *future editions of HEVC may include additional transfer functions.* | HDR Static Metadata (CEA 861.3 [3]) InfoFrame Type 7 Data Byte 1, EOTF bits =2. *Bits are reserved for future transfer functions* |
| Color primaries | VUI colour\_primaries=9  (ITU-R BT.2020 [4]) | AVI InfoFrame (CEA 861-F) Data Byte 3  EC (Extended Colorimetry) bits = 6  (BT.2020 R’G’B or Y’Cb’Cr’ NCL) |
| Color space | VUI matrix\_coeffs=9 (Y’Cb’Cr’ Non-constant luminance ITU-R BT.2020) |

Table 2 Optional HDR/WCG metadata

|  |  |  |
| --- | --- | --- |
| Metadata | HEVC bitstream elements | HDMI metadata elements |
| Mastering Display Color Volume  (ST 2086 [5]) | Mastering Display Color Volume SEI  Section D.2.27 (Syntax), D.3.27 (Semantics) | HDR Static Metadata (CEA 861.3)  InfoFrame Type 7 Descriptor Type1 Static\_Metadata\_Descriptor (Bytes 3-22) |
| MaxFALL and MaxCLL (CEA 861.3) [3] | Content Light Level SEI Section D.2.34 (Syntax), D.3.34 (Semantics) of HEVC v3 draft [6] | HDMI HDR Static Metadata (CEA 861.3)  InfoFrame Type 7 Descriptor Type1 Static\_Metadata\_Descriptor (Bytes 23-26) |

# Consumer Monitors

The following monitors have been identified as supporting “HDR-10” through HMDI 2.0a and/or playback of HEVC Main10 files (usually in a .mp4 file container)

LG EG9600

Panasonic CX850

Samsung JS9500

Sharp UH30

Sony XBR 930C / 940C (2015 update)

Vizio R-series

# Software

The following software control parameters signal a coded video signal that has been mapped to an integer signal container defined by a combination of ITU-R BT.2020 color primaries, YCbCr Non-constant luminance color difference space, narrow (non-full) range video, and SMPTE ST 2084 “PQ” transfer function. Note that ITU-R BT.2020 requires co-sited CbCr samples in both the horizontal (x) and vertical (y) directions, thus chroma location information should be set to value ‘2’ in HEVC and AVC VUI headers. Example characteristics of reference display monitors used during the mastering process by which the content was graded and color timed are given in the tables below:

Table 3 1000 nits P3D65 OLED color reference monitor (BVM-X300)

|  |  |  |
| --- | --- | --- |
| P3 primary | CIE 1931 x coordinate | CIE 1931 y coordinate |
| Green | 0.26500 | 0.69000 |
| Red | 0.68000 | 0.32000 |
| Blue | 0.15000 | 0.06000 |
| D65 white point | 0.31270 | 0.32900 |
| Max. luminance | 1000 candelas/m2 | |
| Min. luminance | 0. 0001 and lower candelas/m2 | |

Table 4 4000 nits P3D65 LCD color reference monitor (Pulsar)

|  |  |  |
| --- | --- | --- |
| P3 primary | CIE 1931 x coordinate | CIE 1931 y coordinate |
| Green | 0.26500 | 0.69000 |
| Red | 0.68000 | 0.32000 |
| Blue | 0.15000 | 0.06000 |
| D65 white point | 0.31270 | 0.32900 |
| Max. luminance | 4000 candelas/m2 | |
| Min. luminance | 0.0047 candelas/m2 | |

Table 5 100 nits BT.2020 laser projector (cinema)

|  |  |  |
| --- | --- | --- |
| BT.2020 primary | CIE 1931 x coordinate | CIE 1931 y coordinate |
| Green (532 nm) | 0.170 | 0.797 |
| Red (630 nm) | 0.708 | 0.292 |
| Blue (467 nm) | 0.131 | 0.046 |
| D65 white point | 0.3127 | 0.3290 |
| Max. luminance | 100 candelas/m2 | |
| Min. luminance | 0.0001 candelas/m2 | |

## HM reference

To obtain the latest copy of the HM reference code:

svn co hevc.hhi.fraunhofer.de/svn/svn\_HEVCSoftware/trunk/

(Note that a future edition of HM may include non-normative improvements for HDR signals, as described in JCTVC-U0040 [7]).

Add the following parameters to the configuration file, such as encoder\_randomaccess\_main10.cfg in the /cfg sub-directory of the above source code (the example here uses values from Table 4):

VideoSignalTypePresent: 1

VideoFullRange: 0

ColourDescriptionPresent: 1

ColourPrimaries: 9

TransferCharacteristics: 16

MatrixCoefficients: 9

SEIMasteringDisplayColourVolume: 1

SEIMasteringDisplayMaxLuminance: 40000000

SEIMasteringDisplayMinLuminance: 47

SEIMasteringDisplayPrimaries: 13250,34500,7500,3000,34000,16000

SEIMasteringDisplayWhitePoint: 15635,16450

ChromaLocInfoPresent: 1

ChromaSampleLocTypeTopField: 2

ChromaSampleLocTypeBottomField: 2

To calculate the values above…

SEIMasteringDisplayMaxLuminance = max. luminance of display (candelas/m2) multiplied by 10000

SEIMasteringDisplayMinLuminance = min. luminance of display (candelas/m2) multiplied by 10000

SEIMasteringDisplayPrimaries = Gx,Gy,Rx,Ry,Bx,By

Where:

Gx is Green primary CIE 1931 x value (between 0 .0and 1.0) multiplied by 50000

Gy is Green primary CIE 1931 y value (between 0.0 and 1.0) multiplied by 50000

Rx is Red primary CIE 1931 x value (between 0.0 and 1.0) multiplied by 50000

Ry is Red primary CIE 1931 y value (between 0.0 and 1.0) multiplied by 50000

Bx is Blue primary CIE 1931 x value (between 0.0 and 1.0) multiplied by 50000

By is Blue primary CIE 1931 y value (between 0.0 and 1.0) multiplied by 50000

SEIMasteringDisplayWhitePoint = Wx,Wy

Where:

Wx is the White CIE 1391 x value (between 0.0 and 1.0) multiplied by 50000

Wy is the White CIE 1391 y value (between 0.0 and 1.0) multiplied by 50000

## x265

To obtain a copy of the latest source code [8]:

hg clone https://bitbucket.org/multicoreware/x265

$ cd x265/build/linux

$ ./make-Makefiles.bash

When running the ./make-Makefiles.bash script, be sure to set “HIGH\_BIT\_DEPTH = On” to enable 10-bit (HEVC Main10) encodes. Finally, make the project:

$ make

The following command line arguments are needed to signal HDR-10 combination in x265:

--input-depth 10 --colorprim bt2020 --transfer smpte-st-2084 --colormatrix bt2020nc –chromaloc 2 –P main10

optional parameters for ST 2086 (using the Table 4 example), MaxFALL, MaxCLL:

--master-display "G(13250,34500)B(7500,3000)R(34000,16000)WP(15635,16450)L(40000000,47) "

--max-cll "4000,0"

The content level example above assumes MaxCLL (Maximum Content [pixel] Light Level) =4000 candelas/m2, while MaxFALL (Maximum Frame Average Light Level) is set to 0 to illustrate a case where the value is unknown or not measured (0 is reserved in both MaxCLL and MaxFALL in the CEA 861.3 specification to indicate that the value is not specified). Example calculation of MaxCLL and MaxFALL measures are provided in JCTVC-T0101 [9]

A complete x265 command line example:

x265 --colorprim bt2020 --transfer smpte-st-2084 --colormatrix bt2020nc --chromaloc 2 \

--master-display "G(13250,34500)B(7500,3000)R(34000,16000)WP(15635,16450)L(40000000,47)"\

--max-cll "4000,0" \

--profile main10 --level-idc 5.0 --fps 24 --input-res 1920x1080 --input-depth 10 \

--input src.yuv –o bitstream.hevc

x265 currently only outputs raw HEVC elementary bitstreams. The mp4box [11] utility can wrap the stream in a .mp4 file container required by some players:

mp4box -add bitstream.hevc:FMT=HEVC -fps 24 -new bitstream.mp4

# References

[1] DECE, “Section B.6: HDR10 Media Profile Definition”,*Common File Format & Media Formats Specification Version 2.1* , February 5, 2015. (Attached to [m35798](http://phenix.int-evry.fr/mpeg/doc_end_user/current_document.php?id=51548&id_meeting=163) [10])

[2] SMPTE ST 2084: “High Dynamic Range Electro-Optical Transfer Function of Mastering Reference Displays”, <http://standards.smpte.org/content/978-1-61482-829-7/st-2084-2014/SEC1>

[3] CEA 863.1: “HDR Static Metadata Extensions”, January 2015.

[4] Recommendation ITU-R BT.2020: “Parameter values for ultra-high definition television systems for production and international programme exchange”, <http://www.itu.int/rec/R-REC-BT.2020/en>

[5] SMPTE ST 2086: “Mastering Display Color Volume Metadata Supporting High Luminance and Wide Color Gamut Images”, <http://standards.smpte.org/content/978-1-61482-833-4/st-2086-2014/SEC1>

[6] [JCTVC-T1005](http://phenix.int-evry.fr/jct/doc_end_user/current_document.php%3Fid=10025): HEVC v3 draft specification.

[7] [JCTVC-U0040](http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=10044): “HM reference software bug fixes and enhancements to address the HDR/WCG CfE”, Warsaw meeting, June 2015.

[8] x265 source code web page: <https://github.com/videolan/x265>

[9] [JCTVC-T0101](http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=9870), “Content Light Level SEI”, Geneva, February 2015.

[10] MPEG [m35798](http://phenix.int-evry.fr/mpeg/doc_end_user/current_document.php?id=51548&id_meeting=163): “Liaison from DECE”, Geneva, February 2015.

[11] mp4box web page: <http://gpac.io>