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| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  24th Meeting: Geneva, CH, 26 May – 1 June 2016 | Document: JCTVC-X0060 |

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| *Title:* | **Usage of CRI for guided mapping (dynamic range adaptation)** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

Colour Remapping Information (CRI) SEI message was identified in 23rd JCT-VC meetings as a potential standardized alternative for enabling guided Dynamic Range Adaptation (DRA) for purpose of backward compatible HDR video coding. This contribution presents results of adopting CRI signalling for DRA in order to provide a guided mapping from HDR to SDR and from SDR to HDR. Two SDR compatible use cases are presented: first is a solution for backward compatibility to SDR/BT2020 capable receivers with HDR reconstruction conducted through the CRI post-processing and second is a solution for optional guided mapping from HDR to SDR/BT.2020 conducted with CRI post-processing. This contribution also proposes a draft text to the document “Conversion and Coding Practices for HDR/WCG Video” to reflect current usage of CRI.

# Introduction

Colour Remapping Information (CRI) is an SEI message that aims at enabling conversion of a video content from one colour volume to another one. For example, CRI can be used in a post-processing step following the decoding to convert a decoded HDR video with BT.2020 primaries and SMPTE ST 2084 transfer function to an SDR video with BT.709 primaries and BT.1886 transfer function ([JCTVC-Q0074](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/17_Valencia/wg11/JCTVC-Q0074-v4.zip)). It has also been demonstrated that CRI can be used as a container for dynamic range adaptation (DRA) in order to improve compression efficiency of HDR content (JCTVC-X0041) and to provide a signaling mechanism for enabling guided dynamic range adaption for purposes of backward compatible HDR video coding.

For example, CRI can be used in a post-processing step following the decoding to convert a decoded HDR video with BT.2020 primaries and SMPTE ST 2084 transfer function to an SDR video with BT.709 primaries and BT.1886 transfer function ([JCTVC-Q0074](http://phenix.it-sudparis.eu/jct/doc_end_user/documents/17_Valencia/wg11/JCTVC-Q0074-v4.zip)). Application of the CRI for providing different types of SDR backward compatibility for video signal with BT.2020 primaries would follow its original intent.

Several CRI-compatible designs providing backward compatibility to SDR receivers (devices capable to handle video with BT.1886 transfer characteristics and BT.2020 colour primaries) has been proposed to MPEG and JCTVC in [] and []. In such design, CRI post-processing can be used to provide a guided mapping (dynamical range adaptation) from SDR/BT.2020 to HDR/BT.2020 representation. Alternatively, CRI post-processing can be used to provide a guided mapping from HDR/BT.2020 to SDR/BT.2020, thus enabling display compatibility.

# Tested configurations

**SDR Type 0: CRI for guided mapping from SDR/BT.2020 to HDR/BT.2020 (bitstream backward compatibility)**

The problem of dynamical range conversion from SDR to HDR has been studied in [1] and [2]. In this document we present CRI-based solution for these use case.

An example of encoding process producing SDR/BT.2020 compatible HEVC bitsream is illustrated in Figure 1. DRA typically applies three transfer functions to the Y, Cb, and Cr components of the input HDR10 signal. These functions are derived from the analysis of the input HDR signal properties and aim to produce an SDR approximation. The resulting YCbCr signal has BT.1886 transfer characteristics and BT.2020 color primaries is then encoded, using an HEVC Main10 compliant encoder. The functions are implemented in the shape of 1D look-up-tables (*LUTDRAk*, for *k*=0, 1, 2), that directly apply to the HDR10 Y, Cb and Cr components.

Linear RGB

HEVC main10  
encoder

HDR/WCG Encoder

Quant 10bits

DRA

Inv. ST.2084

Chroma Sampling  
4:2:0

YCbCr Convers.

DRA control over CRI SEI

YCbCR BT.1886  
BT.2020

Figure . Pre-processing using CRI for producing a backward compatible bitstream

HDR/WCG Decoder

Dequant 10bits

Inverse DRA

Linear RGB

HEVC main10  
decoder

ST.2084  
EOTF

Chroma Sampling  
4:4:4

Inverse  
YCbCr Convers.

DRA control over CRI SEI

YCbCR BT.1886  
BT.2020

Figure . Post-processing using CRI for guided conversion from SDR/BT.2020 to HDR/BT.2020

The decoding process inverse to the described above encoding includes the inverse DRA process is illustrated in Figure 2 After HEVC Main 10-compliant decoding, the decoded signal has BT.1886 transfer characteristics and BT.2020 colour primaries. The CRI-defined post-processed is used to reconstruct the HDR10 compatible signal using the inverse DRA transfer functions. These functions are coded using the three Pre-LUTs of a CRI SEI message. The three-by-three matrix and the Post-LUTs are not activated.

For SDR backwards compatibility, parameters of DRA can be derived from HDR graded signal by using a reference HDR to SDR algorithm or from the graded SDR signal directly when it is available. Figure 3 illustrates the pre-processing chain for DRA derivation.

gradedSDR

Figure . Block diagram of DRA parameters derivation from available SDR/BT.2020 and HDR/BT.2020 version

The following parameters of HEVC main10 bitstreams shall be specified to correctly display at displays compatible to SDR/BT.2020 representation and conduct the HDR reconstruction to HDR10 compatible representation.

* The transfer characteristics shall be set to ITU BT.1886
  + Each VUI parameter transfer\_characteristics shall be present and can be set to 1,6,14 or 15.
* The color space container shall be Rec.2020 [5], non-constant luminance, i.e.,
  + Each VUI parameter colour\_primaries shall be set equal to 9.
  + Each VUI parameter matrix\_coeffs shall be set equal to 9.
* The bitdepth shall be 10 bits with sample values in the standard range, i.e.,
  + Each SPS shall have bit\_depth\_luma\_minus8 and bit\_depth\_chroma\_minus8 set to 2.
  + Each VUI parameter video\_full\_range\_flag shall be set to 0.
* The CRI SEI message shall be included, the following parameters of CRI shall be specified:
  + the value of colour\_remap\_video\_signal\_info\_present\_flag set equal to 1
  + the value of colour\_remap\_transfer\_function set to 16.
  + the value of colour\_remap\_full\_range\_flag shall be set to 0.
  + the value of colour\_remap\_primaries shall be set to 9.
  + the value of colour\_remap\_matrix\_coefficients shall be set to 9.
  + the value of colour\_remap\_output\_bit\_depth shall be set to 10.

**SDR Type 1: CRI for guided mapping from HDR/BT.2020 to SDR/BT.2020 (display backward compatibility)**

Dynamical range conversion from HDR to SDR is an inverse problem of that studied in the in [3] and [4]. Due to invertability of the DRA process, this system design would be straightforward by placing a forward DRA process to the decoder side and signaling DRA parameters through CRI SEI message.

An encoding process producing HDR/BT.2020 compatible HEVC bitsream which includes DRA control parameters for decoder side guided conversion from HDR to SDR is illustrated in Figure 4.

A corresponding decoding process which able to conduct an optional guided mapping from HDR to SDR through forward DRA process is illustrated in Figure 5. After HEVC Main 10-compliant decoding, the decoded signal has ST2084 transfer characteristics and BT.2020 colour primaries which makes it HDR10 compatible. The CRI-defined post-processed can be used to convert decoded HDR/BT.2020 signal to SDR/BT.2020 representation. DRA typically applies three transfer functions to the Y, Cb, and Cr components of the decoded HDR10 signal. The resulting YCbCr signal has BT.1886 transfer characteristics and BT.2020 color primaries. Parameters of DRA can be derived with a method described in the section above. The functions are implemented in the shape of 1D look-up-tables (*LUTDRAk*, for *k*=0, 1, 2), that directly apply to the HDR10 Y, Cb and Cr components. These functions are coded using the three Pre-LUTs of a CRI SEI message. The three-by-three matrix and the Post-LUTs are not activated.

Linear RGB

HEVC main10  
encoder

HDR/WCG Encoder

Quant 10bits

DRA  
Derivation

Inv. ST.2084

Chroma Sampling  
4:2:0

YCbCr Convers.

CRI

YCbCR ST 2084 BT.2020

SDR reference

Figure . Example of pre-processing using CRI for display backward compatibility

HDR/WCG Decoder

Dequant 10bits

DRA

Linear RGB

HEVC main10  
decoder

ST.2084  
EOTF

Chroma Sampling  
4:4:4

Inverse  
YCbCr Convers.

CRI

YCbCR ST 2084  
BT.2020

YCbCR BT.1886BT.2020

Figure . Post-processing using CRI for guided conversion from HDR/BT.2020 to SDR/BT.2020

The following parameters of HEVC main10 bitstreams shall be specified to correctly display video on HDR10 compatible devices and to conduct a guided mapping from SDR to HDR with CRI post-processing.

* The transfer characteristics shall be set to ST 2084
  + Each VUI parameter transfer\_characteristics shall be present and to be set to 16.
* The color space container shall be Rec.2020 [5], non-constant luminance, i.e.,
  + Each VUI parameter colour\_primaries shall be set equal to 9.
  + Each VUI parameter matrix\_coeffs shall be set equal to 9.
* The bitdepth shall be 10 bits with sample values in the standard range, i.e.,
  + Each SPS shall have bit\_depth\_luma\_minus8 and bit\_depth\_chroma\_minus8 set to 2.
  + Each VUI parameter video\_full\_range\_flag shall be set to 0.
* The CRI SEI message shall be included, the following parameters of CRI shall be specified:
  + the value of colour\_remap\_video\_signal\_info\_present\_flag set equal to 1
  + the value of colour\_remap\_transfer\_function set to 1, 6, 14 or 15.
  + the value of colour\_remap\_full\_range\_flag shall be set to 0.
  + the value of colour\_remap\_primaries shall be set to 9.
  + the value of colour\_remap\_matrix\_coefficients shall be set to 9.
  + the value of colour\_remap\_output\_bit\_depth shall be set to 10.

# Simulation results

**SDR Type 0: CRI for guided mapping from SDR/BT.2020 to HDR/BT.2020**

System design, DRA settings (20 ranges for luma and 1 range for Cr,Cb) and derivation algorithms utilized for this configuration is identical to what was proposed in [2]. The CRI SEI message was utilized to signal DRA parameters to the decoder side and CRI post-processing implemented in HM software was utilized to conduct a guided mapping. Simulation results for this configuration are shown in Table 1 and 2. Simulation results of Table 1 are produed with QP settings specified in [2]. Encoder configuration of Table 2 results was set according to the CE1 anchor recommendations, the reference scheme is CE1 anchor 3.2. It was observed that visual quality of resulting SDR version of HDR content is acceptable, no significant deviation in color representation or visually noticeable quality degradations due to conversion process were observed.

Table 1 Comparative results for the tested configuration with QP settings from [2] against the CE1 anchor 3.2



Table 2 Comparative results for the tested configuration against the CE1 anchor 3.2, QP settings of CE1 anchor 3.2



**SDR Type 1: CRI for guided mapping from HDR/BT.2020 to SDR/BT.2020**

System design for this test is depicted in Figure 4 and Figure 5, the process of forward DRA is deployed at the decoder side. DRA settings (20 ranges for luma and 1 range for Cr,Cb) and derivation algorithms utilized for this configuration is identical to what was proposed in [2]. The CRI SEI message was utilized to signal DRA parameters to the decoder side and CRI post-processing implemented in HM software was utilized to conduct a guided mapping. Simulation results for this configuration is shown in Table 3. Encoder configuration for tested scheme is set according to CE1 anchor recommendations, the reference scheme is CE1 anchor 3.2.

Table 3 Comparative results for the tested configuration against the CE1 anchor 3.2

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Simulation results in Table 3 shows insignificant bitrate increase compare to the anchor 3.2 results caused by additional signaling of the CRI data.

# Conclusion

This contribution presents results of adopting CRI signalling and post-processing for DRA in order to provide a guided mapping from HDR to SDR and from SDR to HDR. Two SDR compatible use cases are presented: first is a solution for backward compatibility to SDR/BT2020 capable receivers with HDR reconstruction conducted through the CRI post-processing and second is a solution for optional guided mapping from HDR to SDR/BT.2020 conducted with CRI post-processing. Conducted tests suggest that CRI can be effectively utilized to enable DRA for purpose of providing backward compatible HDR video coding. This contribution also proposes a draft text to the document “Conversion and Coding Practices for HDR/WCG Video” to reflect usage of CRI for these purposes.

# Reference

[1] D. B. Sansli, A. K. Ramasubramonian, D. Rusanovskyy, J. Sole, M. Karczewicz (Qualcomm), HDR CE6: Test 4.1 Reshaper from m37064, JCTVC document W0103, San Diego, USA, Feb. 2016

[2] D.Rusanovskyy, A. Ramasubramonian, D. Bugdayci, S. Lee, J. Sole, M. Karczewicz (QCOM), Report on CE2.1.3 test: Single-layer HDR video coding based on m36256, MPEG document m37064, Geneva, Switzerland, Oct. 2015

# Patent rights declaration(s)

**Qualcomm 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).**