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# Abstract

This document contains a draft of a technical report on prominent video signal property description points and their combinations that are widely used in production and video content workflows.

The combinations of all possible video properties values can result in hundreds of permutations; but many of those combinations are rarely or never used in practice. For example, it is unlikely in a video system that ITU-R BT.2100 perceptual quantization (PQ) transfer characteristics would be combined with ITU-R BT.601 colour primaries. Only a small subset of combinations (such as BT.2100 colour primaries with BT.2100 PQ and hybrid log-gamma transfer characteristics) is used in practice.

This document provides information to aid content processing tool vendors from avoiding visual degradation of video based upon mistaken assumptions of video property values in content conversion operations. This document also will aid in the automation of content workflows across various domains of capture, production, and distribution due to identification of widely used combinations of video properties.. Finally, this documents aims to help its readers, especially toolset developers, repurpose tools to different parts of the workflow where similar content conversions may be performed.

This JCTVC output document is intended for a planned Technical Report (ITU-T H.Sup.UVSTP | ISO/IEC 23091-4) that would be a non-normative document of industry practices for describing existing widely used combinations of video properties. Many video properties in this document originate from the common video coding points document (ITU-T H.Sup.UVSTP ISO/IEC 23091-2). Carriage of these properties may be determined by different specifications depending on the format of the content in each domain.

# Scope

This document describes the non-normative, common industry representation practices if ISO/IEC multimedia standard properties, as these properties are conveyed across video content production and distribution carriage systems.

# References

## Joint ITU-T and ISO/IEC References

Rec. ITU-T H.273 | ISO/IEC 23091-2 Coding-independent code points – Part 2: Video.

Rec. ITU-T H.264 | ISO/IEC 14496-10, Information technology – Coding of audio-visual objects Part 10: Advanced Video Coding.

Rec. ITU-T H.265 | ISO/IEC 23008-2, Information Technology – High efficiency coding and media delivery in heterogeneous environments Part 2: High efficiency video coding.

## ISO/IEC References

ISO/IEC 14496-12 ISO based media file format.

ISO/IEC 14496-14 MP4 file format.

ISO/IEC 14496-15 Carriage of network abstraction layer (NAL) unit structured video in ISO based media file format.

ISO/IEC 13818-1 Part 1: Systems.

## ITU-T References

ITU-T Series H Supp 18- Signalling, backward compatibility and display adaptation for HDR/WCG video coding- Study Group 16.

ITU-T Series H Supp 15- Conversion and coding practices for HDR/WCG Y’CbCr video with PQ transfer characteristics – Study Group 16.

## ITU-R References

ITU-R BT.2100-2 Image parameter values for high dynamic range television for use in production and international programme exchange.

ITU-R BT.709-6 Parameter values for the HDTV standards for production and international programme exchange.

ITU-R BT.1886-0Reference electro-optical transfer function for flat panel displays used in HDTV studio production.

ITU-R BT.2020-2 Parameter values for ultra-high definition television systems for production and international programme exchange.

ITU-R BT.601-7 Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios.

## SMPTE References

SMPTE ST 2067-20 Interoperable Master Format- Application #2.

SMPTE ST 2067-21 Interoperable Master Format- Application #2E.

SMPTE ST 2086 Mastering Display Color Volume Metadata Supporting High Luminance and Wide Color Gamut Images.

SMPTE 377-1 Material Exchange Format (MXF) - File Format Specification.

SMPTE ST 2084 High Dynamic Range Electro-Optical Transfer Function of Mastering Reference Displays.

SMPTE 298 Universal Labels for Unique identification of Digital Data.

SMPTE ST 336 Data Encoding Protocol using Key-Length-Value.

SMPTE ST 335 Metadata Element Dictionary Structure.

SMPTE ST 395 Metadata Groups Register.

SMPTE ST 2003 Types Dictionary Structure.

## Other References

Mp4ra.org, Official Registration Authority of the ISOBMFF family of standards.

# Definitions

This document defines the following terms. The definitions in AVC (Rec. ITU-T H.264 | ISO/IEC 14496-10) and HEVC (Rec. ITU-T H.265 | ISO/IEC 23008-2) also apply.

|  |  |
| --- | --- |
| * 1. **a** | **electro-optical transfer function (EOTF):** The function used in the post-decoding process to convert from a non-linear representation to a linear representation. |
|  | **full range:** A range in a fixed-point (integer) representation that spans the full range of values that could be expressed with that bit depth, such that, for 10-bit signals, black corresponds to code value 0 and nominal peak white corresponds to code value 1023 for Y′, as per the full range definition from Rec. ITU-R BT.2100. |
|  | **inverse electro-optical transfer function (inverse EOTF**): A function used in the pre-encoding process to convert from a linear representation to a non-linear representation, computed as the inverse of the EOTF.  NOTE to entry – In this document the pre-encoding process is assumed to operate on HDR/WCG video content that has been prepared for a hypothetical reference viewing environment as shown in **Error! Reference source not found.**. The content preparation step may contain processing such as applying an opt-optical transfer function (OOTF), in which the HDR/WCG video is converted from one linear representation (corresponding to the scene) to another linear representation (corresponding to the display). The OOTF has the role of applying a “rendering intent”. In systems where no such OOTF is applied in the content preparation step, the process of converting from a linear representation (corresponding to the scene) to a non-linear representation is typically called the opt-electrical transfer function (OETF). |
|  | **narrow range:** A range in a fixed-point (integer) representation that does not span the full range of values that could be expressed with that bit depth such that, for 10 bit representations, the range from 64 (black) to 940 (nominal peak white) is used for Y′ and the range from 64 to 960 is used for Cb and Cr, as per the narrow range definition from Rec. ITU-R BT.2100.  NOTE to entry –  Narrow range is, in some applications, called by synonyms such as: “limited range”, “video range”, “legal range”, “SMPTE range” or “standard range”. |
|  | **opto-electrical transfer function (OETF):** The function that converts linear scene light into the video signal, typically applied within a camera. |
|  | **opto-optical transfer function (OOTF):** A function that maps relative scene linear light (typically the camera output signal) to display linear light (typically, the signal driving a mastering monitor). |
|  | **random access point access unit (RAPAU):** An access unit in the bitstream containing an intra coded picture with the property that all pictures following the intra coded picture in output order can be correctly decoded without using any information preceding the Random Access Point Access Unit in the bitstream. |
|  | **transfer function:** In this document, a transfer function refers to any of the following; EOTF, inverse EOTF, OETF, inverse OETF, OOTF, or inverse OOTF. |
|  | **colour volume:** Space of all colors and intensities that a device or signal can reproduce or convey. |

# Abbreviations and acronyms

This document uses the following abbreviations and acronyms:

|  |  |
| --- | --- |
| 2K | Informally used for HD resolution (1920x1080 or 2048x1080/Film) |
| 4K | Informally used for a UHD resolution (3840x2160 or 4096x 2160/Film) |
| 8K | Informally used for a UHD resolution (7680x4320 or 8192x4320/Film) |
| AVC | Advanced Video Coding (Rec. ITU-T H.264 | ISO/IEC 14496-10) |
| EOTF | Electro-Optical Transfer Function |
| HD | High Definition |
| HDR | High Dynamic Range |
| HEVC | High Efficiency Video Coding (Rec. ITU-T H.265 | ISO/IEC 23008-2) |
| HLG | Hybrid Log-Gamma (as defined in Rec. ITU-R BT.2100) |
| HVS | Human Visual System |
| LUT | Look-up Table |
| NCG | Narrow Colour Gamut (normally referred to 709 as per Rec. ITU-R BT.709) |
| NCL | Non-Constant Luminance |
| PQ | Perceptual Quantizer (as defined in Rec. ITU-R BT.2100) |
| QP | Quantization Parameter |
| RAPAU | Random Access Point Access Unit |
| RGB | Colour System using linear light Red, Green, and Blue components |
| R′G′B′ | Colour System using non-linear (mapped to approximately perceptually uniform steps) Red, Green, and Blue components. The mapping between linear RGB and non-linear R′G′B′ is indicated by the transfer function. The colour representation does not indicate the media component order in the file. |
| SDR | Standard Dynamic Range |
| SEI | Supplemental Enhancement Information |
| OETF | Opto-Electrical Transfer Function |
| OOTF | Opto-Optical Transfer Function |
| UHD | Ultra High Definition |
| VUI | Video Usability Information. A sequence level sub-header in AVC and HEVC bitstreams. |
| WCG | Wide Colour Gamut (a gamut substantially wider than the gamut conveyed by BT.709) |
| XYZ | The CIE 1931 colour space. Y corresponds to the luminance signal. |
| Y′CbCr | Colour space representation commonly used for video/image distribution as a way of encoding RGB information, also commonly expressed as YCbCr, Y′CBCR, or Y′C′BC′R. The relationship between Y′CbCr and RGB is dictated by certain signal parameters, such as colour primaries, transfer characteristics, and matrix coefficients. Unlike the CIE-Y component in the linear light XYZ representation, the non-linear, approximately perceptual uniform Y′ in this representation might not be representing the same quantity, regardless of the transfer function. Y′ is commonly referred to as “luma”. Cb and Cr are colour difference signals commonly referred to as “chroma”. It could also be known as YUV in other documents. |

# Overview

The Coding-Independent Code Points (CICP) standard for Video (ISO/IEC 23091-2) defines code points and fields that identify the video signal type. It is independent from how these properties are carried in a coded video layer bitstream such as an AVC or HEVC bitstream which could differ depending on bitstream format. The compressed representation is often considered to be a temporary, compact distribution, delivery state of the video signal, while the reconstructed video signal output from the decoder should be interpreted as having the same meaning as the video signal immediately prior to compression.

The combinations of all possible video properties and values can result in hundreds of permutations; but many of those combinations are rarely or never used in practice. For example, it is unlikely that ITU-R BT.2100 perceptual quantization (PQ) transfer characteristics would be combined with ITU‑R BT.601 colour primaries. Only a small subset of combinations (such as BT.2020/BT.2100 colour primaries with BT.709/BT.2020 gamma, BT.2100 PQ, or BT.2100 hybrid log-gamma (HLG) transfer characteristics) are used in practice.

Video properties and values are usually expressed in "metadata" that can exist across production and distribution workflows. Knowledge of these properties and their combinations has value as content is processed in the end-to-end (E2E) production-to-distribution workflow chain.

This text is a non-normative document of industry practices for describing present day widely used combinations of video properties and their representations in different carriage domain systems. This document provides information that aims to help vendors of various content processing tools avoid processing mistakes that cause video quality degradation due to a wrong assumption made about video property combinations. There are only limited sets of video property combinations that are widely used in present day production/video distribution equipment chains. This document characterises these limited sets of combinations that are widely used today. This document provides this information and how it is carried to aid in the automation of content workflows across various domains of capture, production, and distribution. Lastly, this Technical Report aims to help its readers, especially toolset developers, to repurpose tools to work across several domains (capture, production, production distribution, service distribution) where similar video conversion functions (e.g. sub-sampling) may be performed.

Sections 7.1 or 7.2 of this Technical Report define system identifier tags for each combination of commonly used values of more intransient video properties and their combinations that go across domains.In addition, these sections will also identify how the video property values are carried in the stream. Future sections of this technical report will characterize more transient video properties/combinations where values may be more determined by the domain and subsampling of the video (e.g. chroma location type).

# Domains- capture, production, production distribution, service distribution

Figure 1 illustrates workflow domains (capture, production, production distribution, service distribution) in which video content may exist, be edited, or be converted. Typical content workflows across these domains are theatrical/scripted TV or live events. There are many similar video processing functions that can be performed in each domain and often may be repeated in the next successive domain (see Figure 1).



Figure 1 Video workflows through different carriage domains

In the capture domain, content is created through sensors on cameras converting optical signals into a digital format. Content is retained at its highest informational format though some conversions to reduce transport bandwidth demands may happen during sensor processing.

In the interface to the production domain, content undergoes processing further transformations such as non-linear transformations (e.g. NCL), Pixel Subsampling (4:4:4🡪4:2:2), colour representation changes (RGB🡪 YCbCr), and bit rate reduction (16 bpp🡪10 bpp). For theatrical/ Scripted TV workflows entering in the production domain, content can be added to by CGI sources, overlayed with graphics, and colour graded using a Mastering display. For Live Event workflows, there is always a real-time constraint, which limits content processing to real-time operations. After the colour grading, both static and dynamic metadata may be generated that are to be attached to the content workflow. However, for live events this may not be practical and metadata may need to be generated further downstream by automated content analysis approaches.

In the production distribution domain, some additional processing is done to the content to further reduce transport bandwidth demands. This may include some pixel transformations (chroma- subsampling[[1]](#footnote-1), bit depth) and compression (e.g. AVC, HEVC) but mostly employing spatial compression techniques.

At the service distribution domain, the content version in the workflow is in final form though the presentation of it may have some additional overlay graphics. Content processing at this interface continues to reduce signal information to address transport bandwidth distribution demands while still maximizing perceptual optimizations to retain content video quality. Operations reduce the content to a 4:2:0 Y’CbCr 8 or 10 bit compressed stream using HEVC, AVC, or even MPEG-2 coded representation. This content workflow then finishes by the content being distributed to the customer through broadcast, multicast, or unicast approaches and then presented for viewing.

A lot of the content processing operations may employ multiple 3rd party content processing tools. Currently most tools are designed and operate within a specific domain with general assumptions of how content was handled in the preceeding domain. Tools may also have further constraints depending on content resolutions (HD or 2K in Film/ UHD or 4K or 8K in Film). Some applications restrict the utilized color volume to be smaller than that of the full BT.2020 and BT.2100 container, such as the smaller P3D65 color gamut and intensity range of a common mastering or reference displays used in content production and delivery presentations. The approved color volume is often indicated with ST 2086 metadata. It is expected that WCG and/or HDR applications will evolve to use more of the potential container color volume.

# Common combinatorial descriptions

This section enumerates common combinations of video properties and values used within the content industry today. This section also describes common methods of conveying video property information for capture, production, production distribution, and service distribution carriage domains.

System identifier tags are to be used in this document to identify succinctly each commonly used combination. System identifier tags may be used as out of band metadata for conversion tools, and by production/distribution teams, to identify the workflow path needed to process and distribute content.

Content conversion tools need the locations and values of stream properties and associated metadata through the knowledge of the appropriate system identifier . In some cases, the information to identify and locate video properties of the stream information is described in the specific coded video stream specification. For example, a SMPTE MXF structured stream indicates parameters and values through SMPTE UL structures[[2]](#footnote-2) located in MXF headers. In another example, HEVC/AVC streams indicate parameters and values through VUI and SEI constructs at the parameter set level.

## Colourimetry and range scalability descriptions

Common colour volume information describes combinations of video properties that are needed to convert between colour volumes. Such conversions may include changes in bit depth, changes in colour sub-sampling, non-linear optimizations, and may also include transformations based on carriage and bit rate restrictions. SD, HD, and UHD material carry certain colorimetry properties as indicated in Table 1 but this information can be carried in different places or inferred depending on the storage or streaming format.

Table 1 SD, HD, UHD Colorimetry Video Properties

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Tag** | **Color** | | **Light** | | **container space properties** | | |
|  | **Gamut** | **Primaries** | **Dynamic Range** | **Transfer function** | **Domain** | **Integer code level scaling** | **4:2:0-only chroma sample vertical alignment  (ChromaLocType)** |
| SD | BT.601\_525 | NCG | BT.601 | SDR | gamma | Y′CbCr | Narrow | Interstitial  (0) [ |
| BT.601\_625 | Y′CbCr | Narrow | Interstitial  (0) |
| HD | BT.709\_YCC | BT.709 | Y′CbCr | Narrow | Interstitial  (0) |
| BT.709\_RGB | R′G′B′ | Narrow | N/A |
| FR709\_RGB | R′G′B′ | Full | N/A |
| UHD | BT.2020\_YCC\_NCL | WCG | BT.2020 | Y′CbCr | Narrow | Co-sited  (2) |
| BT.2020\_RGB | R′G′B′ | Narrow | N/A |
| FR2020\_RGB | R′G′B′ | Full | N/A |
| BT.2100\_PQ\_YCC | BT.2100 | HDR | PQ | Y′CbCr | Narrow | Co-sited  (2) |
| BT.2100\_PQ\_RGB | R′G′B′ | Narrow | N/A |
| BT.2100\_HLG\_YCC | HLG | Y′CbCr | Narrow | Co-sited  (2) |
| BT.2100\_HLG\_RGB | R′G′B′ | Narrow | N/A |

*Note: BT.709 was intended for HD applications (1080i, 720p), but some SD (480i, 576i) systems adopted it.*

Carriage formats for colour properties in each domain (capture, production, production distribution, service distribution) contain the same payload but in different wrappers. In the capture and production domains, the colour property information can be carried in an MXF wrapper using a generic picture essence descriptor as specified by Annex C of ST 2067-21[[3]](#footnote-3). Colour volume information in the distribution domain can be carried within the video stream as syntax information in the selected video format such as AVC, HEVC, MPEG-2, etc., through VUI headers according to ISO/IEC 23091-2. The full and narrow range scalability video property is not carried explicitly in all technologies and may need to be taken implicitly through the system identifier. In common practice, Y′CbCr colour representation uses narrow range-scaled levels.

### Defined properties

For the colourimetry and range scalability descriptions, the following video properties are included, whose values in specific combinations specify what is widely used in industry content. This document uses the coding independent code points terminology as described in ITU-T H.273|ISO/IEC 23091-2 for each video properties below:

1. ColourPrimaries

|  |  |  |
| --- | --- | --- |
| Carriage Parameter Names | Colloquial | Utilization |
| colour\_primaries [HEVC/AVC]  colour primaries [SMPTE-MXF] | colorspace, color gamut | SDR uses a BT.709 colour representation, WCG mayrestricts colours to P3D65 values (ST 2067-10) but in a 2020 colourspace container, HDR over time will use the complete BT.2020 colour representation. |

1. TransferCharacteristics

|  |  |  |
| --- | --- | --- |
| Carriage Parameter Names | Colloquial | Utilization |
| transfer\_characteristics [HEVC/AVC]  transfer charasteristic [SMPTE-MXF] | Transfer curves, log curves | Widely used practices: For HDR uses either PQ or HLG, for SDR uses transfer characteristic for BT.709 assuming a display characteristic corresponding to BT.1886 |

1. MatrixCoefficients[[4]](#footnote-4)

|  |  |  |
| --- | --- | --- |
| Carriage Parameter Names | Colloquial | Utilization |
| matrix\_coeffs [HEVC]  matrix\_coefficients (AVC)  coding equations [SMPTE-MXF] | Color Representation, GBR, NCL, YCC, YUV, Y’UV, R’B’G’ | Widely used practices: Specifies the encoding equations to convert RGB image components to component colour difference image components. No matrix is used for R’G’B’ |

1. VideoFullRangeFlag

|  |  |  |
| --- | --- | --- |
| Carriage Parameter Names | Colloquial | Utilization |
| video\_full\_range\_flag [HEVC/AVC]  n/a [SMPTE-MXF] | Full, narrow, head, legal, QE.1, QE.2 | Y’CbCr colour representation uses narrow range scalability values |

Table 2 indicate the code values for each property that are widely used for video content production and distribution systems.

Table 2 Code point values widely used for colourimetry properties

|  |  |  |
| --- | --- | --- |
| HEVC property | Code point | Meaning |
| colour\_primaries | 1 | BT.709 primaries |
| 5 | BT.601 625-line systems primaries |
| 6 | BT.601 525-line systems primaries |
| 9 | BT.2020 and BT.2100 primaries  (share the same code point since their values are identical) |
| transfer\_characteristics | 1, 6, 14 | functionally equivalent, gamma (SDR) |
| 16 | BT.2100 PQ (Perceptual Quantizer) |
| 18 | BT.2100 HLG (Hybrid Log-Gamma) |
| matrix\_coefficients | 0 | R′G′B′ (identity matrix applied to primaries) |
| 1 | Y′CbCr for BT.709 primaries |
| 5 | Y′CbCr for BT.601 625-line primaries |
| 6 | Y′CbCr for BT.601 525-line primaries |
| 9 | Y′CbCr for BT.2020 and BT.2100 primaries |

### Common descriptions and carriage: Standard Dynamic Range - Narrow Colour Gamut

This colour volume describes SDR video, which includes the majority of the production and distribution workflows used in the industry today. There are several combinations of values of video properties that are used for this colour volume. Table 1 describes these combinations. Note, there are several one-way operations that can be performed for this colour volume including bit depth reductions, colour sampling reductions, and full-to-narrow level range scaling operations.

The following system identifier tags are described:

* BT709\_YCC
* BT709\_RGB
* FR709\_RGB
* BT601\_525
* BT601\_625

Table 3 SDR/NCG Common Colour Volume Descriptions

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **System Identifier** | **BT709\_YCC** | **BT709\_RGB** | | **FR709\_RGB** | | **BT601\_525** | **BT601\_62** |
| *Colour properties* | Colour primaries | BT.709 | BT.709 | | BT.709 | | BT.601 | BT.601 |
| Transfer characteristics | BT.709 (TC) | BT.709 (TC) | | BT.709 (TC) | | BT.709 (TC) | BT.709 (TC) |
| Colour representation | Y′CbCr | R′G′B′ | | R′G′B′ | | Y′CbCr | Y′CbCr |
| *Other* | Full/narrow range | Narrow | Narrow | | Full | | Narrow | Narrow |
| *CICP parameters* | ColourPrimaries | 1 | 1 | | 1 | | 6 | 5 |
| TransferCharacteristics | 1 | 1 | | 1 | | 6 | 6 |
| MatrixCoefficients | 1 | 0 | | 0 | | 6 | 5 |
| |  | | --- | | VideoFullRangeFlag | | 0 | 0 | | 1 | | 0 | 0 |
| *SMPTE MXF parameters* | Colour primaries | 06.0E.2B.34.04.01.01.06.04.01.01.01.03.03.00.00 | | | | | 06.0E.2B.34.04.01.01.06.04.01.01.01.03.01.00.00 | 06.0E.2B.34.04.01.01.06.04.01.01.01.03.02.00.00 |
| Transfer characteristic | 06.0E.2B.34.04.01.01.01.04.01.01.01.01.02.00.00 | | | | | | |
| Coding equations | 06.0E.2B.34.04.01.01.01.04.01.01.01.02.02.00.00 | | N/R | | N/R | 06.0E.2B.34.04.01.01.01.04.01.01.01.02.01.00.00 | |
| Full/Narrow level range  indicated in black ref level, white ref level, colour range | Inferred | | | | | | |

*Note: BT.601 Colour Volumes are used for standard definition (SD) material only.*

*Note: Gamma transfer characteristics of 1, 6, 14, 15 are functionally the same. Blu-Ray and DVB specifications list use of transfer characteristics of 14 for SDR video. ATSC specifications list use of transfer characteristics of 1 for SDR video.*

*Note: Matrix Coefficients of 5 and 6 are functionally the same.*

*Note: CCIP Parameters will follow the specification version as indicated in 23091-2 (CICP-Video) and if not specified then it should follow the referenced specification number and version as indicated in this document.*

### Common descriptions and carriage: Standard Dynamic Range – Wide Colour Gamut

This colour volume describes SDR with wide colour gamut video, which is keyed off the colour primary video property. In some cases, the same colour property may be described with two different values depending on the colour primary container used. It is important for tools to process video according to the colour volume it is operating in to make sure the conversion is consistent.

The following system identifier tags are described:

* BT2020\_YCC\_NCL
* BT2020\_RGB
* FR2020\_RGB

Table 4 SDR w/ WCG Common colour volume descriptions[[5]](#footnote-5)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **System Identifier** | **BT2020\_YCC\_NCL** | **BT2020\_RGB** | **FR2020\_RGB** |
| *Colour properties* | Colour primaries | BT.2020 | BT.2020 | BT.2020 |
| Transfer characteristics | BT.2020 (TC) | BT.2020 (TC) | BT.2020 (TC) |
| Colour representation | YCbCr | RGB | RGB |
| *Other* | Full/narrow range | Narrow | Narrow | Full |
| *CICP parameters* | ColourPrimaries | 9 | 9 | 9 |
| TransferCharacteristics | 14 | 14 | 14 |
| MatrixCoefficients | 9 | 0 | 0 |
| |  | | --- | | VideoFullRangeFlag | | 0 | 0 | 1 |
| *SMPTE MXF parameters* | Colour primaries | 06.0E.2B.34.04.01.01.0D.04.01.01.01.03.04.00.0 | | |
| Transfer characteristic | 06.0E.2B.34.04.01.01.0E.04.01.01.01.01.09.00.00 | | |
| Coding equations | 06.0E.2B.34.04.01.01.0D.04.01.01.01.02.06.00.00 | N/R | N/R |
| Full/narrow level range  indicated in black ref level, white ref level, colour range | Inferred | | |

*Note: Gamma transfer characteristics of 1, 6, 14, 15 are functionally the same. Blu-Ray and DVB specifications list use of transfer characteristics of 14 for SDR video. ATSC specifications list use of transfer characteristics of 1 for SDR video.*

*Note: BT.2020 transfer curve is functionally the same as BT.709 transfer curve. ARIB STD B-32 however uses both with BT.709-6 (TC) for HD and BT.2020 (TC) for UHD.*

*Note: CCIP Parameters will follow the specification version as indicated in 23091-2 (CICP-Video) and if not specified then it should follow the referenced specification number and version as indicated in this document.*

### Common descriptions and carriage: High Dynamic Range- Wide Colour Gamut

This colour volume describes HDR video, which is typically associated with ultra high definition video.

The following system identifier tags are described:

* BT2100\_PQ\_YCC
* BT2100\_HLG\_YCC
* BT2100\_PQ\_RGB
* BT2100\_HLG\_RGB

Table 5 HDR/WCG common colour volume descriptions

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **System Identifier** | **BT2100\_PQ\_YCC** | **BT2100\_HLG\_YCC** | **BT2100\_PQ\_RGB** | **BT2100\_HLG\_RGB** |
| *Colour properties* | Colour primaries | BT.2020 / BT.2100 | BT.2020 / BT.2100 | BT.2020 / BT.2100 | BT.2020 / BT.2100 |
| Transfer characteristics | PQ | HLG | PQ | HLG |
| Colour representation | YCbCr | YCbCr | RGB | RGB |
| *Other* | Full/narrow range | Narrow | Narrow | Narrow | Narrow |
| *CICP parameters* | ColourPrimaries | 9 | 9 | 9 | 9 |
| TransferCharacteristics | 16 | 18 | 16 | 18 |
| MatrixCoefficients | 9 | 9 | 0 | 0 |
| |  | | --- | | VideoFullRangeFlag | | 0 | 0 | 0 | 0 |
| *SMPTE MXF parameters* | Colour primaries | 06.0E.2B.34.04.01.01.0D.04.01.01.01.03.04.00.00 | | | |
| Transfer characteristic | 06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0A.00.00 | 06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0B.00.00 | 06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0A.00.00 | 06.0E.2B.34.04.01.01.0D.04.01.01.01.01.0B.00.00 |
| Coding equations | 06.0E.2B.34.04.01.01.0D.04.01.01.01.02.06.00.00 | | N/R | N/R |
| Full/narrow level range  indicated in black ref level, white ref level, colour range | Inferred | | | |

*Note: CCIP Parameters will follow the specification version as indicated in 23091-2 (CICP-Video) and if not specified then it should follow the referenced specification number and version as indicated in this document.*

## Mastering display colour volume descriptions

Mastering display colour volume (MDCV) information describes the colour characteristics of a display that was used for authoring/grading video content; i.e., it is the display where creative work performed during the mastering process acheived the creative intent of the finished content. When the authored content is shown on other displays, mastering display colour volume information can be used to more closely reproduce the original creative intent.

### Defined Properties

For the mastering display colout volume descriptions, the following mastering display properties are included, whose values in specific combinations represent widely used mastering display setups to grade content. This document uses properties as described in ST 2086 and listed below:

* Mastering display primaries [ST 2086]
* Mastering display white point chromaticity [ST 2086]
* Mastering display maximum luminance [ST 2086]
* Mastering display minimum luminance [ST 2086]

[Ed. Note (Alexis): These also exist in the HEVC and AVC specs. Ideally, they should also be in CICP and we should be referencing those specs also. YS: Agreed

### Common descriptions and carriage: MDCV descriptions

The following system identifier tags are used to describe properties of commonly used mastering displays. (All commonly used mastering display systems have a D65 white point.)

* 709-100 (0.05)- represents a mastering display LCD/LED environment for mastering of SDR content with displays having 100 cd/m2 of peak brightness, 0.05 minimum brightness, and a D65 whitepoint setting within a BT.709 colour representation.
* P3-1000 (0.0005)- represents a mastering display OLED environment for mastering of HDR content with displays having 1000 cd/m2 of peak brightness, 0.0005 minimum brightness, and a D65 whitepoint setting within a BT.2100 colour representation constrained to P3 values.
* 2100-107 (0.0005)- represents a mastering display OLED environment for mastering of SDR/HDR content with displays having 1000 cd/m2 of peak brightness, 0.05 minimum brightness, and a D65 whitepoint setting within a BT.2100 colour representation.

Carriage formats for mastering display colour volume in each of the domains (capture, production, production distribution, service distribution) contain the same payload but in different wrappers. In the capture and production domains, the MDCV information can be carried in an MXF wrapper using Generic Picture Essence descriptor as described by Annex C of ST 2067-21. In the distribution domain, the mastering display colour volume information is carried the mastering display colour volume SEI message (payload 137) that needs to be repeated at least every random-access point access unit (RAPAU).

Table 6 Mastering display colour volume descriptions

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **System identifier** | | **709-100  (0.05)** | **P3-1000 (0.0005)** | **2100-107 (0.0005)** |
| **Mastering display properties defined according to ST 2086** | Primaries (x,y) | | {0.6400, 0.3300}  {0.3000, 0.6000}  {0.1500, 0.0600} | {0.6800, 0.3200}  {0.2650, 0.6900}  {0.1500, 0.0600} | {0.7080, 0.2920} {0.1700, 0.7970} {0.1310, 0.0460} |
| White point chromaticity (x,y) | | {0.3127, 0.3290}  (D65) | | |
| Maximum luminance [cd/m2] | | 100 | 1000 | 1000 |
| Minimum luminance [cd/m2] | | 0.05 for LCD/LED | 0.0005 for OLED | 0.0005 for OLED |
| **AVC/HEVC SEI MDCV** | Display\_primaries\_x[0]/y[0] | | {32000,16500} | {35400,14600} | {34000,16000} |
| Display\_primaries\_x[1]/y[1] | | {15000,30000} | {8500,39850} | {13250,34500} |
| Display\_primaries\_x[2]/y[2] | | {7500,3000} | {6550,2300} | {7500,3000} |
| White\_point\_x/y | | {15635,16450} | | |
| Max/min\_display\_mastering\_luminance | | {1000000,500} | {10000000,5} | {10000000,5} |
| **SMPTE MXF parameters** | MasteringDisplayPrimaries | Registration Identifier | 060e2b34.0101010e.04200401.01010000 | | |
| Coded Decimal | {32000,16500} {15000,30000} {7500,3000} | {35400,14600} {8500,39850} {6550,2300} | {34000,16000} {13250,34500} {7500,3000} |
| MasteringDisplayWhitePointChromaticity | Registration Identifier | 060e2b34.0101010e.04200401.01020000 | | |
| Coded Decimal | {15635,16450} | | |
| MasteringDisplayMaximumLuminance | Registration Identifier | 060e2b34.0101010e.04200401.01030000 | | |
| Coded Decimal | 1000000 | 10000000 | 10000000 |
| MasteringDisplayMinimumLuminance | Registration Identifier | 060e2b34.0101010e.04200401.01030000 | | |
| Coded Decimal | 500 | 5 | 5 |

# [Document End]

1. For 4:2:0 chroma subsampling operations, it is important to make known the initial subsampling location processing of the content to avoid unnecessary quality degradation upon further content processing. For NCG material, ChromaLocType = 0. For WCG material, ChromaLocType = 2. [↑](#footnote-ref-1)
2. SMPTE MXF structures make use of UL (Universal Labels) which are a set of registered labels maintained by SMPTE (registry.smpte-ra.org). This is a 16 byte structure comprised of SMPTE UL Header [4bytes-“0”] [12], SMPTE UL Designator [4bytes-“0”] [13], and an Item Designator [8 bytes-“000”] [14][15][16]. SMPTE MXF Sub tables will provide these 16 byte labels in addition to any values associated with the label. [↑](#footnote-ref-2)
3. In some capture, production, and distribution domains, the colorimetry property information may also be carried combined as single string of values (e.g. “9-1-9”) . [↑](#footnote-ref-3)
4. The colour representation does not indicate the media component order in the file. [↑](#footnote-ref-4)
5. [↑](#footnote-ref-5)