SMPTE STANDARD

Vertical Ancillary Data Mapping of KLV Formatted HDR/WCG Metadata

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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual. This SMPTE Engineering Document was prepared by Technology Committee 32NF.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Document. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

This standard defines the transport of High Dynamic Range and Wide Color Gamut (HDR/WCG) metadata on the SMPTE Serial Digital Interface (SDI) using Key-Length-Value (KLV) encoding as specified in SMPTE ST 336. The HDR/WCG metadata is transmitted as a single HDR/WCG Metadata Message with the video frame to which the metadata applies. The HDR/WCG Metadata Message is carried within one or more SMPTE ST 291-1 ancillary data packets, the HDR/WCG KLV Metadata Ancillary Data Packet. The HDR/WCG Metadata Message includes one or more KLV formatted HDR/WCG Metadata Frames containing HDR/WCG metadata.

Basic signaling parameters that describe aspects of the payload carried on the SMPTE Serial Digital Interface (SDI) are transmitted in a 4-byte payload identifier ancillary data packet as defined in SMPTE ST 352 and application specific documents that reference SMPTE ST 352. This standard does not replace SMPTE ST 352 or related application specific documents as the primary method for SDI format signaling, nor any other SDI format signaling methods, but is intended as an *extension* to such methods when they lack the capability to transmit HDR/WCG metadata parameters that are required or desired by HDR/WCG systems.

SMPTE ST 2108-1 also defines transport of the HDR/WCG metadata in the SDI interface and shares common functionality to this standard in its scope. This standard is limited in scope to HDR/WCG metadata in KLV format, as might be more appropriate for production applications, whereas ST 2108-1 supports HDR/WCG metadata in other formats, such as ITU-T H.265 SEI messages, that might be better suited for other applications. Both standards are appropriate for transport of HDR/WCG metadata in the SDI interface and individual applications can chose whichever standard is better suited to the specific needs of that application.

1 Scope

The standard defines how HDR/WCG metadata is placed into ancillary data packets according to SMPTE ST 291-1, to form the HDR/WCG KLV Metadata Ancillary Data Packet, using Key-Length-Value encoding as specified in SMPTE ST 336.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; then formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this engineering document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this engineering document are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

Recommendation ITU-T H.265 (02/2018) High efficiency video coding

SMPTE ST 291-1:2011, Ancillary Data Packet and Space Formatting

SMPTE ST 336:2017, Data Encoding Protocol Using Key-Length-Value

SMPTE ST 2067-21:2016, Interoperable Master Format – Application #2E

SMPTE ST 2094-2:2017, Dynamic Metadata for Color Volume Transform – KLV Encoding and MXF Mapping

4 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

4.1 DMCVT

Dynamic Metadata for Color Volume Transform as specified by SMPTE ST 2094 series

5 HDR/WCG KLV Metadata Ancillary Data Packet — Specification and Carriage

5.1 Format of the HDR/WCG KLV Metadata Ancillary Data Packet

The HDR/WCG KLV Metadata Ancillary Data Packet shall be a Type 2 ANC packet as defined in SMPTE ST 291-1. It consists of the ancillary data flag (ADF), the data ID (DID), the secondary data ID (SDID), the data count (DC), the user data words (UDW), and the checksum (CS).

The DID word shall be set to the value 41h. The SDID word shall be set to the value 0Dh.

DC is a count of the number of words in the UDW field of the HDR/WCG KLV Metadata Ancillary Data Packet.

The UDW consists of the data payload that contains the Packet Count field, defined in Section 5.3, and all or part of the HDR/WCG Metadata Message defined in Section 5.4.

The Generalized format of the HDR/WCG KLV Metadata Ancillary Data Packet is shown in Table 1.

Table 1 - HDR/WCG KLV Metadata Ancillary Data Packet Format

	b9 (MSB)	b8	b7	b6	b5	b4	b3	b2	b1	b0 (LSB)
Ancillary Data Flag	0	0	0	0	0	0	0	0	0	0
	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1
Data ID (DID)	Not b8	EP	0	1	0	0	0	0	0	1

	b9 (MSB)	b8	b7	b6	b5	b4	b3	b2	b1	b0 (LSB)
Secondary Data ID (SDID)	Not b8	EP	0	0	0	0	1	1	0	1
Data Count (DC) = n	Not b8	EP	Data count range from 02h to a maximum of FFh. Actual range in accordance with the carriage of Metadata as defined in clause 5.3							
UDW 1 Packet Count	Not b8	EP	Packet count as defined in clause 5.3							
UDW 2….n (HDR/WCG Metadata Message)	Not b8	EP	HDR/WCG Metadata Message (all or portion) as defined in clause 5.4							
Checksum	Not b8	Sum of b0~b8 of DID through to the last UDW								

The symbol EP denotes even parity for b0 through b7.

Figure 1 illustrates the structure of the HDR/WCG KLV Metadata Ancillary Data Packet.

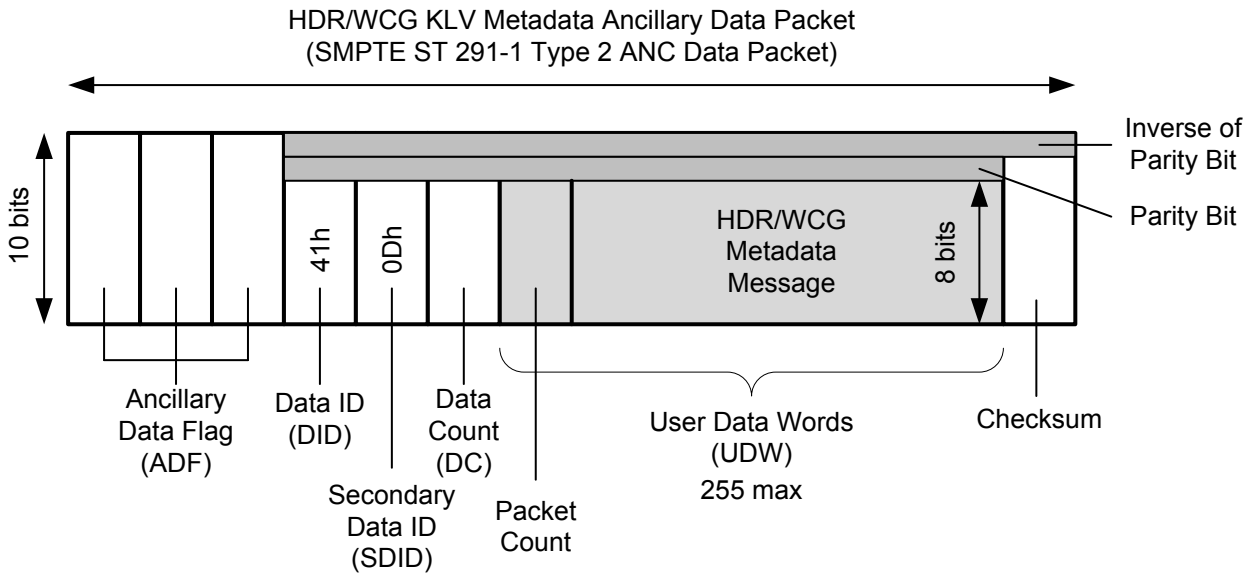

Figure 1 - HDR/WCG KLV Metadata Ancillary Data Packet Structure

5.2 Location and Timing of the HDR/WCG KLV Metadata Ancillary Data Packet

Transmission of HDR/WCG Metadata Message shall take place once per essence video frame with which the metadata is associated. Multiple HDR/WCG KLV Metadata Ancillary Data Packets may be present within a video frame if the HDR/WCG Metadata Message exceeds the size limit of the UDW fields of a single HDR/WCG KLV Metadata Ancillary Data Packet.

The HDR/WCG KLV Metadata Ancillary Data Packet placement is video format-dependent.

The packet shall be placed into any available Vertical Ancillary Data Space (VANC) after the second line following the vertical interval switching point and before the beginning of active video, as defined for the image format or sub image-format to which the packet applies.

Placement of the HDR/WCG KLV Metadata Ancillary Data Packet shall be further constrained by the ancillary data mapping rules defined in each applicable interface standard.

5.3 UDW Format

The UDW fields of the HDR/WCG KLV Metadata Ancillary Data Packet convey the HDR/WCG Metadata Message defined in clause 5.4 and a Packet Count value. As the HDR/WCG Metadata Message contains KLV data defined in 8 bit words, all UDW words in the HDR/WCG KLV Metadata Ancillary Data Packet, including the Packet Count value, encode 8-bit data in bit 0 through bit 7 of the UDW field. Bit 8 and bit 9 of the 10-bit UDW fields are set to even parity and non-parity, respectively, of bits 0 through 7.

UDW 1 of the HDR/WCG KLV Metadata Ancillary Data Packet contains the Packet Count field. The Packet Count field is an 8-bit unsigned integer that identifies the count (in order) of the HDR/WCG KLV Metadata Ancillary Data Packet. Bit 7 represents the MSB and bit 0 represents the LSB of the Packet Count. The first HDR/WCG KLV Metadata Ancillary Data Packet present in a video frame shall set the Packet Count field to the value of 01h. If more than one HDR/WCG KLV Metadata Ancillary Data Packet is required to convey the HDR/WCG Metadata Message for a given frame, the Packet Count shall increment in sequence for each additional packet.

Figure 2 illustrates the mapping of the HDR/WCG Metadata Message to the UDW fields of the HDR/WCG KLV Metadata Ancillary Data Packet when the HDR/WCG Metadata Message can be conveyed in a single packet. The Message Length field (defined in Section 5.4.1) is present in UDW fields 2-3 immediately following the Packet Count, and is followed by one or more HDR/WCG Metadata Frames. The first 8-bit word of an HDR/WCG Metadata Frame Key will always be present in UDW 4 in this case.

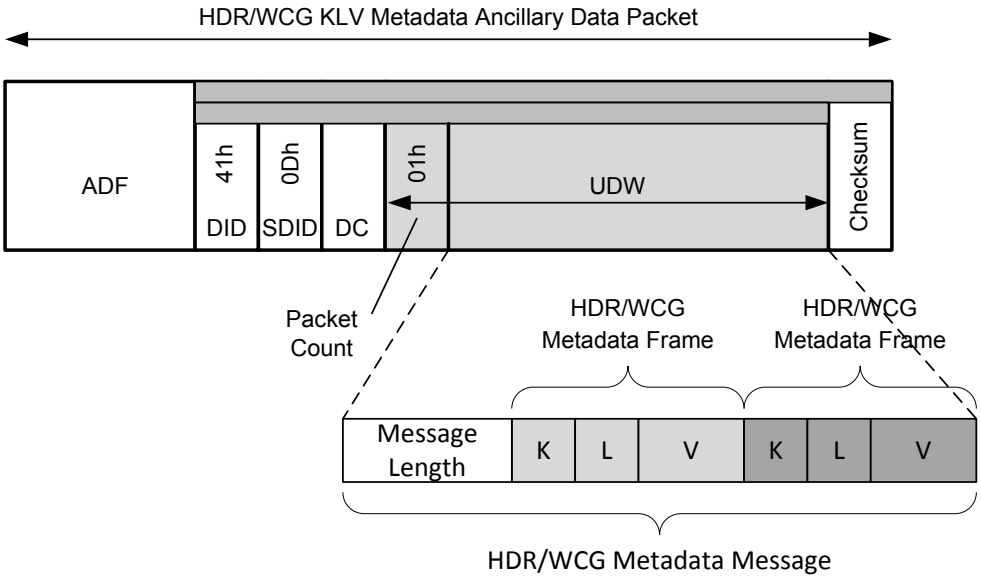

Figure 2 – Mapping of HDR/WCG Metadata Message to HDR/WCG KLV Metadata Ancillary Data Packet (informative)

If the HDR/WCG Metadata Message requires more UDW fields than are present in a single HDR/WCG KLV Metadata Ancillary Data Packet then multiple packets are used to convey the message. The first packet contains the Message Length field in UDW fields 2-3 immediately following the Packet Count. The data from UDW fields in subsequent packets, not including the Packet Count field, is concatenated in sequence to form the complete HDR/WCG Metadata Message.

The UDW fields immediately following the Message Length contain the Key of the first HDR/WCG Metadata Frame in the HDR/WCG Metadata Message, therefore all packets marked with Packet Count = 1 will have the first 8-bit word of a HDR/WCG Metadata Frame Key in a fixed location (UDW field 4). Subsequent packets, if present, might not have HDR/WCG Metadata Frame Keys in any fixed location and UDW field 2 might contain an 8-bit word of any portion of an HDR/WCG Metadata Frame.

Figure 3 illustrates the mapping of the HDR/WCG Metadata Message to the UDW fields of the HDR/WCG KLV Metadata Ancillary Data Packet when the HDR/WCG Metadata Message requires more than one packet.

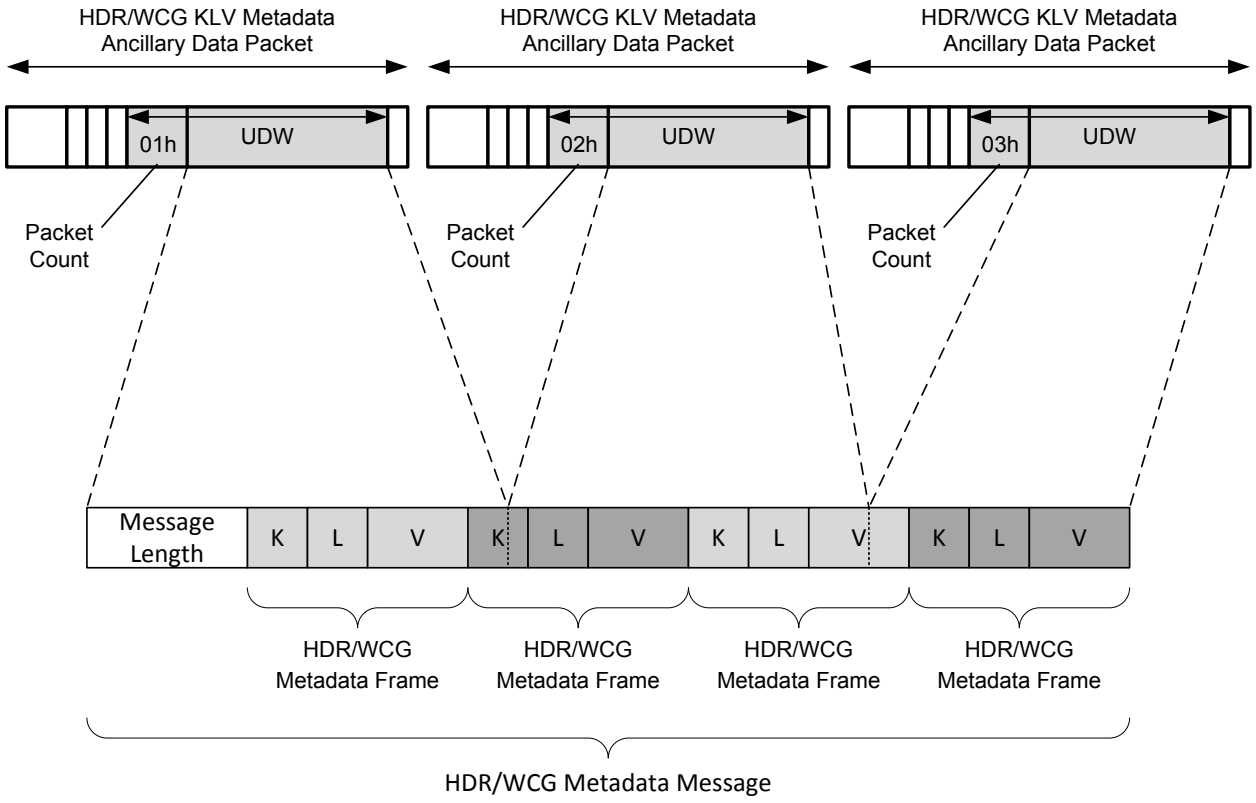

Figure 3 - Mapping of HDR/WCG Metadata Message to multiple HDR/WCG KLV Metadata Ancillary Data Packets (informative)

5.4 Encoding of HDR/WCG Metadata Message

5.4.1 HDR/WCG Metadata Message Structure

HDR/WCG metadata shall be carried in the HDR/WCG KLV Metadata Ancillary Data Packet via the HDR/WCG Metadata Message. HDR/WCG Metadata shall be formatted into HDR/WCG Metadata Frames as described in clause 5.4.2. The HDR/WCG Metadata Message shall consist of a Message Length field followed by a sequence of one or more HDR/WCG Metadata Frames. HDR/WCG Metadata Frames are encoded in KLV according to SMPTE ST 336, therefore the HDR/WCG Metadata Message comprises the Message Length field followed by a sequence of one or more KLV packets.

The Message Length shall indicate the number of 8-bit words (bytes) that encode the sequence of HDR/WCG Metadata Frames, and shall therefore indicate the length of the HDR/WCG Metadata Message, not including the length of the Message Length field itself. The Message Length field shall be a 16-bit unsigned integer encoded in two 8-bit UDW fields. The first data word shall represent the upper 8 bits of the Message Length field and the second data word shall represent the lower 8 bits. Bit 7 of the first word shall represent the MSB of the Message Length value and bit 0 of the second word shall represent the LSB.

Figure 4 illustrates the structure of the HDR/WCG Metadata Message.

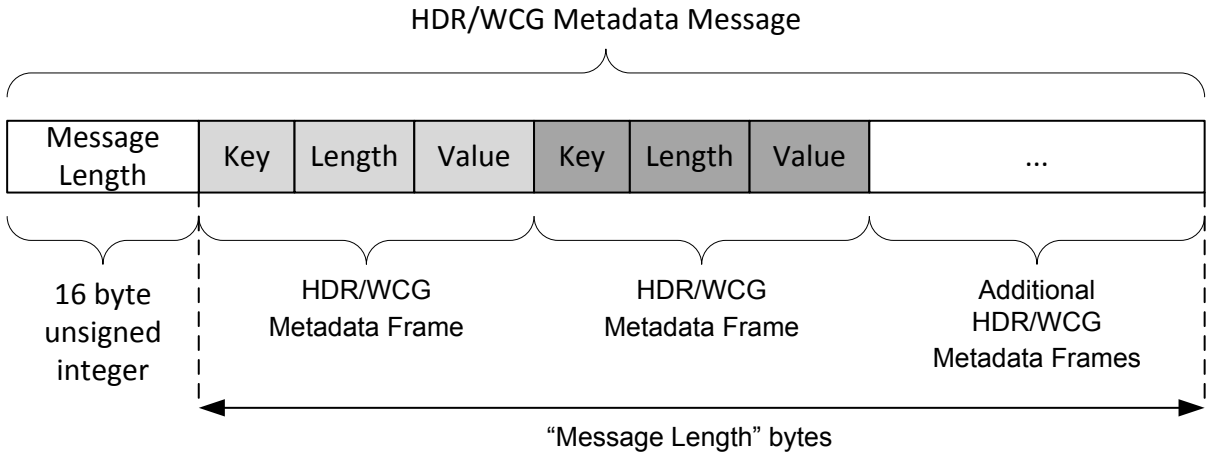

Figure 4 – HDR/WCG Metadata Message Structure (informative)

5.4.2 HDR/WCG Metadata Frames

5.4.2.1 Overview

HDR/WCG Metadata Frames shall be encoded in KLV according to SMPTE ST 336. Only HDR/WCG Metadata Frames described in this clause shall be included in the HDR/WCG Metadata Message. HDR/WCG Metadata Frames may occur in any order within the HDR/WCG Metadata Message.

The types of HDR/WCG Metadata Frames shall be:

- Mastering Display Color Volume Metadata Frame – This metadata may be present and is specified in clause 5.4.2.2.
- Maximum Light Level Metadata Frame – This metadata may be present and is specified in clause 5.4.2.3
- DMCVT Application 1 Metadata Frame – This metadata may be present. If this metadata is present, the Mastering Display Color Volume Metadata Frame shall also be present. This metadata is specified in clause 5.4.2.4.
- DMCVT Application 4 Metadata Frame – This metadata may be present. If this metadata is present, the Mastering Display Color Volume Metadata Frame shall also be present. This metadata is specified in clause 5.4.2.5.

5.4.2.2 Mastering Display Color Volume Metadata Frame

The HDR/WCG Metadata Frame of Mastering Display (MD) Color Volume Metadata shall be encoded as a SMPTE ST 336 defined length pack.

The pack key shall be the 16 byte UL defined in Table 2.

Table 2 - Key for Mastering Display Color Volume Metadata

Item Name	Symbol	Kind	Item UL
Color Transform Packs	ColorTransformPacks	NODE	06.0E.2B.34.02.7F.01.01.05.32.00.00.00.00.00.00
MD Color Volume Metadata	MDColorVolumeMetadata	LEAF	06.0E.2B.34.02.7F.01.01.05.32.01.00.00.00.00.00

The Length of the Mastering Display Color Volume Metadata pack shall be 18h coded per ASN.1 BER length notation, short form.

The data item in the Mastering Display Color Volume Metadata pack shall contain exactly one of each of the items specified in Table 4 in the order shown, with the node as defined in Table 3.

Table 3 – Node for Mastering Display (MD) Color Volume Metadata

Item Name	Symbol	Kind	Item UL
MDColorVolume	MD Color Volume	NODE	06.0E.2B.34.01.01.01.0E.04.20.04.01.02.00.00.00

Table 4 – Mastering Display (MD) Color Volume Metadata

Item Name	Item Symbol	Length	UL	Meaning
MD Primaries	MDPrimaries	12	06.0E.2B.34.01.01.01.0E.04.20.04.01.02.01.00.00	Display Primaries metadata as specified in ST 2086
MD White Point Chromaticity	MDWhitePointChromaticity	4	06.0E.2B.34.01.01.01.0E.04.20.04.01.02.02.00.00	Chromaticity of White Point metadata as specified in ST 2086
MD Maximum Luminance	MDMaximumLuminance	4	06.0E.2B.34.01.01.01.0E.04.20.04.01.02.03.00.00	Maximum Display Mastering Luminance metadata as specified in ST 2086
MD Minimum Luminance	MDMinimumLuminance	4	06.0E.2B.34.01.01.01.0E.04.20.04.01.02.04.00.00	Minimum Display Mastering Luminance metadata as specified in ST 2086

The Mastering Display (MD) Color Volume metadata items in Table 4 are equivalent to the Mastering Display Color Volume Metadata items defined in SMPTE ST 2067-21 Annex C and shall be encoded as described in SMPTE ST 2067-21 Annex C.

MD Primaries is equivalent to the Mastering Display Primaries item and shall be encoded as per SMPTE ST 2067-21 Annex C.2.

MD White Point Chromaticity is equivalent to the Mastering Display White Point Chromaticity item and shall be encoded as per SMPTE ST 2067-21 Annex C.3.

MD Maximum Luminance is equivalent to the Mastering Display Maximum Luminance item and shall be encoded as per SMPTE ST 2067-21 Annex C.4.

MD Minimum Luminance is equivalent to the Mastering Display Minimum Luminance item and shall be encoded as per SMPTE ST 2067-21 Annex C.5.

If a Mastering Display Color Volume Metadata Frame is present, it shall only be present once per video frame.

5.4.2.3 Maximum Light Level Metadata Frame

The HDR/WCG Metadata Frame of Maximum Light Level Metadata shall be encoded as a SMPTE ST 336 defined length pack.

The pack key shall be the 16 byte UL defined in Table 5.

Table 5 - Key for Maximum Light Level Metadata

Item Name	Symbol	Kind	Item UL
Color Transform Packs	ColorTransformPacks	NODE	06.0E.2B.34.02.7F.01.01.05.32.00.00.00.00.00.00
Maximum Light Level Metadata	MaximumLightLevelMetadata	LEAF	06.0E.2B.34.02.7F.01.01.05.32.02.00.00.00.00.00

The Length of the Mastering Display Color Volume Metadata pack shall be 04h coded per ASN.1 BER length notation, short form.

The data item in the Maximum Light Level Metadata pack shall contain exactly one of each of the items specified in Table 6 in the order shown.

Table 6 – Maximum Light Level Metadata

Item Name	Item Symbol	Length	UL	Meaning
Maximum Content Light Level	MaximumContent LightLevel	2	06.0E.2B.34.01.01.01.0E.05.31.01.42.00.00.00.00	Maximum Content Light Level as specified in Rec. ITU-T H.265
Maximum Frame Average Light Level	MaximumFrame AverageLightLevel	2	06.0E.2B.34.01.01.01.0E.05.31.01.43.00.00.00.00	Maximum Frame Average Light Level as specified in Rec. ITU-T H.265

Maximum Content Light Level shall contain the parameter max_content_light_level as defined in Rec. ITU-T H.265 (2/2018) clauses D.2.35 and D.3.35.

Maximum Frame-Average Light Level shall contain the parameter max_pic_average_light_level as defined in Rec. ITU-T H.265 (2/2018) clauses D.2.35 and D.3.35.

Note: The Content light level information SEI message described in Rec. ITU-T H.265 is an encoding of the Maximum Content Light Level (MaxCLL) and Maximum Frame Average Light Level (MaxFALL) metadata items as specified in Consumer Technology Association 861-G specification.

If a Maximum Light Level Metadata Frame is present, it shall only be present once per video frame.

5.4.2.4 DMCVT Application 1 Metadata Frame

The information conveyed in this set corresponds to the metadata specified in SMPTE ST 2094-10:2016 clause 7.1.

The DMCVT Application 1 metadata set for each frame shall be encoded as an ST 336 Local Set as specified in ST 2094-2.

- Each metadata set specified in SMPTE ST 2094-10:2016 Clause 7.1 for a combination of processing window and targeted system display shall be KLV encoded as specified in SMPTE ST 2094-2:2017 clause 6.3.

- The per frame metadata containing zero or more DMCVT Application 1 metadata sets shall be encoded as specified in SMPTE ST 2094-2:2017 clause 7.4.

The DMCVT Application 1 Metadata Frame shall be associated with every frame of the video essence. If this metadata set is present, it shall only be present once per video frame.

5.4.2.5 DMCVT Application 4 Metadata Frame

The information conveyed in this set corresponds to the metadata specified in SMPTE ST 2094-40:2016 clause 9.

The DMCVT Application 4 metadata set for each frame shall be encoded as an ST 336 Local Set as specified in ST 2094-2.

- Each metadata set specified in SMPTE ST 2094-40:2016 Clause 9 for a combination of processing window and targeted system display shall be KLV encoded as specified in SMPTE ST 2094-2:2017 clause 6.6.

- The per frame metadata containing zero or more DMCVT Application 4 metadata sets shall be encoded as specified in SMPTE ST 2094-2:2017 clause 7.4.

The DMCVT Application 4 Metadata Frame shall be associated with every frame of the video essence. If this metadata set is present, it shall only be present once per video frame.

Bibliography (Informative)

SMPTE ST 352:2013, Payload Identification Codes For Serial Digital Interfaces

SMPTE ST 2086:2014, Mastering Display Color Volume Metadata Supporting High Luminance and Wide Color Gamut Images

SMPTE ST 2094-10:2016, Dynamic Metadata for Color Volume Transform – Application #1

SMPTE ST 2094-40:2016, Dynamic Metadata for Color Volume Transform – Application #4

SMPTE ST 2108-1:2018, HDR/WCG Metadata Packing and Signaling in the Vertical Ancillary Data Space

CTA 861-G November 2016, A DTV Profile for Uncompressed High Speed Digital Interfaces