

SMPTE STANDARD



2160-line and 1080-line Source Image and Ancillary Data Mapping for 6G-SDI

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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.

ST 2081-10 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 Standard. 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.

SMPTE ST 2081-10 defines the mapping of various source images and associated ancillary data into a Single-link 6 Gb/s [nominal] SDI bit-serial interface.

The general process for creating a single-link 6G-SDI is illustrated below in Figure 1, Figure 2 and Figure 3. Detailed definitions of how this process applies to each of the modes defined in the scope follow in other sections of this document.

Parameter values included in tables or described in sections marked as (Informative), are based on reference documents of the specific version indicated in the reference section and identified in applicable normative sections of this standard.

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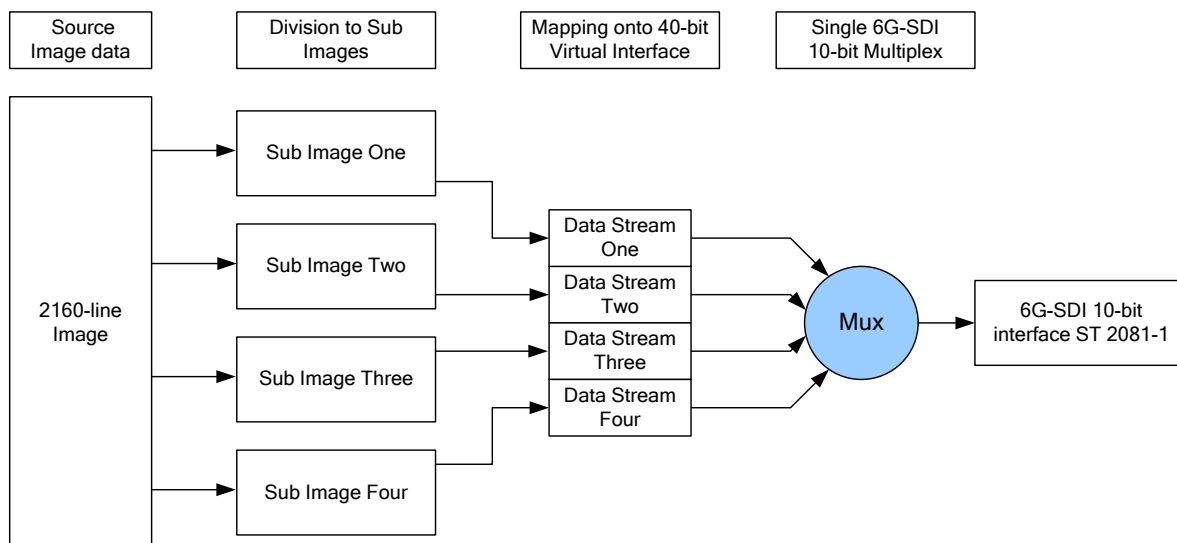


Figure 1 – Carriage of 2160-line images in a Single-link 6G-SDI interface – generalized process

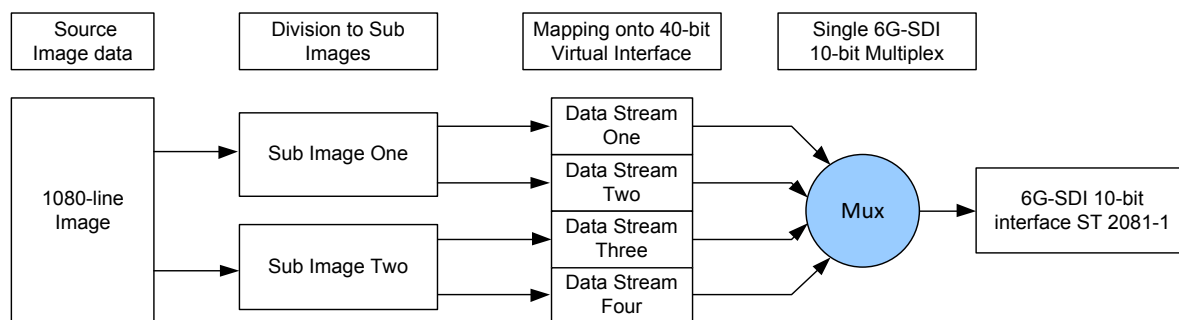


Figure 2 – Carriage of 1080-line images in a Single-link 6G-SDI interface – generalized process

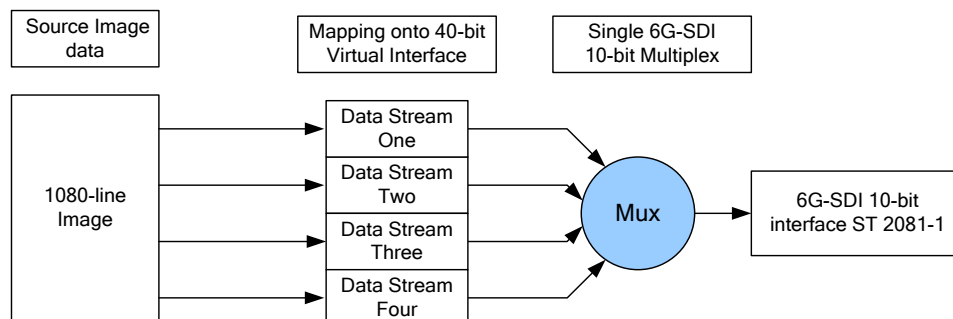


Figure 3 – Carriage of 1080-line HFR images in a Single-link 6G-SDI interface – generalized process

Formatting

The source images are divided into two or four 1080-line sub images, depending on the format of the source image. HFR source images are not divided.

The HFR source image, or the sub images, are then mapped onto a 40-bit virtual interface consisting of four 10-bit data streams.

Multiplex

The 40-bit virtual interface is multiplexed onto a single 6G-SDI 10-bit interface in the order data stream four, data stream two, data stream three, data stream one.

Document ID: ST 2081-10:2018



1 Scope

This Standard defines the mapping of:

- **Mode 1:** 2160-line Source image formats identified in Table 1 into a 6G-SDI 10-bit interface as defined in section 7 Single-link 6G-SDI 10-bit Multiplex, which can then be serialized
- **Mode 2:** 1080-line Source image formats identified in Table 6 into a 6G-SDI 10-bit interface as defined in section 7 Single-link 6G-SDI 10-bit Multiplex, which can then be serialized
- **Mode 3:** 1080-line HFR Source image formats identified in Table 8 into a 6G-SDI 10-bit interface as defined in section 7 Single-link 6G-SDI 10-bit Multiplex, which can then be serialized

This Standard also defines the carriage of ancillary data, and the SMPTE ST 352 payload ID's for the Single-link 6Gb/s SDI interface.

It is not necessary for implementations to include support for all operating modes or image formats that are included in this standard. Implementers are encouraged to indicate supported operating modes and image formats in commercial publications.

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; followed by formal languages; then figures; and then any other language forms.

3 Normative References

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

SMPTE ST 12-3:2016, Time Code for High Frame Rate Signals and Formatting in the Ancillary Data Space

SMPTE ST 274:2008, 1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates

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

SMPTE ST 299-1:2009, 24-Bit Digital Audio Format for SMPTE 292 Bit-Serial Interface

SMPTE ST 299-2:2010, Extension of the 24-Bit Digital Audio Format to 32 Channels for 3 Gb/s Bit-Serial Interfaces

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

SMPTE ST 425-3:2015, Image Format and Ancillary Data Mapping for the Dual Link 3 Gb/s Serial Interface

SMPTE ST 2036-1:2014, Ultra High Definition Television — Image Parameter Values for Program Production

SMPTE ST 2048-1:2011, 2048 × 1080 and 4096 × 2160 Digital Cinematography Production Image Formats FS/709

Amendment 1:2016 to SMPTE ST 2048-1:2011, 2048 × 1080 and 4096 × 2160 Digital Cinematography Production Image Formats FS/709 — Amendment 1

SMPTE RP 2077:2013, Full Range Image Mapping

Recommendation ITU-R BT.2100-1 (06/2017), Image parameter values for high dynamic range television for use in production and international programme exchange

4 Mode 1: Carriage of 2160-line Source image formats and ancillary data

In the case of 2160-line mapping, the image formats supported shall be as defined in Table 1.

Table 1 – 2160-line Source Image Formats

Reference Standard	Image Format	Signal Format Sampling Structure/pixel Depth	Frame Rate (Hz)
SMPTE ST 2036-1, Rec. ITU-R BT.2100	3840 × 2160	4:2:2 (Y'C _B C _R)/10-bit 4:2:2 (I _{C_T} C _P)/10-bit 4:2:0 (Y'C _B C _R)/10-bit 4:2:0 (I _{C_T} C _P)/10-bit	24/1.001, 24, 25, 30/1.001 and 30 Progressive
SMPTE ST 2048-1,	4096 × 2160	4:2:2 (Y'C _B C _R)/10-bit	24/1.001, 24, 25, 30/1.001 and 30 Progressive
Note: In accordance with Recommendation ITU-R BT.2100, I _{C_T} C _P sampling is only applied to High Dynamic Range (HDR) progressive image formats			

The image shall be mapped onto a 40-bit virtual interface in accordance with SMPTE ST 425-3 “Mapping of 2160-line Source Image”.

For I_{C_T}C_P formats the mappings for Y'C_BC_R formats shall be used with Y' replaced by I, C_B replaced by C_T and C_R replaced by C_P.

The 40-bit virtual interface shall include sync and timing (TRS) words, Cyclic redundancy code (CRC) words, line numbers, HANC and VANC data – except audio - according to SMPTE ST 425-3 “Mapping of 2160-line Source Image”.

Time code, when present, shall be included in the 40-bit virtual interface according to SMPTE ST 425-3 “Mapping of 2160-line Source Image”.

Informative annex A provides information about the amount of HANC and VANC data space available in this operating mode.

4.1 Image Mapping (Informative)

Figure 4 illustrates the process for the carriage of SMPTE ST 2036-1 and SMPTE ST 2048-1 2160-line source image formats in a Single-link 6G-SDI interface.

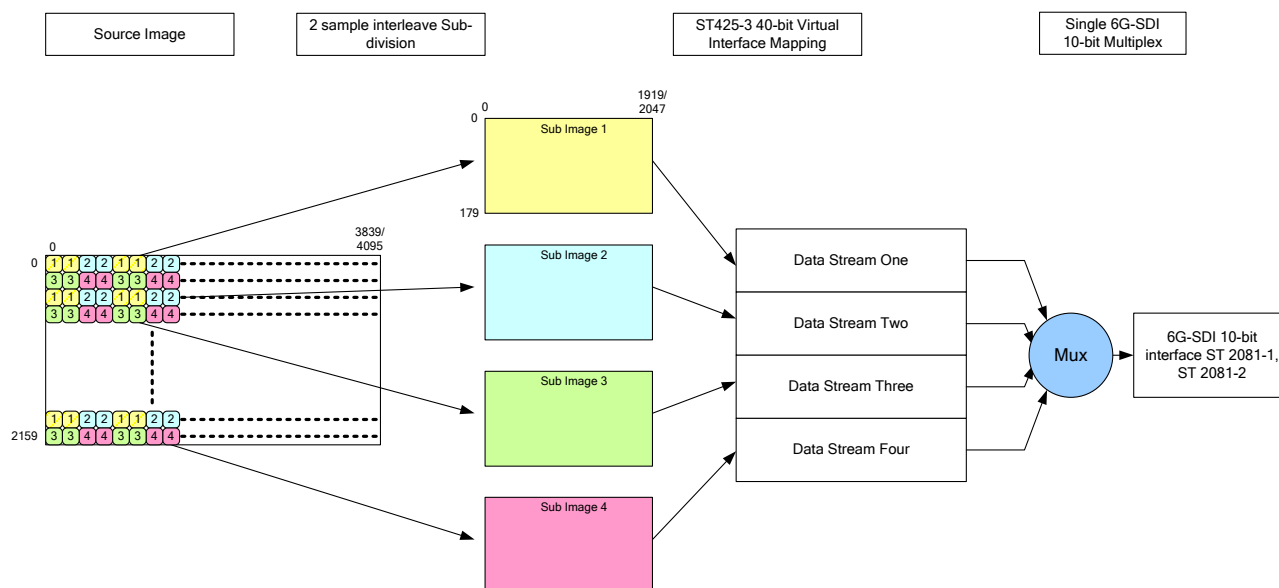


Figure 4 – Carriage of 2160-line source image formats in a single-link 6G-SDI interface

4.1.1 Image sub-division (Informative)

The 2160-line source image is divided into four 1080-line sub images in accordance with the 2 sample interleave sub-division method referenced in SMPTE ST 425-3 2160-line Mapping.

For 4:2:0 source images, the 10-bit C'_B and C'_R samples in sub images 3 and 4 are set to the value 200h.

Each 1080-line sub image conforms to the sub image format defined in Table 14 – “Sub Image Formats for 2160-line Source Image” of SMPTE ST 425-3 repeated here for convenience in Table 2.

Table 2 – 1080-line Sub Image Formats for 2160-line Source Images (Informative)

Reference SMPTE Standard	Image Format	Signal Format Sampling Structure/Pixel Depth	Frame Rate (Hz)
ST 274	1920 × 1080	4:2:2 (Y'C _B C _R)/10-bit	24/1.001, 24, 25, 30/1.001 and 30 Progressive
ST 2048-2	2048 × 1080	4:2:2 (Y'C _B C _R)/10-bit	24/1.001, 24, 25, 30/1.001 and 30 Progressive

Each sub image is then mapped into one of four data streams each of which complies with the 1.5 Gb/s data stream defined in SMPTE ST 292-1. Each data stream consists of two interleaved channels. Each channel includes sync and timing (TRS) words, Cyclic redundancy code (CRC) words, line numbers, HANC and VANC data including audio and time code as defined in SMPTE ST 425-3 2160-line Mapping

Sub image 1 is mapped into data stream one. Sub image 2 is mapped into data streams two. Sub image 3 is mapped into data stream three. Sub image 4 is mapped into data stream four.

The four 10-bit data streams are then combined onto a 40-bit virtual interface.

4.1.2 2160-line 40-bit Virtual Interface Mapping (Informative)

The video data words from each sub image are conveyed in the following order in the data streams of the 40-bit virtual interface:

Sub image 1 is mapped into data stream one:

data stream one: C'_{B0} , $Y'0$, C'_{R0} , $Y'1$, C'_{B2} , $Y'4$, C'_{R2} , $Y'5$...from even lines as per Figure 4

Sub image 2 is mapped into data stream two:

data stream two: C'_{B1} , $Y'2$, C'_{R1} , $Y'3$, C'_{B3} , $Y'6$, C'_{R3} , $Y'7$...from even lines as per Figure 4

Sub image 3 is mapped into data stream three:

data stream three: C'_{B0} , $Y'0$, C'_{R0} , $Y'1$, C'_{B2} , $Y'4$, C'_{R2} , $Y'5$...from odd lines as per Figure 4

Sub image 4 is mapped into data stream four:

data stream four: C'_{B1} , $Y'2$, C'_{R1} , $Y'3$, C'_{B3} , $Y'6$, C'_{R3} , $Y'7$...from odd lines as per Figure 4

For 4:2:0 source images, the 10-bit C'_B and C'_R samples in sub images 3 and 4 are set to the value 200h.

For IC_{TC_P} , Y' is replaced with I , C'_B with C'_T and C'_R with C'_P

4.1.2.1 6G-SDI Link Multiplex Structure (Informative)

Following the 6G SDI 10-bit multiplex according to Section 7, the 6G-SDI data stream is conveyed in the following order:

6G-SDI data stream: C'_{B1Odd} , C'_{B1} , C'_{B0Odd} , C'_{B0} , $Y'2Odd$, $Y'2$, $Y'0Odd$, $Y'0$, C'_{R1Odd} , C'_{R1} , C'_{R0Odd} , C'_{R0} , $Y'3Odd$, $Y'3$, $Y'1Odd$, $Y'1$, C'_{B3Odd} , C'_{B3} , C'_{B2Odd} , C'_{B2} , $Y'6Odd$, $Y'6$, $Y'4Odd$, $Y'4$, C'_{R3Odd} , C'_{R3} , C'_{R2Odd} , C'_{R2} , $Y'7Odd$, $Y'7$, $Y'5Odd$, $Y'5$...

Note: the term "Odd" in subscript above indicates that the samples are derived from the odd numbered lines of the original source image.

4.2 Audio Data

When present, audio data shall be mapped into the HANC space of data streams one, two, three and four as defined in SMPTE ST 425-3 "Mapping of 2160-line Source Image – Audio Data".

4.2.1 Number of Audio Channels

The number of audio channels shall be as defined in SMPTE ST 425-3 "Mapping of 2160-line Source Image – Number of Audio Channels".

4.2.2 Audio Copy

As an alternative to the mapping of the maximum number of unique audio channels described above, blocks of audio channels may be copied within the interface. This may be as a result of the single-link 6G-SDI signal being created by combining dual-link 3G-SDI signals. It may alternatively be done in the original single-link 6G-SDI signal in order to permit simple splitting of the single-link 6G-SDI signal into a dual-link 3G-SDI signal.

Note: Audio copy reduces the number of channels that can be transported by the interface.

In the case where the audio data has been embedded according to SMPTE ST 425-3, for example when the audio was embedded in a dual-link 3G interface that has been combined into a single-link 6G interface, the audio in data stream pair three/four may be a copy of the audio in data stream pair one/two.

The audio copy status of each data stream shall be signaled in the PID as described in Section 4.3.

Figure 5 shows a dual-link 3G interface combined into a single 6G-SDI interface, and the possible status of audio copy on each data stream.

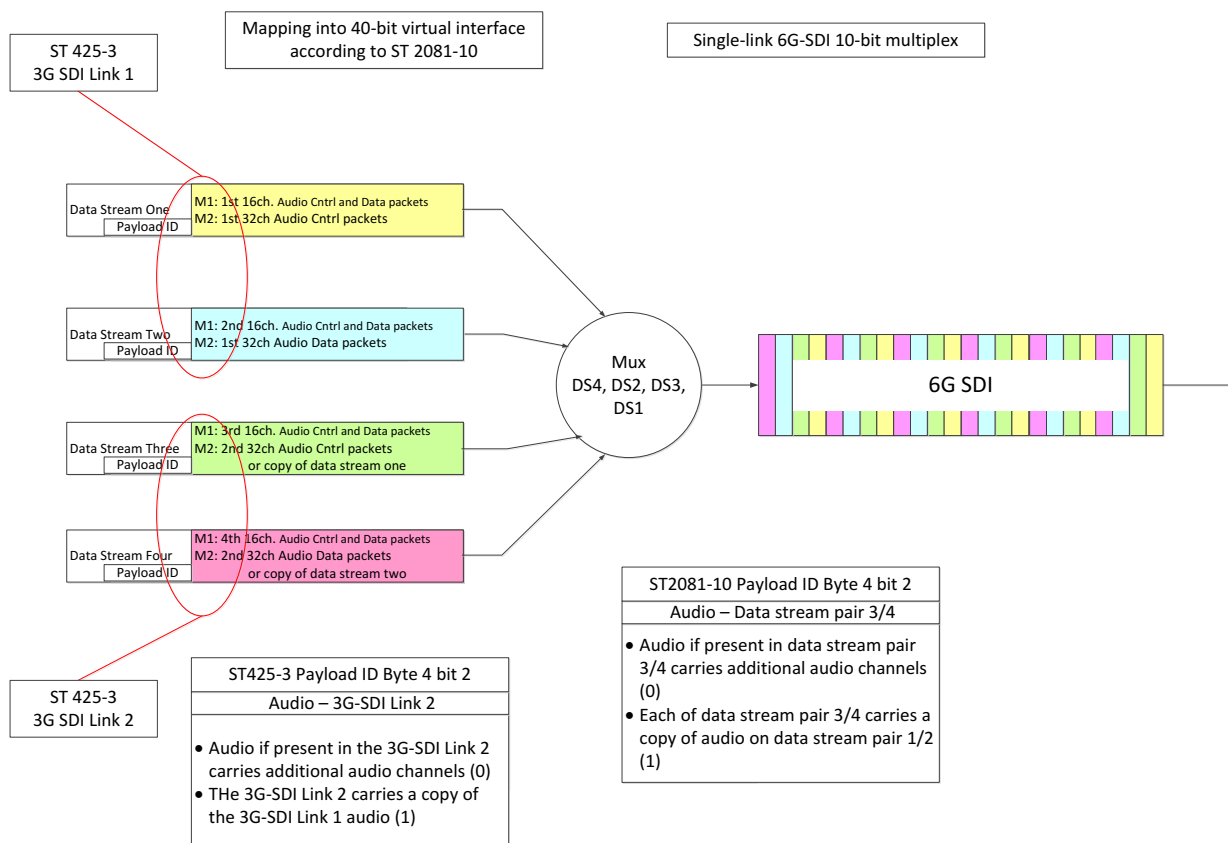


Figure 5 – Inherited audio copy as a result of combining a dual-link 3G-SDI signal

4.2.2.1 Originated Audio Copy in 6G-SDI signal

Audio may also be copied within the 6G interface in order to simplify division of a single 6G signal into dual-link 3G with audio copy between links.

Note: Audio copy reduces the number of channels that can be transported by the interface.

If audio is copied:

Data stream pair one/two shall always carry original audio

Data stream pair three/four shall carry a copy of the audio data and control packets from data stream pair one/two.

The audio copy status of each data stream shall be signaled in the PID as described in Section 4.3.

4.3 Payload Identifier Structure

Table 3 shows the payload identifier definitions for 2160-line Video Payloads. As stated in SMPTE ST 352, the payload identifier consists of 4 bytes where each byte has a separate significance. The first byte of the payload identifier has the highest significance and subsequent bytes define lower order video and ancillary payload information.

The recommended location for the payload identifier is defined in SMPTE ST 425-3.

Table 3 – Payload Identifier Definitions for Mode 1 - 2160-line mapping on a single-link 6Gb/s (nominal) Serial Interface

Bits	Byte 1	Byte 2	Byte 3	Byte 4
Bit 7	1	Progressive transport (1)	Aspect Ratio 16:9 (1) or Unknown (0)	Link assignment Single link 6G-SDI (0h)
Bit 6	1	Progressive picture (1)	Sub image horizontal sampling 1920 (0) or 2048 (1)	
Bit 5	0	Transfer characteristics SDR-TV (0h) HLG (1h) PQ (2h) Unspecified (3h)	Colorimetry Rec 709* ¹ (0h) Color VANC Packet (1h) UHDTV* ² (2h) Unknown (3h)	
Bit 4	0			
Bit 3	0	Picture rate (See Table 4)	Sampling structure (see Table 5)	Reserved (0)
Bit 2	0			Audio copy status: Audio in this data stream carries additional channels (0) Audio in this data stream is copied (1)
Bit 1	0			Bit depth 10-bit Full Range (0h) 10-bit (1h) Other Values are Reserved
Bit 0	0			

Notes:

*1 Rec 709 indicates Recommendation ITU-R BT.709 colorimetry is employed, and is equivalent to SMPTE ST 2036-1 Conventional System Colorimetry.

*2 UHDTV indicates SMPTE ST 2036-1 UHDTV colorimetry and is equivalent to Recommendation ITU-R BT.2020 colorimetry

3 The usage of bytes 2, 3 and 4 is consistent for all modes in this document but the definitions are repeated for the convenience of the reader

4.3.1 Byte 1 - Digital Interface and Payload Identification

Byte 1 of the payload identifier identifies the video payload and the digital interface and shall be set to [C0h] for 2160-line image formats listed in Table 1 on to single-link 6G-SDI.

4.3.2 Byte 2 – Picture Rate and Scanning Method

Byte 2 of the payload identifier shall be used to identify the picture and transport scanning methods and the picture rate.

Bit b7 shall be set to 1 (progressive transport).

Bit b6 shall be set to 1 (progressive picture).

Bits b5 and b4 shall be used to indicate Transfer Characteristic such that:

b5:b4 = 0h identifies SDR-TV in accordance with SMPTE ST 274 or SMPTE ST 2036-1

b5:b4 = 1h identifies HLG HDR-TV in accordance with Recommendation ITU-R BT.2100

b5:b4 = 2h identifies PQ HDR-TV in accordance with Recommendation ITU-R BT.2100

b5:b4 = 3h identifies Unspecified Transfer Characteristics

In the case where bits b5:b4 of Byte 3 indicates “Color VANC packet as defined in SMPTE ST 2048-1”, if the Transfer Characteristic signaled in the Color VANC packet is active, then it takes precedence over the Transfer Characteristic signaled in b5:b4.

Note: The Reference EOTF as defined in SMPTE ST 2084 is the same as the Reference PQ EOTF defined in Recommendation ITU-R BT.2100.

Bits b3 to b0 shall be used to identify the picture rate in Hz according to Table 4 and shall only use the values as permitted for image formats in Table 1.

Table 4 SMPTE ST 352 Byte 2 Picture rate extended to include high picture (frame) rates

Value	Picture rate Hz	Value	Picture rate Hz	Value	Picture rate Hz	Value	Picture rate Hz
0h	Not defined	1h	96/1.001	2h	24/1.001	3h	24
4h	48/1.001	5h	25	6h	30/1.001	7h	30
8h	48	9h	50	Ah	60/1.001	Bh	60
Ch	96	Dh	100	Eh	120/1.001	Fh	120

4.3.3 Byte 3 – Sub Image Sampling Structure, Aspect Ratio, Horizontal Size and Colorimetry

Byte 3 of the payload identifier shall be used to identify the aspect ratio, horizontal pixel array size, sampling structure and colorimetry of the sub image video payload.

Bit b7 shall be used to identify the aspect ratio such that:

b7 = 0 identifies unknown aspect ratio

b7 = 1 identifies a 16:9 aspect ratio

Bit b6 shall be used to identify the number of active Luma/R'G'B' samples for the sub image such that:

b6 = 0 identifies 1920 active Luma/R'G'B' samples

b6 = 1 identifies 2048 active Luma/R'G'B' samples