SMPTE STANDARD

4320-line and 2160-line Source Image and Ancillary Data Mapping for Quad-link 6G-SDI

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MOTION PICTURE AND TELEVISION ENGINEERS
3 Barker Avenue, White Plains, NY 10601
(914) 761-1100

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Foreword

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SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual.

SMPTE ST 2081-12 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

SMPTE ST 2081-12 defines the mapping of various source images and associated ancillary data into a Quad-link 6 Gb/s [nominal] SDI bit-serial interface.

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

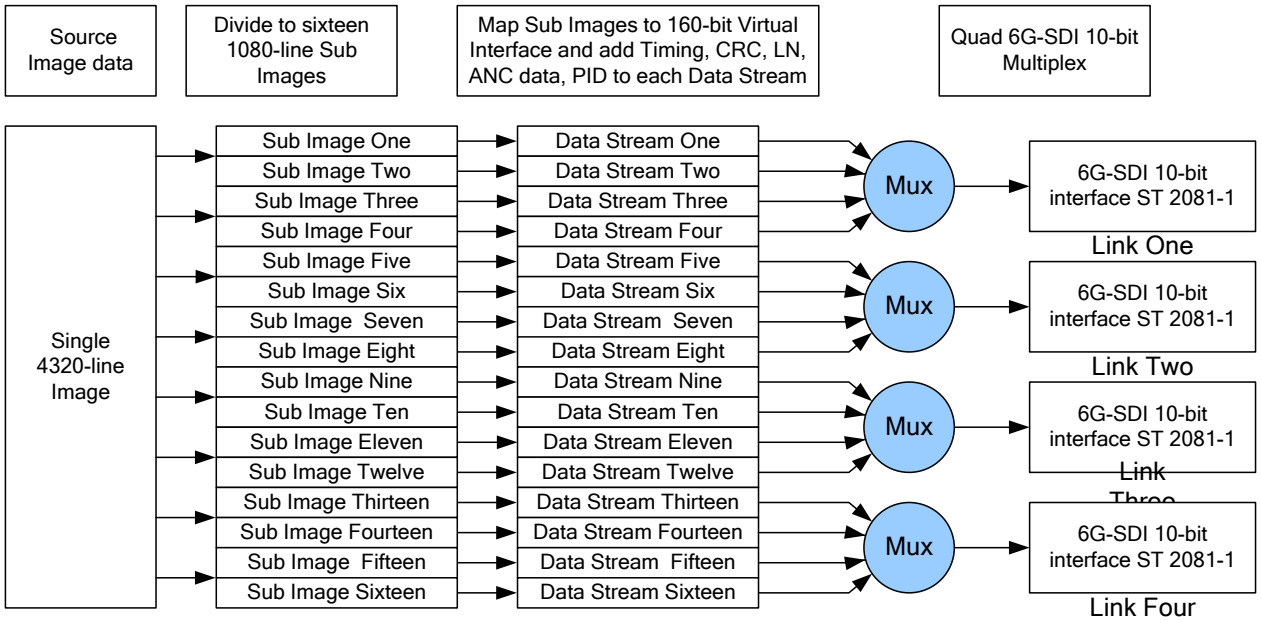


Figure 1 – Carriage of 4320-line Images on a Quad-link 6G interface — generalized process as used for Mode 1

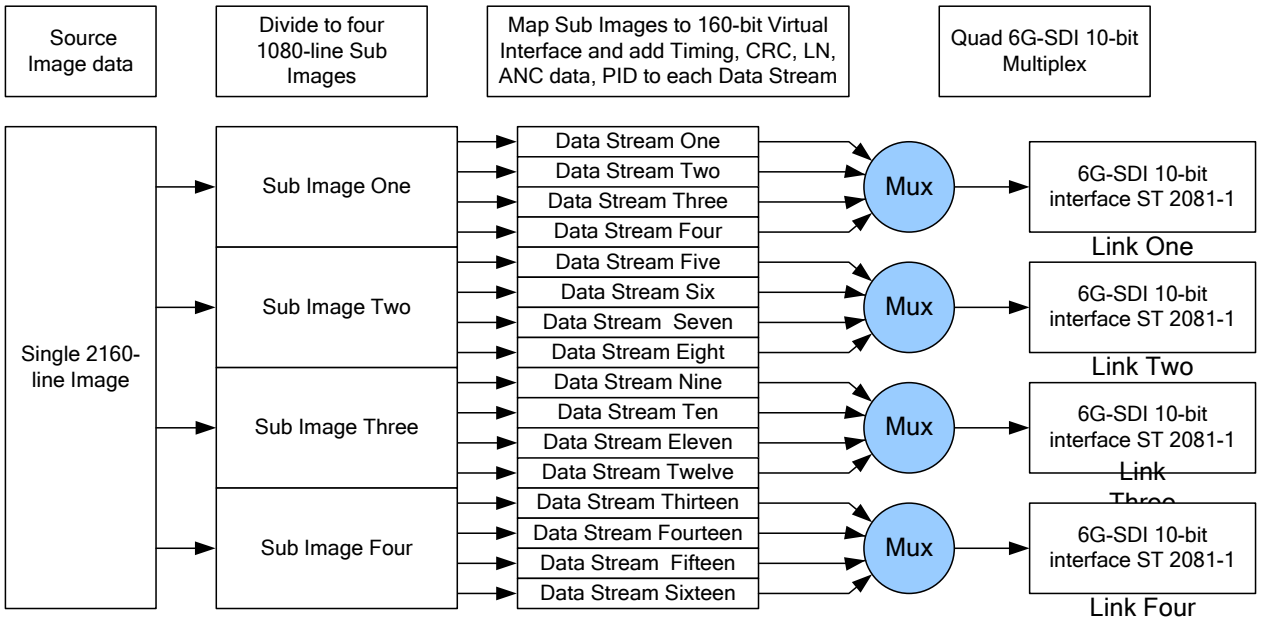


Figure 2 – Carriage of 2160-line Images on a Quad-link 6G interface — generalized process as used for Mode 2 and Mode 3

The source images are divided to into four or sixteen 1080-line sub images as appropriate to the source image format.

The sub images are then mapped on to a 160-bit virtual interface consisting of sixteen 10-bit data streams.

Each 10-bit data stream includes timing and sync words, line numbers, cyclic redundancy codes, ancillary data, including audio, and payload identification packets.

Multiplex

The 160-bit virtual interface is then multiplexed onto four 6G-SDI 10-bit interfaces.

The first four data streams are multiplexed in the order data stream four, data stream two, data stream three, data stream one…onto 6G-SDI Link 1.

The second four data streams are multiplexed in the order data stream eight, data stream six, data stream seven, data stream five…onto 6G-SDI Link 2.

The third four data streams are multiplexed in the order data stream twelve, data stream ten, data stream eleven, data stream nine…onto 6G-SDI Link 3.

The fourth four data streams are multiplexed in the order data stream sixteen, data stream fourteen, data stream fifteen, data stream thirteen…onto 6G-SDI Link 4.

1 Scope

This standard defines the mapping of:

- **MODE 1:** 4320-line $Y'C'_BC'_R$ 4:2:2 and 4:2:0 10-bit image formats and ancillary data on a Quad-link 6 Gb/s [nominal] SDI bit-serial interface.
- **MODE 2:** 2160-line $R'G'B'$, $Y'C'_BC'_R$ 4:4:4(:4) 10-bit and 4:4:4 12-bit image formats and ancillary data on a Quad-link 6 Gb/s [nominal] SDI bit-serial interface.
- **MODE 3:** 2160-line $Y'C'_BC'_R$ 4:2:2 and 4:2:0 10-bit Additional Frame Rate Source image formats and ancillary data on a Quad-link 6 Gb/s [nominal] SDI bit-serial interface.

This standard also defines the carriage of the SMPTE ST 352 payload ID's for the Quad-link 6Gb/s SDI interface.

It is not necessary for implementations to include support for all formats that are included in this Standard. Implementers should indicate supported 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

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 274:2008) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 274M-2008). Documents with the same root number (e.g. 274) and publication year (e.g. 2008) are functionally identical.

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 12-2:2014, Transmission of Time Code in the Ancillary Data Space

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

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

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 425-5:2015, Image Format and Ancillary Data Mapping for the Quad 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

SMPTE ST 2048-2:2011, 2048 × 1080 Digital Cinematography Production Image FS/709 Formatting for Serial Digital Interface

SMPTE ST 2081-10:2015, 2160-line and 1080-line Source Image and Ancillary Data Mapping for Single-link 6G-SDI

4 Mode 1: Carriage of 4320-line $Y'C'_BC'_R$ 4:2:2 and 4:2:0 10-bit Source Image Formats and Ancillary Data

In the case of 4320-line mapping, the image formats supported are defined in Table 1.

Table 1 – Supported Image sample structures and frame rates

Reference SMPTE Standard	Image Format	Signal Format Sampling Structure/pixel Depth	Frame Rate
ST 2036-1	7680 × 4320	4:2:2 ($Y'C'_BC'_R$), 4:2:0 ($Y'C'_BC'_R$)/10-bit	24/1.001, 24, 25, 30/1.001 and 30 Progressive

4.1 Mapping

The 4320-line image shall be divided into four 2160-line intermediate sub images in accordance with the 2 sample interleave sub-division method as shown in Figure 3.

For a 4:2:0 source image, the C'_B and C'_R samples in intermediate sub images 3 and 4 shall be set to the value 200h.

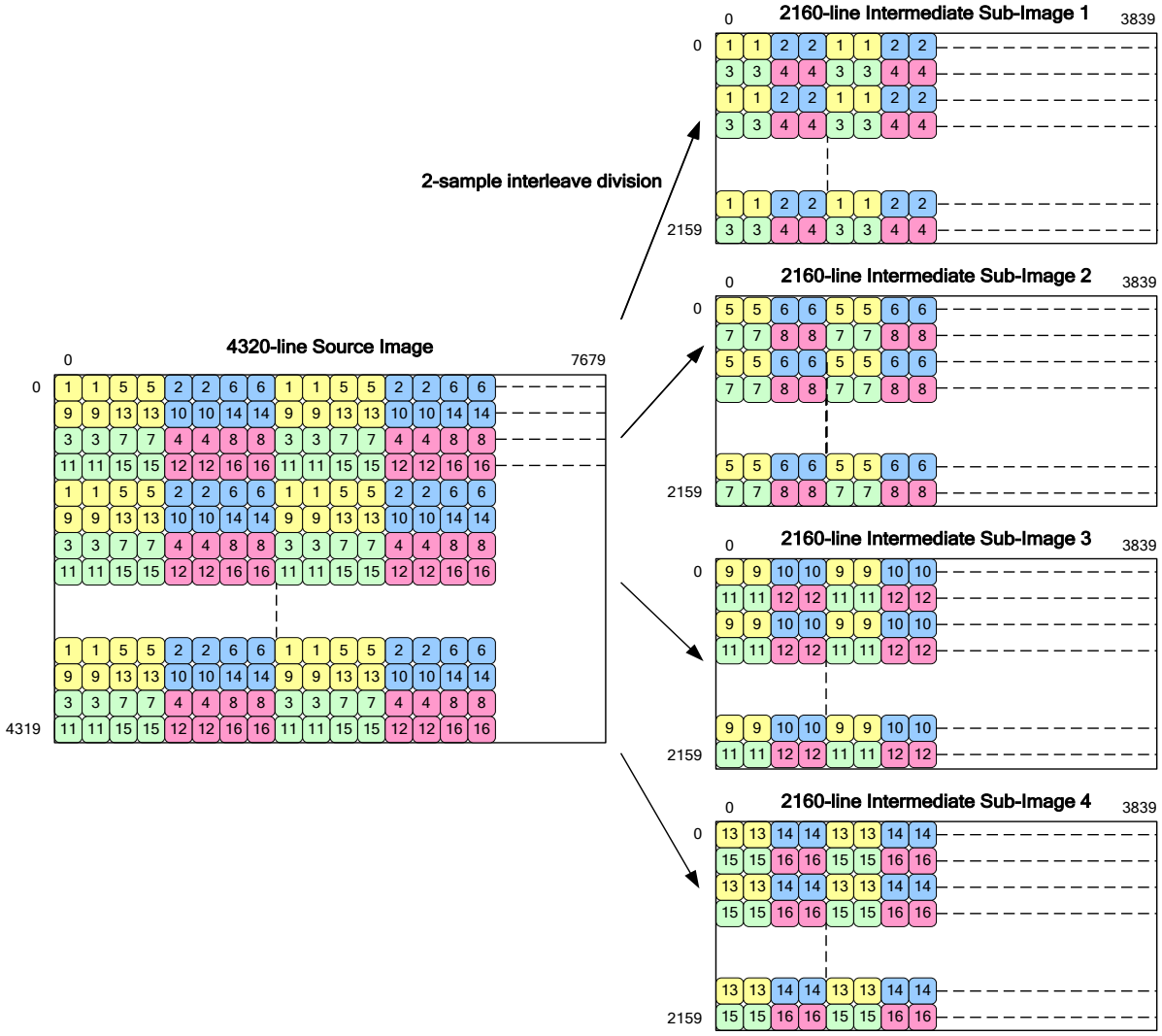


Figure 3 – Two sample division of a 4320-line image to four 2160-line intermediate sub images

Each 2160-line intermediate sub image shall then be divided into four 1080-line sub images and mapped to a 40-bit virtual interface according to SMPTE ST 2081-10 Mode 1 “Carriage of 2160-line Source image formats and ancillary data” as illustrated in Figure 4.

Intermediate sub image 1 shall be divided to sub images 1 through 4 and mapped to data streams one through four.

Intermediate sub image 2 shall be divided to sub images 5 through 8 and mapped to data streams five through eight.

Intermediate sub image 3 shall be divided to sub images 9 through 12 and mapped to data streams nine through twelve.

Intermediate sub image 4 shall be divided to sub images 13 through 16 and mapped to data streams thirteen through sixteen.

Note: For 4:2:0 source images, the 10-bit C'_B and C'_R samples in sub images 9 through 16 are set to the value 200h.

The sixteen 10-bit data streams so constructed shall each contain timing reference code words (SAV/EAV); line numbers and line based CRC's as defined in SMPTE ST 2081-10 Mode 1.

The sixteen data streams, data stream one through data stream sixteen, shall be combined into a 160-bit virtual interface.

The virtual interface shall contain ancillary data and audio as defined elsewhere in this standard.

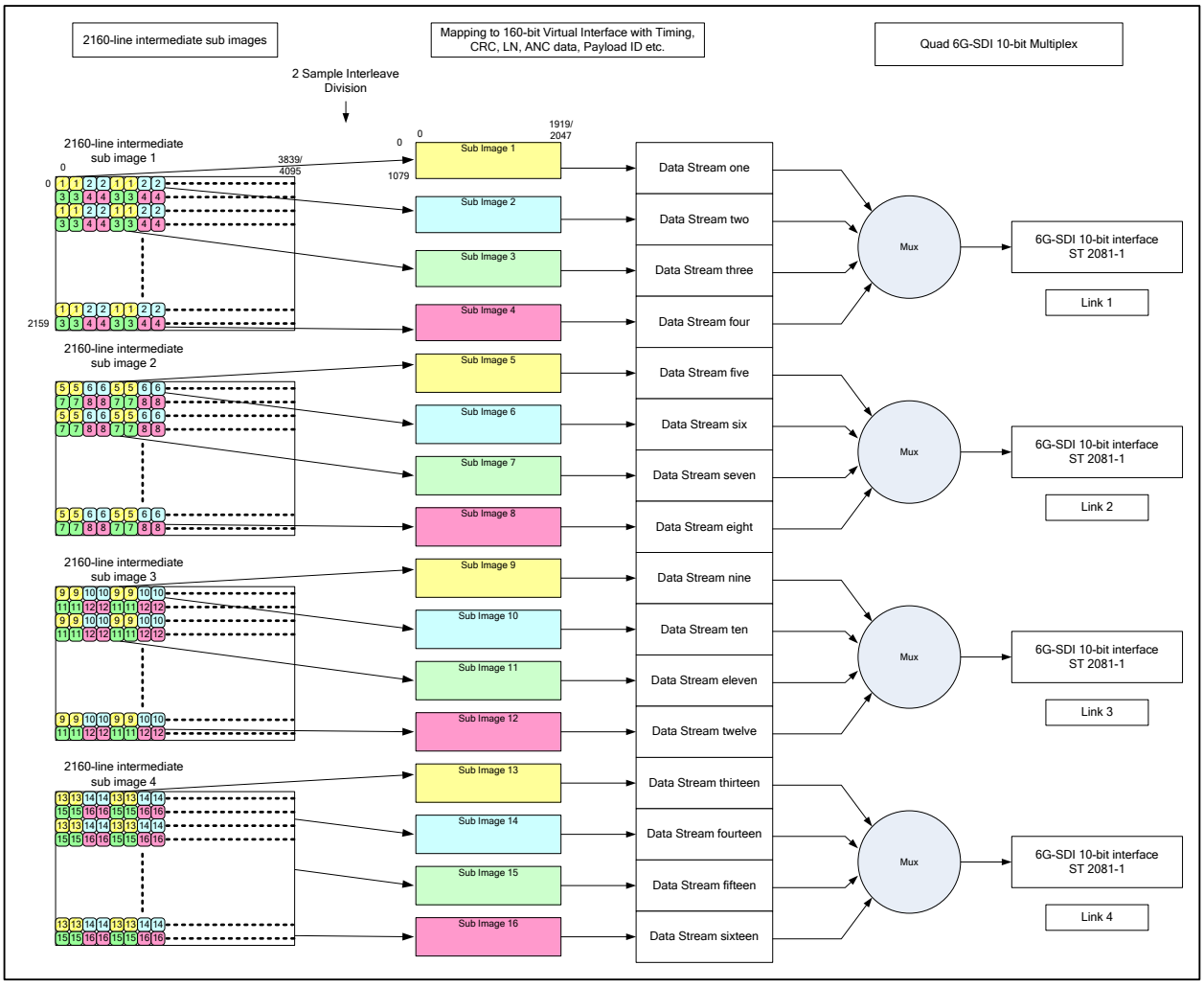


Figure 4 – 2 sample division of the four 2160-line intermediate sub images to sixteen 1080-line sub images, and mapping into a Quad-link 6G-SDI interface

4.2 Intermediate Sub Image Mapping (Informative)

Each 2160-line intermediate sub image is divided to four 1080-line sub images in accordance with SMPTE ST 2081-10 Mode 1 using the 2 sample interleave sub-division method referenced in SMPTE ST 425-5 “2160-line image division into four sub images”.

Each 1080-line sub image conforms to the SMPTE ST 274 or SMPTE ST 2048-2 sub image formats defined in Table 14 of SMPTE ST 425-3 repeated here for convenience in Table 2.

Table 2 – 1080-line Sub Image Formats for 4320-line Source Images

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

Each sub image is then mapped into a data stream which complies with the 1.5 Gb/s data stream defined in SMPTE ST 292-1. Sub image 1 is mapped into data stream one. Sub image 2 is mapped into data stream two. Sub image 3 is mapped into data stream three. Sub image 4 is mapped into data stream four. Sub image 5 is mapped into data stream five. Sub image 6 is mapped into data stream six. Sub image 7 is mapped into data stream seven. Sub image 8 is mapped into data stream eight. Sub image 9 is mapped into data stream nine. Sub image 10 is mapped into data stream ten. Sub image 11 is mapped into data stream eleven. Sub image 12 is mapped into data stream twelve. Sub image 13 is mapped into data stream thirteen. Sub image 14 is mapped into data stream fourteen. Sub image 15 is mapped into data stream fifteen. Sub image 16 is mapped into data stream sixteen.

Each of the sixteen 10-bit data streams so constructed contains timing reference code words (SAV/EAV), line numbers and line based CRC’s as defined in SMPTE ST 425-3 2160-line Mapping.

4.3 6G-SDI Link Multiplex Structure (Informative)

Following multiplexing onto a quad-link 6G-SDI 10-bit interface according to Section 7, the 6G-SDI data streams are conveyed in the following order:

{n} indicates the number of the sub image

6G-SDI Link 1:

Sub images 1, 2, 3 and 4: {4} C'_B0, {2} C'_B0, {3} C'_B0, {1} C'_B0, {4} $Y'0$, {2} $Y'0$, {3} $Y'0$, {1} $Y'0$, {4} C'_R0, {2} C'_R0, {3} C'_R0, {1} C'_R0, {4} $Y'1$, {2} $Y'1$, {3} $Y'1$, {1} $Y'1$, {4} C'_B1, {2} C'_B1, {3} C'_B1, {1} C'_B1, {4} $Y'2$, {2} $Y'2$, {3} $Y'2$, {1} $Y'2$, {4} C'_R1, {2} C'_R1, {3} C'_R1, {1} C'_R1, {4} $Y'3$, {2} $Y'3$, {3} $Y'3$, {1} $Y'3$…

6G-SDI Link 2:

Sub images 5, 6, 7 and 8: {8} C'_B0, {6} C'_B0, {7} C'_B0, {5} C'_B0, {8} $Y'0$, {6} $Y'0$, {7} $Y'0$, {5} $Y'0$, {8} C'_R0, {6} C'_R0, {7} C'_R0, {5} C'_R0, {8} $Y'1$, {6} $Y'1$, {7} $Y'1$, {5} $Y'1$, {8} C'_B1, {6} C'_B1, {7} C'_B1, {5} C'_B1, {8} $Y'2$, {6} $Y'2$, {7} $Y'2$, {5} $Y'2$, {8} C'_R1, {6} C'_R1, {7} C'_R1, {5} C'_R1, {8} $Y'3$, {6} $Y'3$, {7} $Y'3$, {5} $Y'3$…

6G-SDI Link 3:

Sub images 9, 10, 11 and 12: {12} C'_B0, {10} C'_B0, {11} C'_B0, {9} C'_B0, {12} $Y'0$, {10} $Y'0$, {11} $Y'0$, {9} $Y'0$, {12} C'_R0, {10} C'_R0, {11} C'_R0, {9} C'_R0, {12} $Y'1$, {10} $Y'1$, {11} $Y'1$, {9} $Y'1$, {12} C'_B1, {10} C'_B1, {11} C'_B1, {9} C'_B1, {12} $Y'2$, {10} $Y'2$, {11} $Y'2$, {9} $Y'2$, {12} C'_R1, {10} C'_R1, {11} C'_R1, {9} C'_R1, {12} $Y'3$, {10} $Y'3$, {11} $Y'3$, {9} $Y'3$…

6G-SDI Link 4:

Sub images 13, 14, 15 and 16: {16} C'_B0, {14} C'_B0, {15} C'_B0, {13} C'_B0, {16} $Y'0$, {14} $Y'0$, {15} $Y'0$, {13} $Y'0$, {16} C'_R0, {14} C'_R0, {15} C'_R0, {13} C'_R0, {16} $Y'1$, {14} $Y'1$, {15} $Y'1$, {13} $Y'1$, {16} C'_B1, {14} C'_B1, {15} C'_B1, {13} C'_B1, {16} $Y'2$, {14} $Y'2$, {15} $Y'2$, {13} $Y'2$, {16} C'_R1, {14} C'_R1, {15} C'_R1, {13} C'_R1, {16} $Y'3$, {14} $Y'3$, {15} $Y'3$, {13} $Y'3$…

For 4:2:0 source images, the 10-bit C'_B and C'_R samples in sub images 9 through 16 are set to the value 200h.

4.4 Ancillary Data

When present, ancillary data packets shall be mapped into the HANC or the VANC spaces of each data stream in accordance with the SMPTE ST 292-1 ancillary data mapping rules.

Ancillary data packets shall be mapped into either the Luma (Y′) data channel or the Color-Difference (C'_B, C'_R) data channel. On each data stream the layout of the Luma (Y′) data channel and the Color-Difference (C'_B, C'_R) data channel shall be as shown in the Figure “Interleaved data stream” of SMPTE ST 292-1.

Unless otherwise stated, the ancillary data shall be preferentially mapped into data stream one first and any remaining data shall then be mapped onto data stream two, then into data stream three, data stream four and so on up to data stream sixteen. Data space requirements and locations for each data service are defined by their respective application documents. In some cases it is required by specific applications that ancillary data be mapped into all sixteen data streams (e.g. Payload ID.)

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

4.5 Audio Data

When present, audio data shall be mapped into the HANC space of data streams one through sixteen and shall be in conformance with SMPTE ST 299-1.

Audio control packets are mapped into the Luma (Y′) data channel on each data stream.

Audio data packets are mapped into the Color-Difference (C'_B,C'_R) data channel on each data stream.

Audio control and data packets shall be mapped into data stream one first and any remaining audio data shall then be mapped onto data stream two, then into data stream three, data stream four and so on up to data stream sixteen.

The audio clock phase data as defined in the section “CLK (audio clock phase data)” of SMPTE ST 299-1 shall be calculated at the clock frequency of 74.25 (/1.001) MHz.

4.5.1 Number of Audio Channels

Up to 256 audio channels sampled at 32 kHz, 44.1 kHz or 48 kHz may be mapped into data streams one through sixteen of the 160-bit virtual interface. At 96 kHz sampling, up to 128 audio channels may be mapped into the virtual interface.

4.5.1.1 Carriage of up to 256 Channels of Audio at up to 48 kHz Sampling

For audio at up to 48 kHz sampling, the audio data and control packets for the first 16 channels shall be mapped into data stream one in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the second 16 channels shall be mapped into data stream two in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the third 16 channels shall be mapped into data stream three in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

In the same way, successive sets of 16 channels shall be mapped into successive data streams, up to...

The audio data and control packets for the sixteenth 16 channels shall be mapped into data stream sixteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

4.5.1.2 Carriage of up to 128 Channels of Audio at 96 kHz Sampling

For audio at 96 kHz sampling, the audio data and control packets for the first 8 channels shall be mapped into data stream one in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the second 8 channels shall be mapped into data stream two in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the third 8 channels shall be mapped into data stream three in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

In the same way, successive sets of 8 channels shall be mapped into successive data streams, up to...

The audio data and control packets for the sixteenth 8 channels shall be mapped into data stream sixteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

4.5.2 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 done in order for Links 2, 3 and 4 to carry a copy of the audio on Link 1, or for Links 3 and 4 to carry a copy of audio on links 1 and 2 respectively.

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

If audio is copied:

Data streams one through four shall always carry original audio.

Data streams five through eight may also carry original audio.

Data streams nine through sixteen may carry copied audio from data streams one through eight.

Data streams five through eight may carry copied audio from data streams one through four. In this case data streams nine through twelve, and data streams thirteen through sixteen shall also carry the same copied audio.

The audio copy status of each data stream shall be signaled in the PID for that data stream as described in Section 4.7.

4.6 Time Code Data

When present the time code shall be mapped into the HANC space of data stream one, and shall be in conformance with SMPTE ST 12-2.

The time code may also be mapped onto data stream two, data stream three, data stream four, and so on up to data stream sixteen, in which case the corresponding Time Address values shall be identical.

4.7 Payload Identifier

A payload identifier packet shall be placed in each data stream.

Table 3 shows the payload identifier definitions for 4320-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 horizontal placement of the packet should be immediately following the last CRC code word (CR1) of the line(s) specified in SMPTE ST 352 for 1125-line systems.

Note: The line numbers defined in SMPTE ST 352 for the placement of the payload identifier packet in 1125-line systems avoid those lines used by SMPTE ST 299-1 for the carriage of digital audio control packets.

Table 3 – Payload Identifier Definitions for 4320-line Video Payload for Mapping on a Quad-link 6Gb/s (nominal) Serial Interface

<table>
<tr><th>Bits</th><th>Byte 1</th><th>Byte 2</th><th>Byte 3</th><th>Byte 4</th></tr>
<tr><td>Bit 7</td><td>1</td><td>Progressive transport (1)</td><td>Aspect Ratio
16:9 (1) or Unknown (0)</td><td rowspan="4">Link assignment
6G-SDI Link 1 (0h)
6G-SDI Link 2 (1h)
6G-SDI Link 3 (2h)
6G-SDI Link 4 (3h)</td></tr>
<tr><td>Bit 6</td><td>0</td><td>Progressive picture (1)</td><td>Sub image horizontal sampling
1920 (0) or 2048 (1)</td></tr>
<tr><td>Bit 5</td><td>1</td><td>Reserved (0)</td><td rowspan="2">Colorimetry
Rec 709*1 (0h)
Color VANC Packet (1h)
UHDTV*2 (2h)
Unknown (3h)</td></tr>
<tr><td>Bit 4</td><td>1</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 3</td><td>0</td><td rowspan="3">Picture rate
(See Table 4)</td><td rowspan="3">Sampling structure
(See Table 5)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 2</td><td>1</td><td>Audio copy status:
Audio in this data stream carries additional channels or audio not present (0)
Audio in this data stream is copied (1)</td></tr>
<tr><td>Bit 1</td><td>0</td><td rowspan="2">Bit depth
10-bit (1h)
Other values are Reserved</td></tr>
<tr><td>Bit 0</td><td>0</td><td></td><td></td></tr>
</table>

Notes:

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

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

4.7.1 Byte 1 – Digital Interface and Payload Identification

Byte 1 of the payload identifier identifies the video payload and the digital interface and shall be as defined below.

Byte 1 shall be set to [C4h] for 4320-line image formats listed in Table 1 transported via quad-link 6G-SDI.

4.7.2 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).

Bit b5 shall be set to 0 (reserved).

Bit b4 shall be set to 0 (reserved).

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 additional 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

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

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

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

b7 = 0 shall identify unknown aspect ratio

b7 = 1 shall identify 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 shall identify 1920 active Luma/R′G′B′ samples

b6 = 1 shall identify 2048 active Luma/R′G′B′ samples

Bits b5 and b4 shall identify the colorimetry for the image formats identified in Table 1 such that:

b5:b4 = 0h shall identify Rec 709 colorimetry

b5:b4 = 1h shall identify that the colorimetry is defined in the Color VANC packet defined in SMPTE ST 2048-1

b5:b4 = 2h shall identify UHDTV colorimetry

b5:b4 = 3h shall identify unknown colorimetry

Bits b3 to b0 shall be used to identify the sampling structure in accordance with Table 5 and shall only use the values as permitted for image formats in Table 1.

Table 5 – SMPTE ST 352 Byte 3 Sampling Structure

Value	Sampling	Value	Sampling	Value	Sampling	Value	Sampling
0h	4:2:2 ($Y'C'_BC'_R$)	1h	4:4:4 ($Y'C'_BC'_R$)	2h	4:4:4 (R′G′B′)	3h	4:2:0 ($Y'C'_BC'_R$)
4h	4:2:2:4 ($Y'C'_BC'_R$+A)	5h	4:4:4:4 ($Y'C'_BC'_R$+A)	6h	4:4:4:4 (R′G′B′+A)	7h	Reserved
8h	4:2:2:4 ($Y'C'_BC'_R$+D)	9h	4:4:4:4 ($Y'C'_BC'_R$+D)	Ah	4:4:4:4 (R′G′B′+D)	Bh	Reserved
Ch	Reserved	Dh	Reserved	Eh	4:4:4 (X′Y′Z′)	Fh	Reserved

4.7.4 Byte 4 – Link assignment Identification, Audio copy status and Quantization Bit Depth

Byte 4 of the payload identifier shall be used to identify the link assignment, the audio copy status and the bit depth of the sample quantization.

Bits b7 to b5 shall be used to identify Link assignment and set to:

b7:b5 = 0h shall identify 6G-SDI Link 1

b7:b5 = 1h shall identify 6G-SDI Link 2

b7:b5 = 2h shall identify 6G-SDI Link 3

b7:b5 = 3h shall identify 6G-SDI Link 4

Bit b4 shall be reserved and set to 0.

Bit b3 shall be reserved and set to 0.

For data streams one through four bit b2 shall be set to 0 (reserved).

For data streams five through sixteen bit b2 shall be used to identify whether audio data in this data stream is copied:

b2 = 0 shall identify that all audio if present in this data stream carries additional channels

b2 = 1 shall identify that audio if present in this data stream is copied

Bits b1 to b0 shall be used to identify the bit depth of the sample quantization such that:

b1:b0 = 1h shall identify quantization using 10 bits per sample

Other values shall be reserved.

4.8 Blanking (Informative)

HANC and VANC spaces with no ancillary data packets or audio data packets contain data words that represent video black level for the video structure being carried.

In the case of 4:2:2 $Y'C'_BC'_R$ 10-bit video structure, even numbered words in each data stream take the value 200h and odd numbered words in each data stream take the value 040h.

The word numbering is defined such that the first word of active video in each line in each data stream is numbered zero, and so is an even numbered word.

4.9 Multiplex

The 160-bit virtual interface shall then be multiplexed onto four Type 2 6G-SDI 10-bit interfaces according to Section 7.

4.10 Levels of Operation (Informative)

To define the level of support for SMPTE ST 2081-10 Mode 1, manufacturers are encouraged to indicate in publications which mapping format is supported. For example:

SMPTE ST 2081-12 MODE 1 – 4320-line Source image formats and ancillary data into a Quad-link 6 Gb/s [nominal] SDI bit-serial interface

Manufacturers are also encouraged to indicate in publications supported audio and video formats.

5 Mode 2: Carriage of 2160-line R′G′B′, Y′C′$_B$C′$_R$ 4:4:4(:4) 10-bit and 4:4:4 12-bit Source Image Formats and Ancillary Data

In the case of 2160-line mapping, the source image formats shall be as defined in Table 6.

Table 6 – Supported Image sample structures and frame rates

Reference SMPTE Standard	Image Format	Signal Format Sampling Structure/pixel Depth	Frame Rate	Sub Image Mapping Structure
ST 2036-1	3840 × 2160	4:4:4 (R′G′B′), 4:4:4:4 (R′G′B′ +A)/10-bit	50, 60/1.001 and 60 Progressive	II
ST 2048-1	4096 × 2160*2	4:4:4 (R′G′B′*1), 4:4:4:4 (R′G′B′*1+A)/10-bit	48/1.001, 48, 50, 60/1.001 and 60 Progressive	
ST 2036-1	3840 × 2160	4:4:4 (Y′C′$_B$C′$_R$), 4:4:4:4 (Y′C′$_B$C′$_R$+A)/10-bit	50, 60/1.001 and 60 Progressive	
ST 2048-1	4096 × 2160*2	4:4:4 (Y′C′$_B$C′$_R$), 4:4:4:4 (Y′C′$_B$C′$_R$+A)/10-bit	48/1.001, 48, 50, 60/1.001 and 60 Progressive	
ST 2036-1	3840 × 2160	4:4:4 (R′G′B′)/12-bit	50, 60/1.001 and 60 Progressive	III
ST 2048-1	4096 × 2160*2	4:4:4 (R′G′B′*1)/12-bit	48/1.001, 48, 50, 60/1.001 and 60 Progressive	
ST 2036-1	3840 × 2160	4:4:4 (Y′C′$_B$C′$_R$)/12-bit	50, 60/1.001 and 60 Progressive	
ST 2048-1	4096 × 2160*2	4:4:4 (Y′C′$_B$C′$_R$)/12-bit	48/1.001, 48, 50, 60/1.001 and 60 Progressive	
ST 2036-1	3840 × 2160	4:2:2 (Y′C′$_B$C′$_R$)/12-bit 4:2:0 (Y′C′$_B$C′$_R$)/12-bit	50, 60/1.001 and 60 Progressive	IV
ST 2048-1	4096 × 2160*2	4:2:2 (Y′C′$_B$C′$_R$)/12-bit	48/1.001, 48, 50, 60/1.001 and 60 Progressive	
ST 2048-1	4096 × 2160*2	4:2:2:4 (Y′C′$_B$C′$_R$+A)/12-bit	48/1.001, 48, 50, 60/1.001 and 60 Progressive	

Notes:

*1 In this image format R′G′B′ indicates either R′G′B′ or R′$_{FS}$G′$_{FS}$B′$_{FS}$.

*2 This is the maximum pixel array, the active image may not fill the maximum array.

Figure 5 and Figure 6 illustrate the generalized process for the carriage of 2160-line source image formats in a quad-link 6G-SDI interface.

Figure 5 illustrates the division of the source image format into four sub images.

Figure 6 illustrates the mapping of sub image one onto 6G-SDI Link 1.

Sub image two is similarly mapped onto 6G_SDI Link 2.

Sub image three is similarly mapped onto 6G_SDI Link 3.

Sub image four is similarly mapped onto 6G_SDI Link 4.

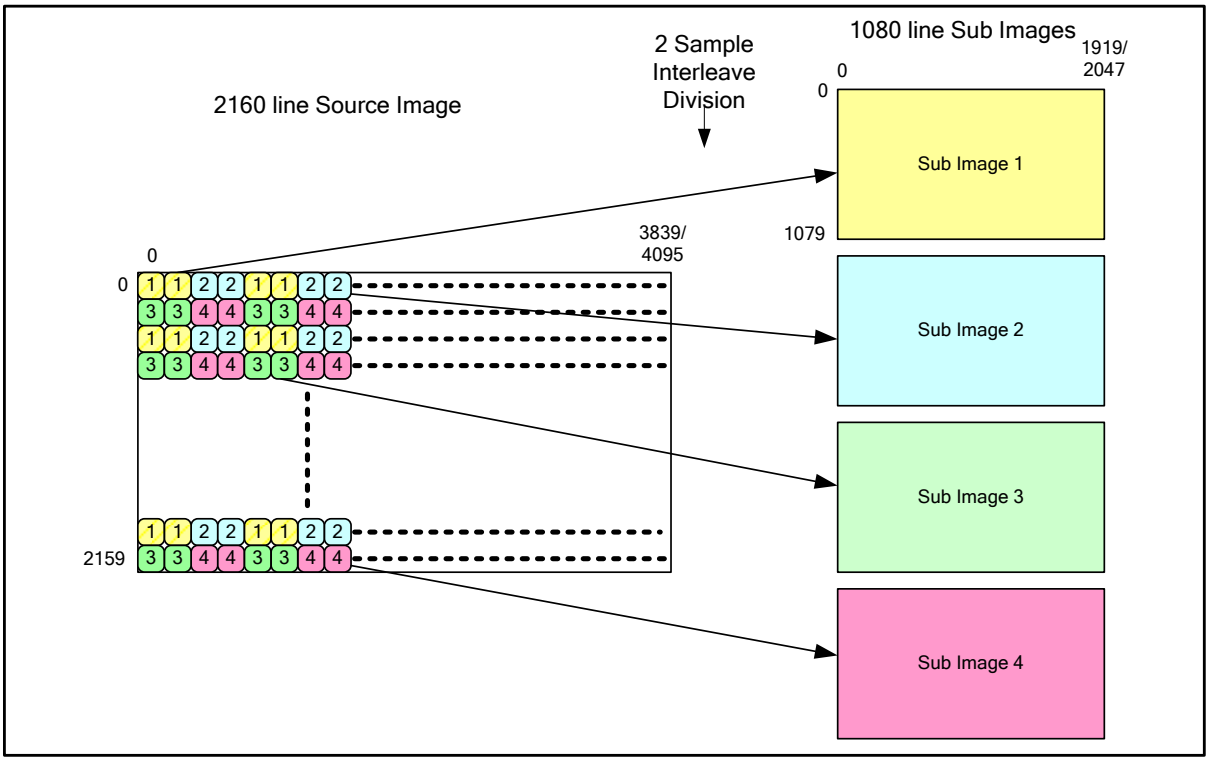


Figure 5 – Division of 2160-line source image into 1080-line sub images

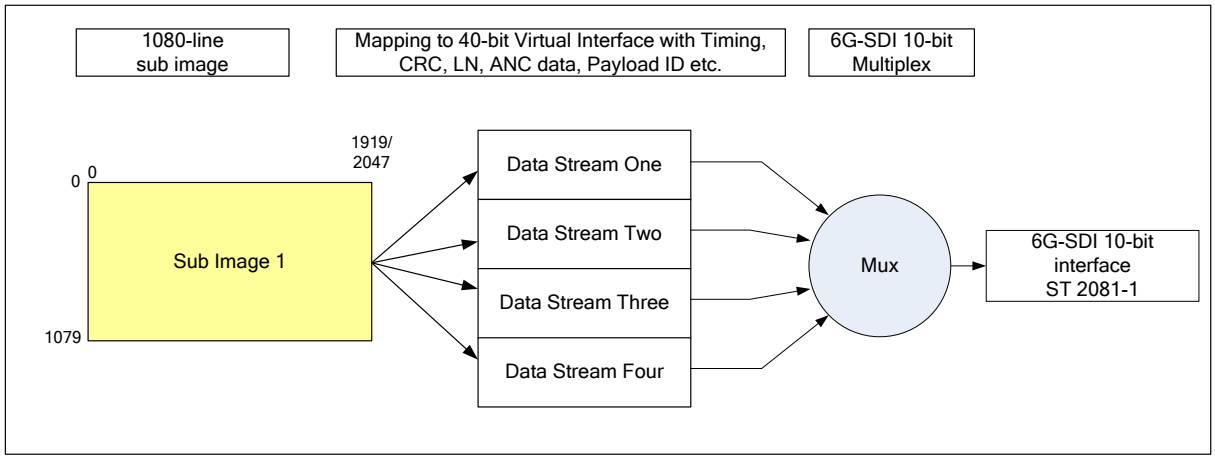


Figure 6 – Carriage of sub image 1 on 6G-SDI interface Link 1 – overall process

5.1 Mapping

The 2160-line source image shall be divided into four 1080-line sub images in accordance with the 2 sample interleave sub-division method referenced in SMPTE ST 425-5 “2160-line image division into four sub images”.

The resulting 1080-line sub images shall conform to the SMPTE ST 274 or SMPTE ST 2048-2 image formats shown in Table 7.

Table 7 – Sub Image Formats

Source Image		Sub Image	
Reference SMPTE Standard	**Image Format**	**Reference SMPTE Standard**	**Sub Image Format**
ST 2036-1	3840 × 2160	ST 274	1920 × 1080
ST 2048-1	4096 × 2160	ST 2048-2	2048 × 1080

Each 1080-line sub image shall be mapped onto a 40-bit virtual interface consisting of four 10-bit data streams according to SMPTE ST 2081-10 Mode 2 “Carriage of 1080-line Source image formats and ancillary data”.

Sub image one shall be mapped on to data streams one through four. Sub image two shall be mapped similarly on to data streams five through eight. Sub image three shall be mapped similarly on to data streams nine through twelve. Sub image four shall be mapped similarly on to data streams thirteen through sixteen.

The sixteen data streams, data stream one through data stream sixteen, shall be combined into a 160-bit virtual interface.

The 160-bit virtual interface shall have an interface frequency of 148.5 MHz or 148.5/1.001 MHz.

Each 10-bit data stream in the 160-bit virtual interface so constructed shall contain timing reference code words (SAV/EAV), line numbers, line based CRC’s and SMPTE ST 352 payload ID’s as defined in SMPTE ST 2081-10 Mode 2.

5.2 Mapping for 4:4:4 (R′G′B′)/ (Y′C′$_B$C′$_R$) and 4:4:4:4 (R′G′B′+A)/ (Y′C′$_B$C′$_R$+A)/10-bit Signals

Each 1080-line sub image shall be mapped onto a 40-bit virtual interface consisting of four 10-bit data streams according to SMPTE ST 2081-10 Mode 2 Mapping Structure II.

5.2.1 6G-SDI Link Multiplex Structure (Informative)

Following multiplexing onto a quad-link 6G-SDI 10-bit interface according to Section 7 the 6G-SDI data streams are conveyed in the following order:

6G-SDI Link 1:

Sub image 1, B′1, B′0, A0, G′0, R′1, R′0, A1, G′1, B′3, B′2, A2, G′2, R′3, R′2, A3, G′3 …

6G-SDI Link 2:

Sub image 2, B′1, B′0, A0, G′0, R′1, R′0, A1, G′1, B′3, B′2, A2, G′2, R′3, R′2, A3, G′3 …

6G-SDI Link 3:

Sub image 3, B′1, B′0, A0, G′0, R′1, R′0, A1, G′1, B′3, B′2, A2, G′2, R′3, R′2, A3, G′3 …

6G-SDI Link 4:

Sub image 4, B′1, B′0, A0, G′0, R′1, R′0, A1, G′1, B′3, B′2, A2, G′2, R′3, R′2, A3, G′3 …

5.3 Mapping for 4:4:4 (R′G′B′)/(Y′C′$_B$C′$_R$)/12-bit Signals

Each 1080-line sub image shall be mapped onto a 40-bit virtual interface consisting of four 10-bit data streams according to SMPTE ST 2081-10 Mode 2 Mapping Structure III.

5.3.1 6G-SDI Link Multiplex Structure (Informative)

Following multiplexing onto a quad-link 6G-SDI 10-bit interface according to Section 7, the 6G-SDI data streams are conveyed in the following order:

6G-SDI Link 1:

Sub image 1, B′1:2-11, B′0:2-11, G′B′R′0:0-1, G′0:2-11, R′1:2-11, R′0:2-11, G′B′R′1:0-1, G′1:2-11, B′3:2-11, B′2:2-11, G′B′R′2:0-1, G′2:2-11, R′3:2-11, R′2:2-11, G′B′R′3:0-1, G′3:2-11 …

6G-SDI Link 2:

Sub image 2, B′1:2-11, B′0:2-11, G′B′R′0:0-1, G′0:2-11, R′1:2-11, R′0:2-11, G′B′R′1:0-1, G′1:2-11, B′3:2-11, B′2:2-11, G′B′R′2:0-1, G′2:2-11, R′3:2-11, R′2:2-11, G′B′R′3:0-1, G′3:2-11 …

6G-SDI Link 3:

Sub image 3, B′1:2-11, B′0:2-11, G′B′R′0:0-1, G′0:2-11, R′1:2-11, R′0:2-11, G′B′R′1:0-1, G′1:2-11, B′3:2-11, B′2:2-11, G′B′R′2:0-1, G′2:2-11, R′3:2-11, R′2:2-11, G′B′R′3:0-1, G′3:2-11 …

6G-SDI Link 4:

Sub image 4, B′1:2-11, B′0:2-11, G′B′R′0:0-1, G′0:2-11, R′1:2-11, R′0:2-11, G′B′R′1:0-1, G′1:2-11, B′3:2-11, B′2:2-11, G′B′R′2:0-1, G′2:2-11, R′3:2-11, R′2:2-11, G′B′R′3:0-1, G′3:2-11 …

5.4 Mapping for 4:2:2 (Y′C′$_B$C′$_R$)/12-Bit and 4:2:2:4 (Y′C′$_B$C′$_R$ +A)/12-Bit Signals

Each 1080-line sub image shall be mapped onto a 40-bit virtual interface consisting of four 10-bit data streams according to SMPTE ST 2081-10 Mode 2 Mapping Structure IV.

5.4.1 6G-SDI Link Multiplex Structure (Informative)

Following multiplexing onto a quad-link 6G-SDI 10-bit interface according to Section 7, the 6G-SDI data streams are conveyed in the following order, where {n} indicates the number of the sub image:

6G-SDI Link 1:

Sub image 1, A0, C'_B0:2-11, $Y'C'_BC'_R$0:0-1, Y′0:2-11, A1, C'_R0:2-11, Y′1:0-1, Y′1:2-11, A2, C'_B 2:2-11, $Y'C'_BC'_R$2:0-1, Y′2:2-11, A3, C'_R2:2-11, Y′3:0-1 Y′3:2-11 …

6G-SDI Link 2:

Sub image 2, A0, C'_B0:2-11, $Y'C'_BC'_R$0:0-1, Y′0:2-11, A1, C'_R0:2-11, Y′1:0-1, Y′1:2-11, A2, C'_B 2:2-11, $Y'C'_BC'_R$2:0-1, Y′2:2-11, A3, C'_R2:2-11, Y′3:0-1 Y′3:2-11 …

6G-SDI Link 3:

Sub image 3, A0, C'_B0:2-11, $Y'C'_BC'_R$0:0-1, Y′0:2-11, A1, C'_R0:2-11, Y′1:0-1, Y′1:2-11, A2, C'_B 2:2-11, $Y'C'_BC'_R$2:0-1, Y′2:2-11, A3, C'_R2:2-11, Y′3:0-1 Y′3:2-11 …

6G-SDI Link 4:

Sub image 4, A0, C'_B0:2-11, $Y'C'_BC'_R$0:0-1, Y′0:2-11, A1, C'_R0:2-11, Y′1:0-1, Y′1:2-11, A2, C'_B 2:2-11, $Y'C'_BC'_R$2:0-1, Y′2:2-11, A3, C'_R2:2-11, Y′3:0-1 Y′3:2-11 …

5.5 Ancillary Data

When present, ancillary data packets shall be mapped into the HANC or the VANC spaces of each data stream. The HANC and VANC spaces of each sub image are defined in the reference standard for each sub image format referenced in Table 7.

Unless otherwise stated, the ancillary data shall be preferentially mapped into data stream one first and any remaining data shall then be mapped onto data stream three, then into data stream five, then into data stream seven and so on up to data stream fifteen. Data space requirements and locations for each data service are defined by their respective application documents. In some cases it is required by specific applications that ancillary data be mapped into all sixteen data streams (e.g. Payload ID.)

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

5.6 Audio Data

When present, audio data shall be mapped into the HANC space of data streams one through sixteen and shall be in conformance with SMPTE ST 299-1 and SMPTE ST 299-2.

Audio control packets shall be mapped into the odd numbered data streams.

Audio data packets shall be mapped into the even numbered data streams.

Audio control and data packets shall be mapped into the data stream pair one/two first and any remaining data shall then be mapped into data stream pair three/four; then into data stream pair five /six, and so on up to data stream pair fifteen/sixteen.

The audio clock phase data as defined in the section “CLK (audio clock phase data)” of SMPTE ST 299-1 shall be calculated at the clock frequency of 148.5 (/1.001) MHz.

Note: Some audio applications use non-PCM audio data. These may require the use of a marker as defined in SMPTE ST 2051 (see Bibliography) to indicate which frame contains the SDI switching point for the non-PCM data payload.

5.6.1 Number of Audio Channels

Up to 256 audio channels sampled at 32 kHz, 44.1 kHz or 48 kHz may be mapped into data streams one through sixteen of the 160-bit virtual interface. At 96 kHz sampling, up to 128 audio channels may be mapped into the virtual interface.

The maximum number of audio channels that can be mapped into the available ancillary data space of each data stream pair varies in accordance with the video format and the video frame rate. Table 8 shows the overall capacity of the 160-bit virtual interface.

Table 8 – Number of Audio Channels supported Source Image Format, Frame Rate and Audio Sampling Rate

Image Format	Frame Rate	Maximum number of audio channels at 32 kHz, 44.1 kHz or 48 kHz sampling	Maximum number of audio channels at 96 kHz sampling
3840x2160	50, 60/1.001 and 60 Progressive	Up to 256 channels	Up to 128 channels
4096x2160	48 and 50 Progressive	Up to 256 channels	Up to 128 channels
	60 Progressive	Up to 128 channels	Up to 64 channels

5.6.1.1 Carriage of up to 256 Channels of Audio at up to 48 kHz Sampling

For audio at up to 48 kHz sampling embedded into 4096 x 2160 image formats at frame rates of 60, the audio data and control packets for the first 16 channels shall be mapped into data stream pair one/two in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the second 16 channels shall be mapped into data stream pair three/ four in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

In the same way, successive sets of 16 channels shall be mapped into successive data stream pairs, up to...

The audio data and control packets for the eighth 16 channels shall be mapped into data stream pair seven/eight in conformance with SMPTE ST 299-1 (audio groups 1 to 4)

For audio at up to 48 kHz sampling, embedded into all other 2160-line image formats shown in Table 8, the audio data and control packets for the first 16 channels shall be mapped into data stream pair one/two in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The extended audio data and control packets for the second 16 channels shall be mapped into data stream pair one/two in conformance with SMPTE ST 299-2 (audio groups 5 to 8).

The audio data and control packets for the third 16 channels shall be mapped into data stream pair three/four in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The extended audio data and control packets for the fourth 16 channels shall be mapped into data stream pair three/four in conformance with SMPTE ST 299-2 (audio groups 5 to 8).

In the same way, successive sets of 32 channels shall be mapped into successive data stream pairs, up to...

The audio data and control packets for the fifteenth 16 channels shall be mapped into data stream pair fifteen/sixteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The extended audio data and control packets for the sixteenth 16 channels shall be mapped into data stream pair fifteen/sixteen in conformance with SMPTE ST 299-2 (audio groups 5 to 8).

5.6.1.2 Carriage of up to 128 Channels of Audio at 96 kHz Sampling

For audio at 96 kHz sampling embedded into 4096 x 2160 image formats at frame rates of 60, the audio data and control packets for the first 8 channels shall be mapped into data stream pair one/two in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the second 8 channels shall be mapped into data stream pair three/four in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the third 8 channels shall be mapped into data stream pair five/ six in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

In the same way, successive sets of 8 channels shall be mapped into successive data stream pairs, up to...

The audio data and control packets for the eighth 8 channels shall be mapped into data stream pair seven/eight in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

For audio at 96 kHz sampling, embedded into all other 2160-line image formats shown in Table 8, the audio data and control packets for the first 8 channels shall be mapped into data stream pair one/two in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The extended audio data and control packets for the second 8 channels shall be mapped into data stream pair one/two in conformance with SMPTE ST 299-2 (audio groups 5 to 8).

The audio data and control packets for the third 8 channels shall be mapped into data stream pair three/four in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The extended audio data and control packets for the fourth 8 channels shall be mapped into data stream pair three/four in conformance with SMPTE ST 299-2 (audio groups 5 to 8).

In the same way, successive sets of 16 channels shall be mapped into successive data stream pairs, up to...

The audio data and control packets for the fifteenth 8 channels shall be mapped into data stream pair fifteen/sixteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The extended audio data and control packets for the sixteenth 8 channels shall be mapped into data stream pair fifteen/sixteen in conformance with SMPTE ST 299-2 (audio groups 5 to 8).

5.6.2 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 done in order for 6G-SDI Links 2, 3 and 4 to carry a copy of the audio on 6G-SDI Link 1, or for 6G-SDI Links 3 and 4 to carry a copy of audio on 6G-SDI links 1 and 2 respectively.

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

If audio is copied:

Data stream pairs one/two and three/four shall always carry original audio.

Data stream pairs five/six and seven/eight may also carry original audio.

Data stream pairs nine/ten, eleven/twelve, thirteen/fourteen and fifteen/sixteen may carry copied audio from data stream pairs one/two, three/four, five/six and seven/eight, respectively.

Data stream pairs five/six and seven/eight may carry copied audio from data stream pairs one/two and three/four, respectively. In this case data stream pairs nine/ten and eleven/twelve, and data stream pairs thirteen/fourteen and fifteen/sixteen shall also carry the same copied audio.

The audio copy status of each data stream shall be signaled in that data stream's PID as described in Section 4.7

5.7 Time Code Data

When present the time code shall be mapped into the HANC space of data stream one, and shall be in conformance with SMPTE ST 12-2.

The time code may also be mapped onto data stream three, data stream five, data stream seven, and so on up to data stream fifteen, in which case the corresponding Time Address values shall be identical.

5.8 Payload Identifier

A payload identifier packet shall be placed in each data stream.

Table 9 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 horizontal placement of the packet should be immediately following the last CRC code word (CR1) of the line(s) specified in SMPTE ST 352 for 1125-line systems.

Note: The line numbers defined in SMPTE ST 352 for the placement of the payload identifier packet in 1125-line systems avoid those lines used by SMPTE ST 299-1 and SMPTE ST 299-2 for the carriage of digital audio control packets and extended audio control packets, respectively.

Table 9 – Payload Identifier Definitions for 2160-line Video Payload for Mapping on a Quad-link 6Gb/s (nominal) Serial Interface

<table>
<tr><th>Bits</th><th>Byte 1</th><th>Byte 2</th><th>Byte 3</th><th>Byte 4</th></tr>
<tr><td>Bit 7</td><td>1</td><td>Progressive transport (1)</td><td>Aspect Ratio
16:9 (1) or Unknown (0)</td><td rowspan="3">Link assignment
6G-SDI Link 1 (0h)
on 6G-SDI Link 2 (1h)
on 6G-SDI Link 3 (2h)
on 6G-SDI Link 4 (3h)</td></tr>
<tr><td>Bit 6</td><td>0</td><td>Progressive picture (1)</td><td>Sub image horizontal sampling
1920 (0) or 2048 (1)</td></tr>
<tr><td>Bit 5</td><td>1</td><td>Reserved (0)</td><td rowspan="2">Colorimetry
Rec 709*1 (0h)
Color VANC Packet (1h)
UHDTV*2 (2h)
Unknown (3h)</td></tr>
<tr><td>Bit 4</td><td>1</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 3</td><td>0</td><td rowspan="4">Picture rate
(See Table 4)</td><td rowspan="4">Sampling structure
(See Table 5)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 2</td><td>1</td><td>Audio copy status:
Audio in this data stream carries additional channels or audio not present (0)
Audio in this data stream is copied (1)</td></tr>
<tr><td>Bit 1</td><td>0</td><td rowspan="2">Bit depth
10-bit (1h)
12-bit (2h)
Other values are Reserved</td></tr>
<tr><td>Bit 0</td><td>1</td></tr>
</table>

Notes:

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

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

5.8.1 Byte 1 – Digital Interface and Payload Identification

Byte 1 of the payload identifier identifies the video payload and the digital interface and shall be as defined below.

Byte 1 shall be set to [C5h] for 2160-line image formats listed in Table 6 transported via quad-link 6G-SDI.

5.8.2 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).

Bit b5 shall be set to 0 (reserved).

Bit b4 shall be set to 0 (reserved).

Bits b3 to b0 shall be used to identify the picture rate in Hz in accordance with Table 2 of SMPTE ST 352 and shall only use the values as permitted for image formats in Table 6.

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

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

Bit 7 shall be used to identify the aspect ratio such that:

b7 = 0 shall identify unknown aspect ratio

b7 = 1 shall identify a 16:9 aspect ratio

Bit 6 shall be used to identify the number of active Luma/R′G′B′ samples for the sub image such that:

b6 = 0 shall identify 1920 active Luma/R′G′B′ samples

b6 = 1 shall identify 2048 active Luma/R′G′B′ samples

Bits b5 and b4 shall identify the colorimetry for the image formats identified in Table 6 such that:

b5:b4 = 0h shall identify Rec 709 colorimetry

b5:b4 = 1h shall identify that the colorimetry is defined in the Color VANC packet defined in SMPTE ST 2048-1

b5:b4 = 2h shall identify UHDTV colorimetry

b5:b4 = 3h shall identify unknown colorimetry

Bits b3 to b0 shall be used to identify the sampling structure in accordance with Table 5 and shall only use the values as permitted for image formats in Table 6.

5.8.4 Byte 4 – Link Assignment Identification, Audio Copy Status and Quantization Bit Depth

Byte 4 of the payload identifier shall be used to identify the link assignment, the audio copy status and the bit depth of the sample quantization.

Bits b7 to b5 shall be used to identify Link assignment and set to:

b7:b5 = 0h shall identify 6G-SDI Link 1

b7:b5 = 1h shall identify 6G-SDI Link 2

b7:b5 = 2h shall identify 6G-SDI Link 3

b7:b5 = 3h shall identify 6G-SDI Link 4

Bit b4 shall be reserved and set 0.

Bit b3 shall be reserved and set 0.

For data streams one through four bit b2 shall be set to 0 (reserved).

For data streams five through sixteen bit b2 shall be used to identify whether audio data in this data stream is copied:

b2 = 0 shall identify that all audio if present in this data stream carries additional channels

b2 = 1 shall identify that audio if present in this data stream is copied

Bits b1 to b0 shall be used to identify the bit depth of the sample quantization such that:

b1:b0 = 1h shall identify quantization using 10 bits per sample

b1:b0 = 2h shall identify quantization using 12 bits per sample

Other values shall be reserved.

5.9 Blanking (Informative)

As defined in the sub image source format documents SMPTE ST 274 and SMPTE ST 2048-2, HANC and VANC space with no ancillary data packets or audio data packets contain data words that represent video black level for the video structure being carried.

In the case of 4:4:4 R′G′B′ or R′G′B′+A 10-bit video structure, all words in each data stream take the value 040h.

In the case of 4:4:4 $Y'C'_BC'_R$ or $Y'C'_BC'_R$+A 10-bit video structure, all words in odd numbered data streams take the value 040h and all words in even numbered data streams take the value 200h.

In the case of 4:4:4 R′G′B′ 12-bit video structure, all words in data streams one, two, four, five, six, eight, nine, ten, twelve, thirteen, fourteen and sixteen take the value 040h. All words in data streams three, seven, eleven and fifteen take the value 200h

In the case of 4:4:4 $Y'C'_BC'_R$ 12-bit video structure, all words in data streams one, five, nine and thirteen take the value 040h. All words in data streams two, three, four, six, seven, eight, ten, eleven, twelve, fourteen, fifteen and sixteen take the value 200h.

In the case of 4:2:2 $Y'C'_BC'_R$ 12-bit or 4:2:2:4 $Y'C'_BC'_R$+A 12-bit video structure, all words in data streams one, four, five, eight, nine, twelve, thirteen and sixteen take the value 040h. All words in data streams two, three, six, seven, ten, eleven, fourteen and fifteen take the value 200h.

5.10 Multiplex

The 160-bit virtual interface shall then be multiplexed onto four Type 1 6G-SDI 10-bit interfaces according to Section 7.

5.11 Levels of Operation (Informative)

To define the level of support for SMPTE ST 2081-12 Mode 1, manufacturers are encouraged to indicate in publications which mapping format is supported. For example:

SMPTE ST 2081-12 MODE 1 – 2160-line Source image formats and ancillary data into a Quad-link 6 Gb/s [nominal] SDI bit-serial interface

Manufacturers are also encouraged to indicate in publications supported audio and video formats.

6 MODE 3: Carriage of 2160-line $Y'C'_BC'_R$ 4:2:2 and 4:2:0 10-bit Additional Frame Rate (AFR) Source Image Formats and Ancillary Data

For this mode, the Source Image Formats shall be as defined in Table 10.

Table 10 – Supported Image sample structures and frame rates

Reference SMPTE Standard	Image Format	Signal Format Sampling Structure/pixel Depth	Additional Frame Rates (AFR)
ST 2036-1	3840 x 2160	4:2:2 ($Y'C'_BC'_R$)/10-bit 4:2:0 ($Y'C'_BC'_R$)/10-bit	120 frames progressive
			120/1.001 frames progressive
			100 frames progressive
ST 2048-1	4096 x 2160	4:2:2 ($Y'C'_BC'_R$)/10-bit	120 frames progressive
			120/1.001 frames progressive
			100 frames progressive
			96 frames progressive
			96/1.001 frames progressive

6.1 Mapping

Figure 7 and Figure 8 illustrate the process for the carriage of 2160-line AFR source image formats in a Quad-link 6G-SDI interface.

Figure 7 illustrates the division of the source image format into four sub images.

Figure 8 illustrates the mapping of sub image one onto 6G-SDI Link 1.

Sub image two is similarly mapped onto 6G_SDI Link 2.

Sub image three is similarly mapped onto 6G_SDI Link 3.

Sub image four is similarly mapped onto 6G_SDI Link 4.

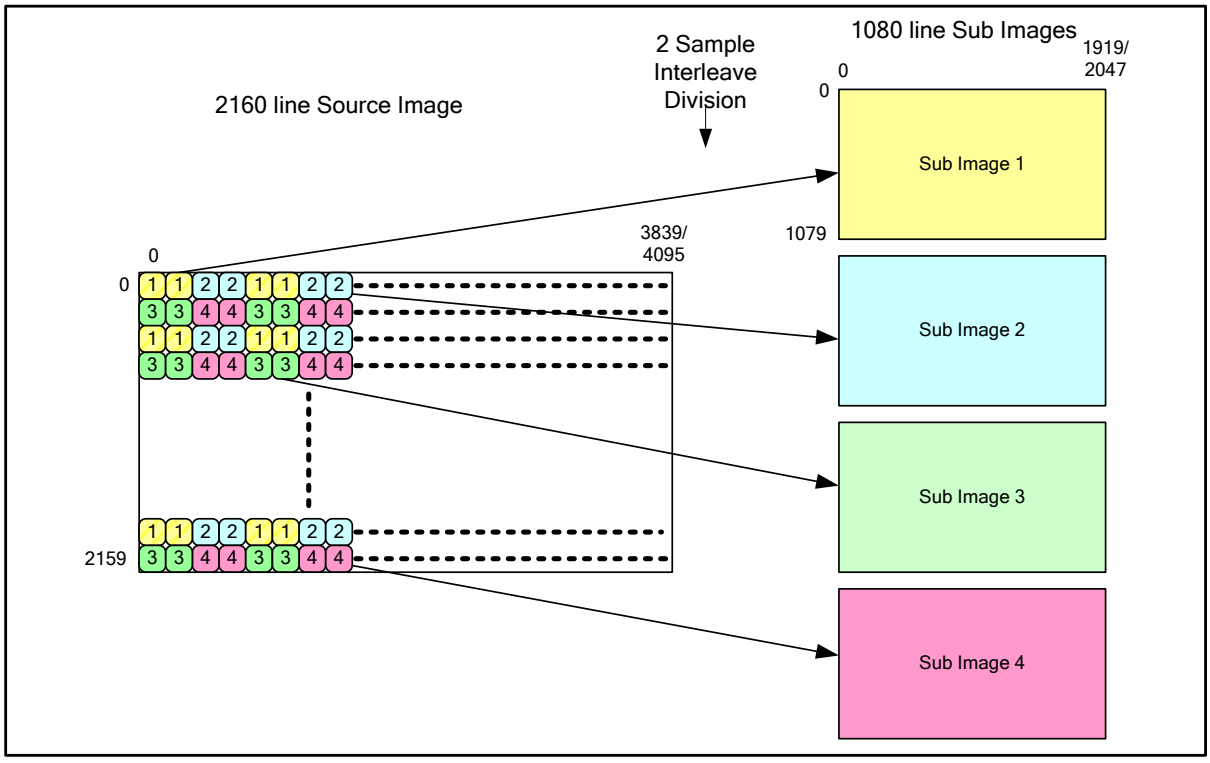


Figure 7 – Division of 2160-line source image into 1080-line sub images

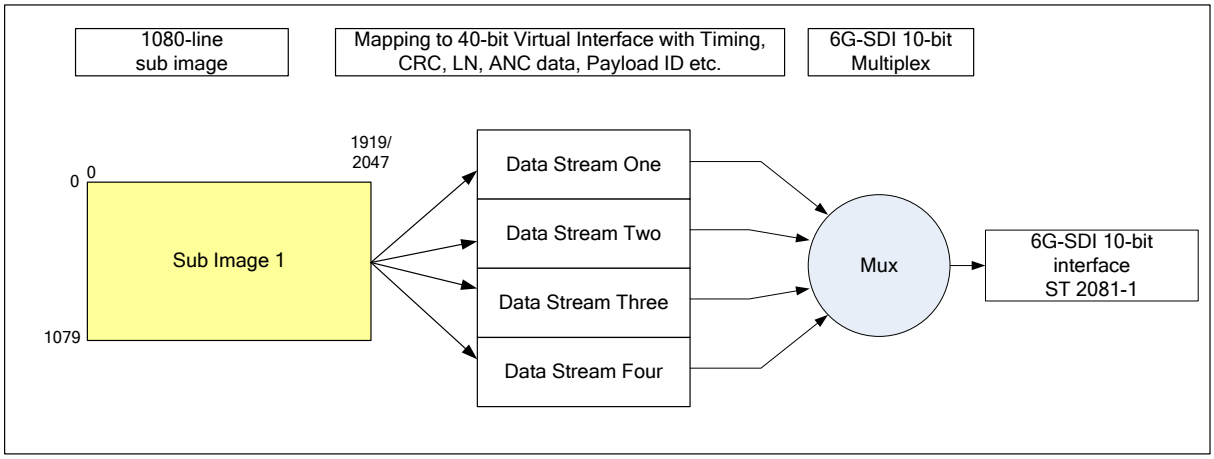


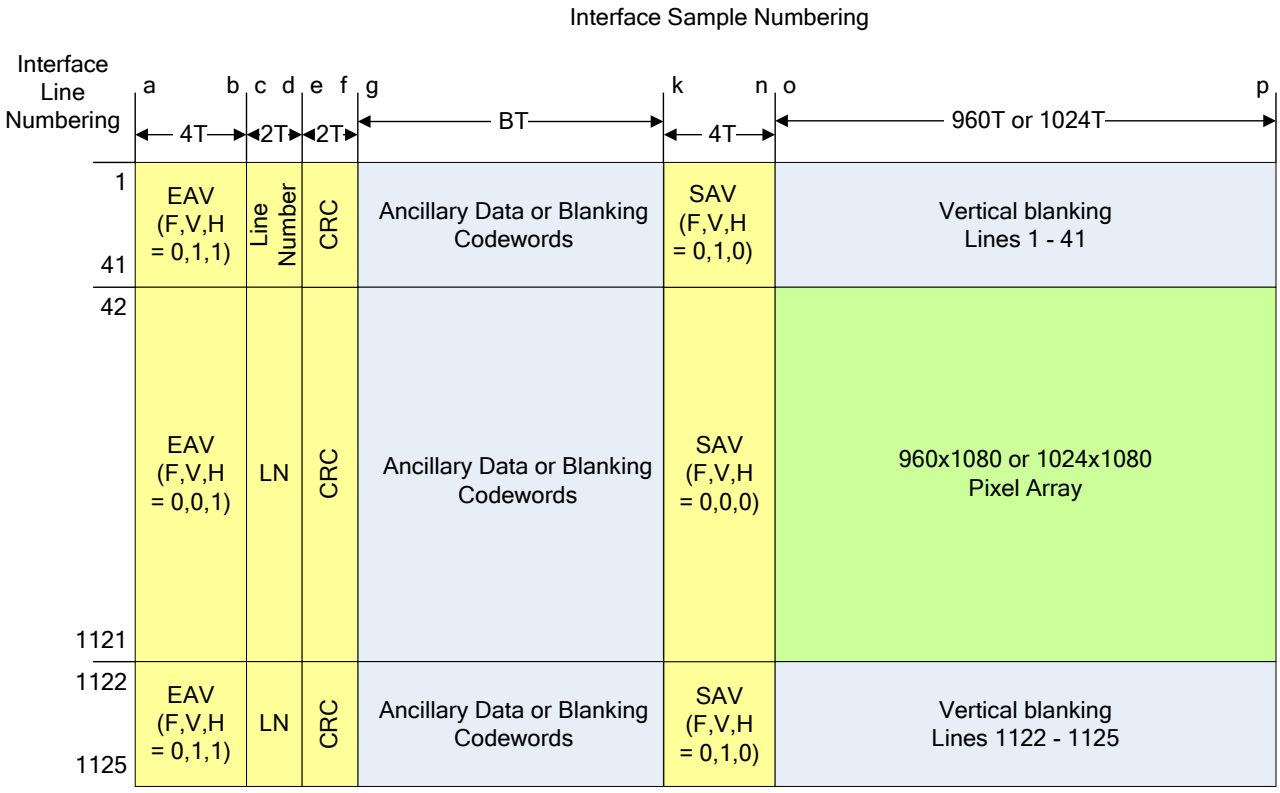
Figure 8 – Carriage of sub image 1 on 6G-SDI interface Link 1 – overall process

The 2160-line source images shall be divided into four 1080-line 4:2:2 or 4:2:0 sub images in accordance with the 2 sample interleave sub-division method referenced in SMPTE ST 425-5 “2160-line image division into four sub images”.

For a 4:2:0 source image, the C'_B and C'_R samples in sub images 3 and 4 shall be set to the value 200h.

6.2 Mapping of 1080-line Sub Images

Each 1080-line 4:2:2 sub image shall be mapped to a 40-bit virtual interface consisting of four data streams. The structure of each data stream shall be as illustrated in Figure 9.



Sub Image Format	a	b	c	d	e	f	g	BT	k	n	o	p
1920 x 1080 / 120	960	963	964	965	966	967	968	128	1096	1099	0	959
1920 x 1080 / 120/1.001	960	963	964	965	966	967	968	128	1096	1099	0	959
1920 x 1080 / 100	960	963	964	965	966	967	968	348	1316	1319	0	959
2048 x 1080 / 120	1024	1027	1028	1029	1030	1031	1032	64	1096	1099	0	1023
2048 x 1080 / 120/1.001	1024	1027	1028	1029	1030	1031	1032	64	1096	1099	0	1023
2048 x 1080 / 100	1024	1027	1028	1029	1030	1031	1032	284	1316	1319	0	1023
2048 x 1080 / 96	1024	1027	1028	1029	1030	1031	1032	339	1371	1374	0	1023
2048 x 1080 / 96/1.001	1024	1027	1028	1029	1030	1031	1032	339	1371	1374	0	1023

Figure 9 – Structure of each Data Stream for 120 Hz, 120/1.001 Hz, 100 Hz, 96 Hz or 96/1.001 Hz frame rates

Sub image 1 shall be mapped on to data streams one through four.

Data stream one shall carry the odd Y′ samples Y′1, Y′3, Y′5, Y′7 …

Data stream two shall carry the C'_R samples C'_R0, C'_R1, C'_R2…

Data stream three shall carry the even Y′ samples Y′0, Y′2, Y′4, Y′6 …

Data stream four shall carry the C'_B samples C'_B0, C'_B1, C'_B2…

Sub image 2 shall be mapped similarly on to data streams five through eight. Sub image 3 shall be mapped similarly on to data streams nine through twelve. Sub image 4 shall be mapped similarly on to data streams thirteen through sixteen.

The sixteen data streams, data stream one through data stream sixteen, shall be combined into a 160-bit virtual interface.

The 160-bit virtual interface shall have an interface frequency of 148.5 MHz or 148.5/1.001 MHz.

6.2.1 6G-SDI Link Multiplex Structure (Informative)

Following multiplexing onto a quad-link 6G-SDI 10-bit interface according to § 7 the 6G-SDI data streams are conveyed in the following order:

6G-SDI Link 1:

Sub image 1, C'_B0, C'_R0, Y′0, Y′1, C'_B1, C'_R1, Y′2, Y′3, C'_B2, C'_R2, Y′4, Y′5, C'_B3, C'_R3, Y′6, Y′7, ….

6G-SDI Link 2:

Sub image 2, C'_B0, C'_R0, Y′0, Y′1, C'_B1, C'_R1, Y′2, Y′3, C'_B2, C'_R2, Y′4, Y′5, C'_B3, C'_R3, Y′6, Y′7, ….

6G-SDI Link 3:

Sub image 3, C'_B0, C'_R0, Y′0, Y′1, C'_B1, C'_R1, Y′2, Y′3, C'_B2, C'_R2, Y′4, Y′5, C'_B3, C'_R3, Y′6, Y′7, ….

6G-SDI Link 4:

Sub image 4, C'_B0, C'_R0, Y′0, Y′1, C'_B1, C'_R1, Y′2, Y′3, C'_B2, C'_R2, Y′4, Y′5, C'_B3, C'_R3, Y′6, Y′7, ….

Figure 10 shows the mapping structure for mapping sub image 1 onto data streams one through four. Sub image 2 is similarly mapped onto data streams five through eight. Sub image 3 is similarly mapped onto data streams nine through twelve. Sub image 2 is similarly mapped onto data streams thirteen through sixteen.

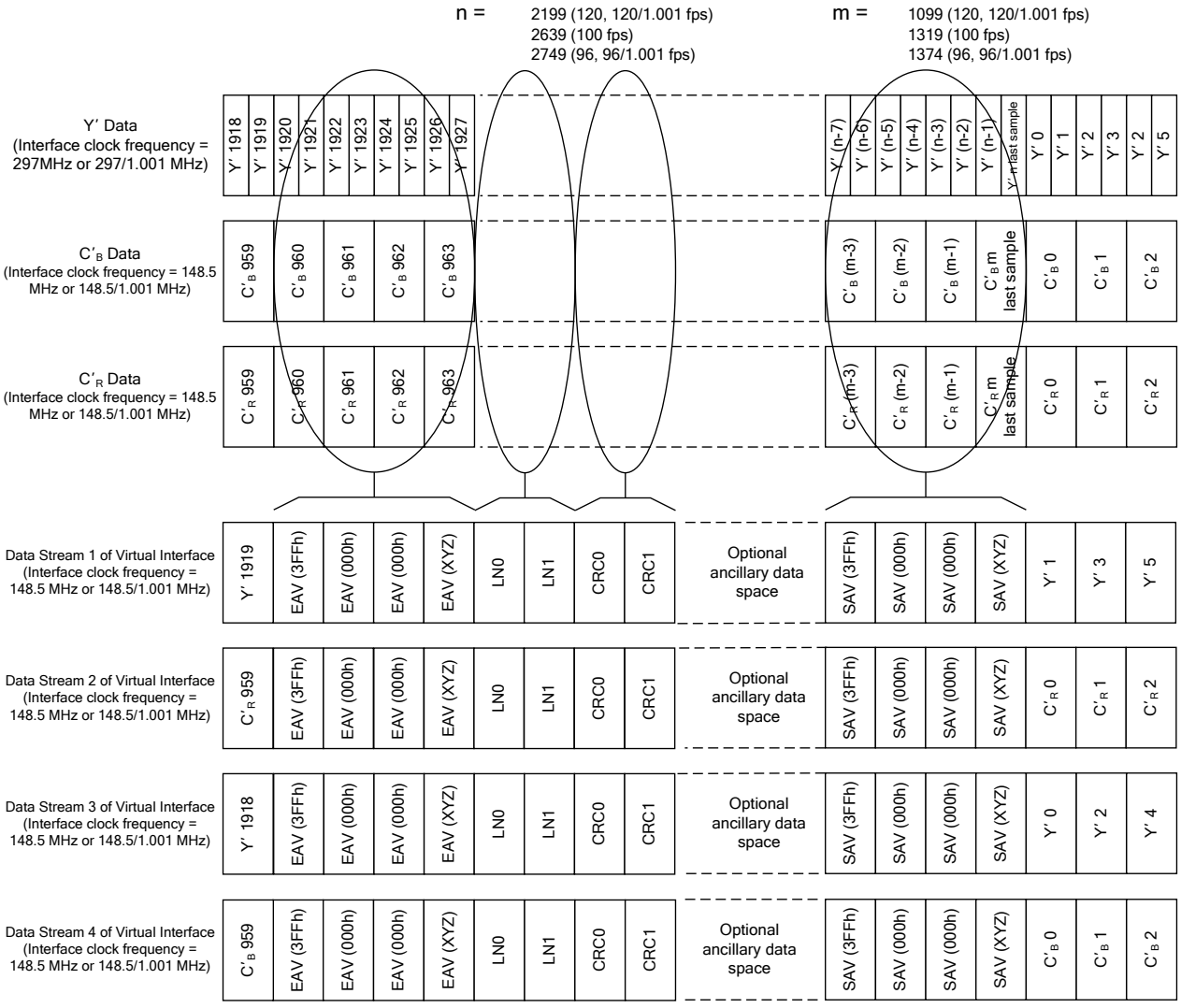


Figure 10 – Mapping Structure 4:2:2 (Y′C′BC′R)/10-Bit Signals at 96, 96/1.001, 100, 120 and 120/1.001 Progressive Frames/Sec – Sub image 1

6.3 Timing and Reference Signals

EAV (End of Active Video) and SAV (Start of Active Video) timing references shall be inserted into each data stream of the 160-bit virtual interface on a line-by-line basis as illustrated in Figure 10.

The EAV and SAV sequence, F (field/ frame), V (vertical), H (horizontal) and parity bits P3 through P1 shall be as defined in Table 11 and Table 12.

Table 11 – Bit assignment for timing reference codes

Word	Value	Bit number									
		b9 (MSB)	b8	b7	b6	b5	b4	b3	b2	b1	b0 (LSB)
1	FFFh	1	1	1	1	1	1	1	1	1	1
2	000h	0	0	0	0	0	0	0	0	0	0
3	000h	0	0	0	0	0	0	0	0	0	0
4	XYZ	1	F	V	H	P_3	P_2	P_1	P_0	0	0

Table 12 – Protection Parity bits for timing reference codes

Bit number	b8	b7	b6	b5	b4	b3	b2
Function	F	V	H	P_3	P_2	P_1	P_0
Bit pattern 0	0	0	0	0	0	0	0
Bit pattern 1	0	0	1	1	1	0	1
Bit pattern 2	0	1	0	1	0	1	1
Bit pattern 3	0	1	1	0	1	1	0

6.4 Line Numbers

Line numbers shall be inserted into each data stream of the 160-bit virtual interface starting at the first data word (of the virtual interface) following the EAV XYZ word, as illustrated in Figure 10.

Line number data are composed of two words, LN0 and LN1, and shall be as shown in Table 13.

Table 13 – Line Number Data

	B9 (msb)	B8	B7	B6	B5	B4	B3	B2	B1	B0 (lsb)
LN0	$\overline{B8}$	L6	L5	L4	L3	L2	L1	L0	Res	Res
LN1	$\overline{B8}$	Res	Res	Res	L10	L9	L8	L7	Res	Res
Notes: 1 L10 : L0 = line number in binary code. 2 Res = reserved, set to “0” and shall be ignored by receivers.										

6.5 Line CRC Codes

CRC (Cyclic Redundancy Check) codes shall be inserted into each data stream of the 160-bit virtual interface starting at the first data word (of the virtual interface) following the final word of the line number – LN1, as illustrated in Figure 10.

The CRC code words are used to detect errors in the active digital line, the EAV timing reference signal and line number words that follow it. The error detection code consists of two words determined by the polynomial generator equation:

$CRC(X) = X^{18} + X^5 + X^4 + 1$

The initial value of the CRC shall be zero. The calculation shall start at the first active line word of the interface and shall end at the final word of the line number – LN1.

Independent CRC codes shall be produced for each data stream of the 160-bit virtual interface.

The two words of the CRC code shall be as shown in Table 14.

Table 14 – CRC Data

	B9(msb)	B8	B7	B6	B5	B4	B3	B2	B1	B0(lsb)
CR0	$\overline{B8}$	CRC8	CRC7	CRC6	CRC5	CRC4	CRC3	CRC2	CRC1	CRC0
CR1	$\overline{B8}$	CRC17	CRC16	CRC15	CRC14	CRC13	CRC12	CRC11	CRC10	CRC9

6.6 HANC and VANC Space of Data Streams

When present, ancillary data packets shall be mapped into the HANC or the VANC spaces of each data stream and shall be in accordance with SMPTE ST 291.

The HANC and VANC spaces of each data stream are defined in Figure 9 of Section 6.2.

Unless otherwise stated, the ancillary data shall be preferentially mapped into data stream one first and any remaining data shall then be mapped onto data stream three; then into data stream five, data stream seven and so on up to data stream fifteen. Data space requirements and locations for each data service are defined by their respective application documents. In some cases it is required by specific applications that ancillary data be mapped into all sixteen data streams (e.g. Payload ID.)

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

6.7 Audio Data

When present, audio data shall be mapped into the HANC space of data streams one through sixteen and shall be in conformance with SMPTE ST 299-1.

Audio control packets shall be mapped into the odd numbered data streams.

Audio data packets shall be mapped into the even numbered data streams.

Audio control and data packets shall be mapped into the data stream pair one/two first and any remaining data shall then be mapped onto data stream pair three/four; then into data stream pair five /six, and so on up to data stream pair fifteen/sixteen.

The audio clock phase data as defined in the section “CLK (audio clock phase data)” of SMPTE ST 299-1 shall be calculated at the data stream clock frequency of 148.5 MHz or 148.5/1.001 MHz.

Note: Some audio applications use non-PCM audio data. These may require the use of a marker as defined in SMPTE ST 2051 to indicate which frame contains the SDI switching point for the non-PCM data payload.

6.7.1 Number of Audio Channels

Informative Note:

1080p images at 96, 100 and 120 fps have horizontal line rates of 108 kHz, 112.5 kHz and 135 kHz respectively.

As SMPTE ST299-1 states that an audio sample should be placed in the next available line, and calculates the phase word from the line, it is only possible to embed audio samples in one line every 20.833 us on average (i.e. at 48 kHz). This means that the majority of the lines are not available for audio embedding, and the number of audio channels that can be transported is significantly less than appears from a simple calculation of the total HANC space.

Informative Note ends

Up to 128 audio channels sampled at 32 kHz, 44.1 kHz or 48 kHz may be mapped into data streams one through sixteen of the 160-bit virtual interface. At 96 kHz sampling, up to 64 audio channels may be mapped into the virtual interface.

The maximum number of audio channels that can be mapped into the available ancillary data space of each data stream pair varies in accordance with the video format and the video frame rate. Table 15 shows the overall capacity of the 160-bit virtual interface.

Table 15 – Number of Audio Channels supported Source Image Format, Frame Rate and Audio Sampling Rate

Source Image Format	Frame Rate	Maximum number of audio channels at 32 kHz, 44.1 kHz or 48 kHz sampling	Maximum number of audio channels at 96 kHz sampling
3840x2160	100 and 120 Progressive	Up to 128 channels	Up to 64 channels
4096x2160	96 and 100 Progressive	Up to 128 channels	Up to 64 channels
	120 Progressive	Up to 64 channels	Up to32 channels

6.7.1.1 Carriage of up to 128 Channels of Audio at up to 48 kHz Sampling

For audio at up to 48 kHz sampling embedded into 4096 x 2160 image formats at frame rates of 120, the audio data and control packets for the first 8 channels shall be mapped into data stream pair one and two in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the second 8 channels shall be mapped into data stream pair three and four in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the third 8 channels shall be mapped into data stream pair five and six in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the fourth 8 channels shall be mapped into data stream pair seven and eight in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the fifth 8 channels shall be mapped into data stream pair nine and ten in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the sixth 8 channels shall be mapped into data stream pair eleven and twelve in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the seventh 8 channels shall be mapped into data stream pair thirteen and fourteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the eighth 8 channels shall be mapped into data stream pair fifteen and sixteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

For audio at up to 48 kHz sampling, embedded into all other 2160-line image formats shown in Table 15, the audio data and control packets for the first 16 channels shall be mapped into data stream pair one and two in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the second 16 channels shall be mapped into data stream pair three and four in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the third 16 channels shall be mapped into data stream pair five and six in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the fourth 16 channels shall be mapped into data stream pair seven and eight in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the fifth 16 channels shall be mapped into data stream pair nine and ten in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the sixth 16 channels shall be mapped into data stream pair eleven and twelve in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the seventh 16 channels shall be mapped into data stream pair thirteen and fourteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the eighth 16 channels shall be mapped into data stream pair fifteen and sixteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

6.7.1.2 Carriage of up to 64 Channels of Audio at 96 kHz Sampling

For audio at 96 kHz sampling embedded into 4096 x 2160 image formats at frame rates of 120, the audio data and control packets for the first 4 channels shall be mapped into data stream pair one and two in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the second 4 channels shall be mapped into data stream pair three and four in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the third 4 channels shall be mapped into data stream pair five and six in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the fourth 4 channels shall be mapped into data stream pair seven and eight in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the fifth 4 channels shall be mapped into data stream pair nine and ten in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the sixth 4 channels shall be mapped into data stream pair eleven and twelve in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the seventh 4 channels shall be mapped into data stream pair thirteen and fourteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the eighth 4 channels shall be mapped into data stream pair fifteen and sixteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

For audio at 96 kHz sampling, embedded into all other 2160-line image formats shown in Table 15, the audio data and control packets for the first 8 channels shall be mapped into data stream pair one and two in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets and audio data and control packets for the second 8 channels shall be mapped into data stream pair three and four in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the third 8 channels shall be mapped into data stream pair five and six in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the fourth 8 channels shall be mapped into data stream pair seven and eight in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the fifth 8 channels shall be mapped into data stream pair nine and ten in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the sixth 8 channels shall be mapped into data stream pair eleven and twelve in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the seventh 8 channels shall be mapped into data stream pair thirteen and fourteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

The audio data and control packets for the eighth 8 channels shall be mapped into data stream pair fifteen and sixteen in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

6.7.2 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 done in order for 6G-SDI Links 2, 3 and 4 to carry a copy of the audio on 6G-SDI Link 1, or for 6G-SDI Links 3 and 4 to carry a copy of audio on 6G-SDI links 1 and 2 respectively.

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

If audio is copied:

Data streams one through four shall always carry original audio.

Data streams five through eight may also carry original audio.

Data streams nine through sixteen may carry copied audio from data streams one through eight respectively.

Data streams five through eight may carry copied audio from data streams one through four respectively. In this case data streams nine through twelve, and data streams thirteen through sixteen shall also carry the same copied audio.

The audio copy status of each data stream shall be signaled in that data stream's PID as described in Section 6.9 of this document.

6.8 Time Code Data

When present the data format of ATC packets shall be in conformance with SMPTE ST 12-3.

Where present the packet or packets shall be mapped into the HANC or VANC space of data stream one. The preferred location should be as indicated in Table 16.

Table 16 – Preferred locations for time code insertion into data streams

Payload Type	Location
ATC_HFRTC	HANC, Line 11
ATC_HFRTC *	HANC, Line 12
ATC_HFRTC * ATC_HFRTC *	HANC, Line 13 HANC, Line 14

Note: * Transmissions of multiple ancillary time code packets with different instance identifications (bitstream numbers) per video frame are permissible under the provisions of SMPTE ST 12-3. The default bitstream number is zero. Lines 12, 13 and 14 are for use when necessary based on the number of bitstreams

The ATC_HFRTC packet with bitstream number zero shall be preferentially mapped onto line 11 first and any remaining bitstreams shall then be mapped onto the same line. If there is insufficient space remaining on the same line, remaining bitstreams shall be mapped onto line 12, then onto line 13, then onto line 14.

The time code may also be mapped into data stream three, data stream five, data stream seven, and any or all odd-numbered data streams up to data stream fifteen, in which case the corresponding Time Address values shall be identical.

6.8.1 Two-Frame Marker

When present the two-frame marker shall be mapped into the HANC space of data stream one, and shall be in conformance with SMPTE ST 2051.

The two-frame marker may also be mapped onto data stream three, data stream five, data stream seven, and so on up to data stream fifteen, in which case the corresponding two-frame marker values shall be identical.

6.9 Payload Identifier

A payload identifier packet shall be placed in each data stream.

Table 17 shows the payload identifier definitions for 2160-line AFR 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 horizontal placement of the packet should be immediately following the last CRC code word (CR1) of the line(s) specified in SMPTE ST 352 for 1125-line systems.

Note: The line numbers defined in SMPTE ST 352 for the placement of the payload identifier packet in 1125-line systems avoid those lines used by SMPTE ST 299-1 and SMPTE ST 299-2 for the carriage of digital audio control packets and extended audio control packets, respectively.

Table 17 – Payload Identifier Definitions for 2160-line AFR Video Payload for Mapping on a Quad-link 6Gb/s (nominal) Serial Interface

<table>
<tr><th>Bits</th><th>Byte 1</th><th>Byte 2</th><th>Byte 3</th><th>Byte 4</th></tr>
<tr><td>Bit 7</td><td>1</td><td>Progressive transport (1)</td><td>Aspect Ratio
16:9 (1) or Unknown (0)</td><td rowspan="3">Link assignment
6G-SDI Link 1 (0h)
6G-SDI Link 2 (1h)
6G-SDI Link 3 (2h)
6G-SDI Link 4 (3h)</td></tr>
<tr><td>Bit 6</td><td>0</td><td>Progressive picture (1)</td><td>Sub image horizontal sampling
1920 (0) or 2048 (1)</td></tr>
<tr><td>Bit 5</td><td>1</td><td>Reserved (0)</td><td rowspan="2">Colorimetry
Rec 709*1 (0h)
Color VANC Packet (1h)
UHDTV*2 (2h)
Unknown (3h)</td></tr>
<tr><td>Bit 4</td><td>1</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 3</td><td>0</td><td rowspan="4">Picture rate
(See Table 4)</td><td rowspan="4">Sampling structure
(See Table 5)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 2</td><td>1</td><td>Audio copy status:
Audio in this data stream carries additional channels or audio not present (0)
Audio in this data stream is copied (1)</td></tr>
<tr><td>Bit 1</td><td>0</td><td rowspan="2">Bit depth
10-bit (1h)
Other values are Reserved</td></tr>
<tr><td>Bit 0</td><td>1</td></tr>
</table>

Notes:

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

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

6.9.1 Byte 1 – Digital Interface and Payload Identification

Byte 1 of the payload identifier identifies the video payload and the digital interface and shall be as defined below.

Byte 1 shall be set to [C5h] for 2160-line image formats listed in Table 10 transported via quad-link 6G-SDI.

6.9.2 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).

Bit b5 shall be set to 0 (reserved).

Bit b4 shall be set to 0 (reserved).

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 10.

6.9.3 Byte 3 – Sampling Structure, Aspect Ratio and Horizontal Size

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

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

b7 = 0 shall identify unknown aspect ratio

b7 = 1 shall identify a 16:9 aspect ratio

Bit b6 shall be used to identify the number of active Luma samples for the sub image such that:

b6 = 0 shall identify 1920 active Luma samples

b6 = 1 shall identify 2048 active Luma samples

Bits b5 and b4 shall identify the colorimetry for the image formats identified in Table 10 such that:

b5:b4 = 0h shall identify Rec 709 colorimetry

b5:b4 = 1h shall identify that the colorimetry is defined in the Color VANC packet referenced in SMPTE ST 2048-1

b5:b4 = 2h shall identify UHDTV colorimetry

b5:b4 = 3h shall identify unknown colorimetry

Bits b3 to b0 shall be used to identify the sampling structure in accordance with Table 5 and shall only use the values as permitted for image formats in Table 10.

6.9.4 Byte 4 – Link Identification, Audio Copy Status and Quantization Bit Depth

Byte 4 of the payload identifier shall be used to identify the link assignment, the audio copy status and the bit depth of the sample quantization.

Bits b7 to b5 shall be used to identify Link assignment and set to:

b7:b5 = 0h for 6G-SDI Link 1

b7:b5 = 1h for 6G-SDI Link 2

b7:b5 = 2h for 6G-SDI Link 1

b7:b5 = 3h for 6G-SDI Link 4

Bits b4 and b3 shall be set to 0h (reserved).

For data streams one through four bit b2 shall be set to 0 (reserved).

For data streams five through sixteen, bit b2 shall be used to identify whether audio data in this data stream is copied:

b2 = 0 shall identify that all audio if present in this data stream carries additional channels

b2 = 1 shall identify that audio if present in this data stream is copied

Bits b1 to b0 shall be used to identify the bit depth of the sample quantization such that:

b1:b0 = 1h shall identify quantization using 10 bits per sample

Other values shall be reserved.

6.10 Blanking

HANC and VANC space with no ancillary data packets or audio data packets shall contain data words that represent video black level for the video structure being carried.

6.10.1 Blanking Values (Informative)

In the case of 4:2:2 or 4:2:0 $Y'C'_BC'_R$ 10-bit video structure, all words in all odd numbered data streams take the value 040h. All words in all even numbered data streams take the value 200h.

6.11 Multiplex

The 160-bit virtual interface shall then be multiplexed onto four Type 1 6G-SDI 10-bit interfaces according to Section 7.

6.12 Levels of Operation (Informative)

To define the level of support for SMPTE ST 2081-12 Mode 2, manufacturers are encouraged to indicate in publications which mapping format is supported. For example:

SMPTE ST 2081-12 MODE 2 – 2160-line AFR Source image formats and ancillary data into a Quad-link 6 Gb/s [nominal] SDI bit-serial interface

Manufacturers are also encouraged to indicate in publications supported audio and video formats.

7 Quad-link 6G-SDI 10-bit Multiplex

Prior to serialization data streams one through sixteen of the 160-bit virtual interface shall be multiplexed word-by-word into four 6G-SDI 10-bit interfaces.

The first 10-bit interface shall consist of a word multiplex of data streams one through four, in the order data stream four, data stream two, data stream three, data stream one…This 10-bit interface shall then be serialized according to SMPTE ST 2081-1 to create 6G-SDI Link 1.

The second 10-bit interface shall consist of a word multiplex of data streams five through eight, in the order data stream eight, data stream six, data stream seven, data stream five… This 10-bit interface shall then be serialized according to SMPTE ST 2081-1 to create 6G-SDI Link 2.

The third 10-bit interface shall consist of a word multiplex of data streams nine through twelve, in the order data stream twelve, data stream ten, data stream eleven, data stream nine… This 10-bit interface shall then be serialized according to SMPTE ST 2081-1 to create 6G-SDI Link 3.

The fourth 10-bit interface shall consist of a word multiplex of data streams thirteen through sixteen, in the order data stream sixteen, data stream fourteen, data stream fifteen, data stream thirteen… This 10-bit interface shall then be serialized according to SMPTE ST 2081-1 to create 6G-SDI Link 4.

Each of the four 10-bit parallel interfaces so produced shall have an interface frequency of 594 MHz or 594/1.001MHz as shown in the illustrative examples of Figure 11 and Figure 12.

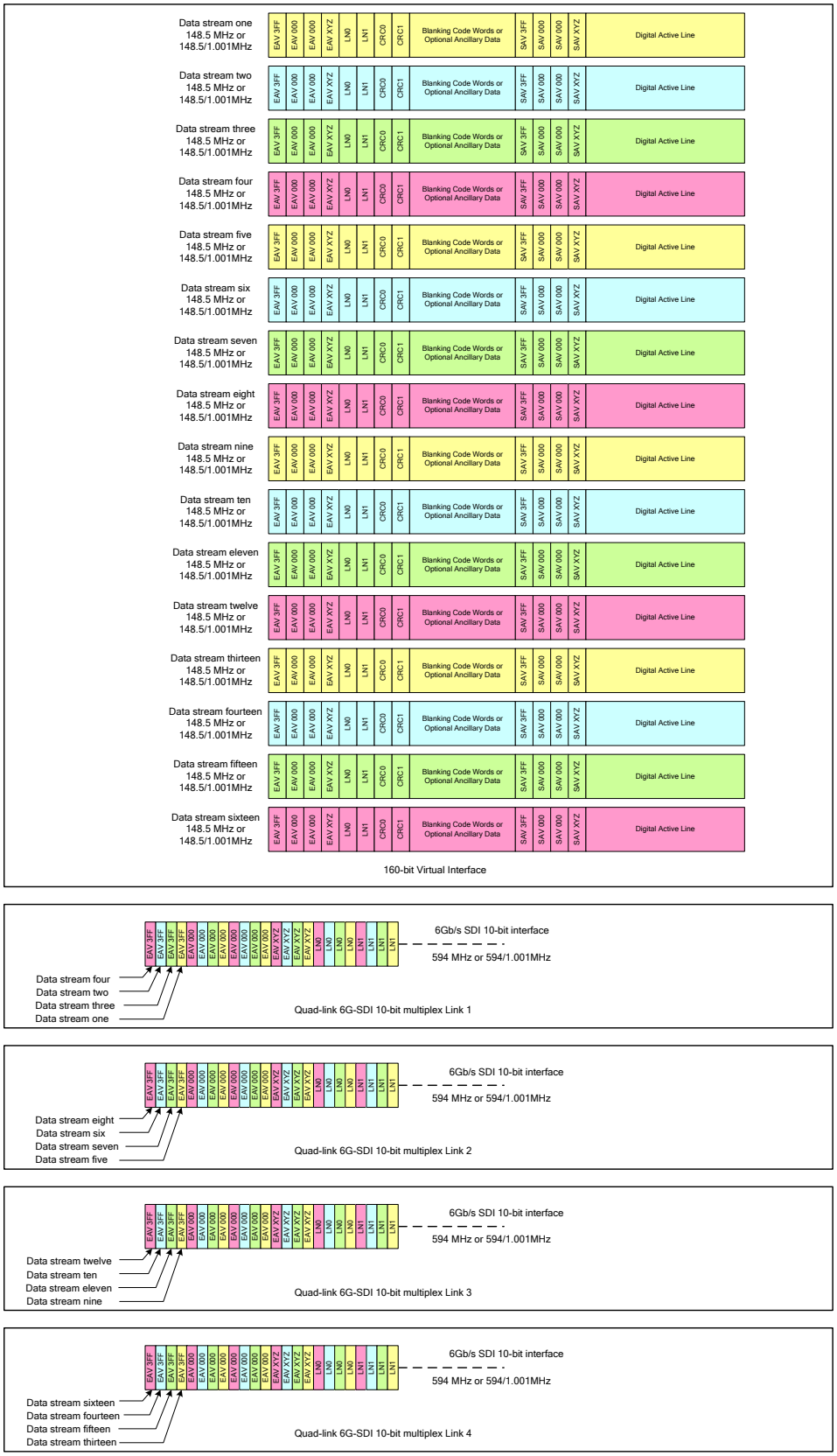


Figure 11 – Quad-link 6G-SDI 4 x 10-bit Multiplex – Type 1

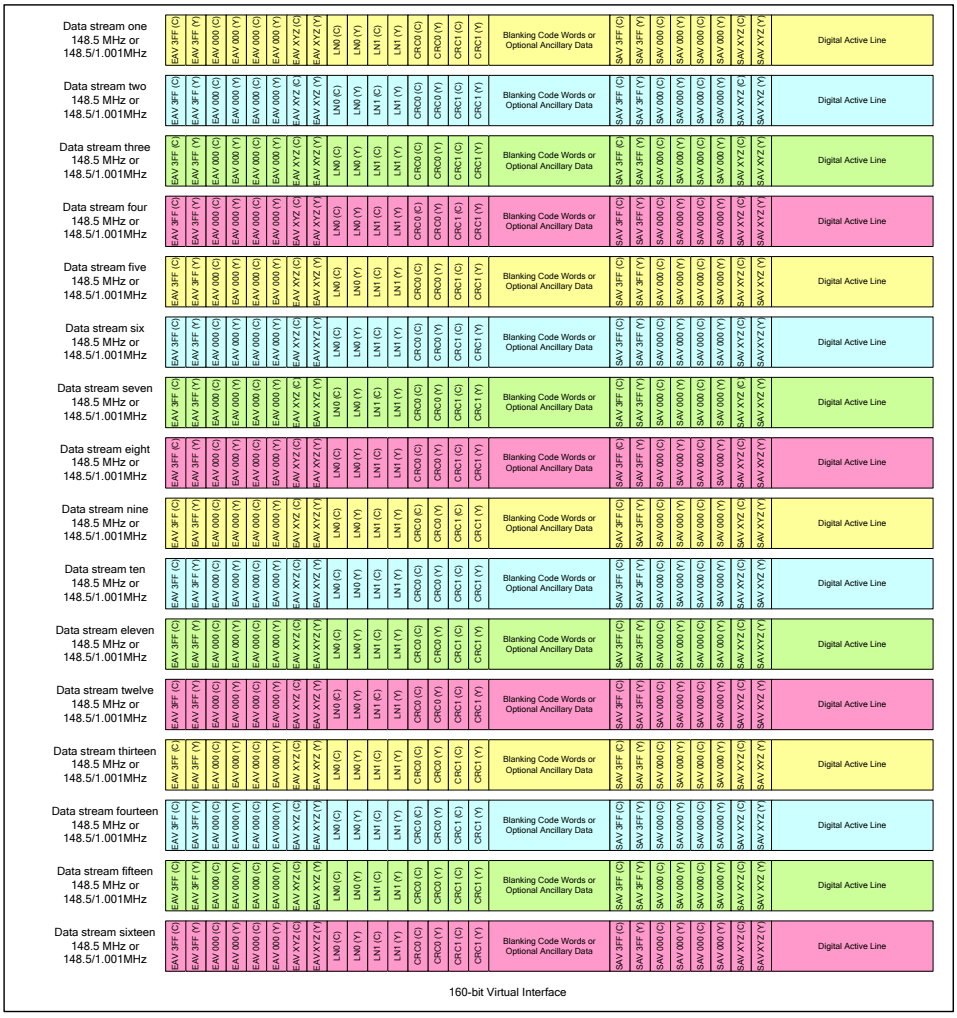


Figure 12 – Quad-link 6G-SDI 4 x 10-bit Multiplex – Type 2

8 6G-SDI Link 1 / 6G-SDI Link 2 / 6G-SDI Link 3 / 6G-SDI Link 4 Interface Timing

The timing difference between the EAV / SAV of any pair of 6G-SDI Link 1, 6G-SDI Link 2, 6G-SDI Link 3 and 6G-SDI Link 4 shall not exceed 250 ns at the serial output of source equipment. This difference should be taken into consideration when designing systems and destination equipment input stages.

Annex A Ancillary Data Capacity of the Quad-link 6G-SDI Interface (Informative)

The ancillary data space available in serial digital interface transports is approximately equivalent to horizontal interval space and vertical interval space for the video format being transported. In the case of images transported on the interface specified in this standard, it is dependent on the horizontal interval space and vertical interval space for each of the data streams being carried on the interface, multiplied by the number of data streams.

SMPTE RP 291-2 provides information on the size of the ancillary data space in a SMPTE ST 425-1 and SMPTE ST 292-1 interface.

For Mode 1 4320-line source image formats specified in this standard, the available HANC and VANC data space on the interface is 16 times the HANC and VANC data space available (as shown in the tables of SMPTE RP 291-2) on a SMPTE ST 292 interface carrying the corresponding sub-image.

For Mode 2 2160-line source image formats specified in this standard, the available HANC and VANC data space on the interface is 8 times the HANC and VANC data space available (as shown in the tables of SMPTE RP 291-2) on a SMPTE ST 425-1 interface carrying the corresponding sub-image.

For Mode 3 2160-line source image formats specified in this standard, the available HANC and VANC data space on each of the sixteen data streams of the interface is defined in Section 6.6 of this document.

SMPTE RP 291-2 also provides a method of calculating the available ancillary data space on any interface. These calculations provide the reader with the underlying formulas used to calculate the numbers in the tables, as well as providing a mechanism to calculate the space for interfaces not covered explicitly by SMPTE RP 291-2.

Annex B Bibliography (Informative)

SMPTE ST 12-1:2014, Time and Control Code

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

SMPTE RP 291-2:2013, Ancillary Data Space Use — 4:2:2 SDTV and HDTV Component Systems and 4:2:2 2048 ×1080 Production Image Formats

SMPTE ST 292-1:2012, 1.5 Gb/s Signal/Data Serial Interface

SMPTE ST 425-1:2014, Source Image Format and Ancillary Data Mapping for the 3 Gb/s Serial Interface

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

SMPTE ST 2051:2014, Two-Frame Marker for 48(/1.001)-Hz, 50-Hz and 60(/1.001)-Hz Progressive Digital Video Signals on 1.5 Gb/s and 3 Gb/s Interfaces

SMPTE ST 2081-1:2015, 6G-SDI – Signal/Data Serial Interface — Electrical

Recommendation ITU-R BT.709-5, Parameter Values for the HDTV Standards for Production and International Programme Exchange

Recommendation ITU-R BT.2020, Parameter Values for Ultra-High Definition Television Systems for Production and International Programme Exchange