

SMPTE STANDARD

4320-line and 2160-line Source Image and Ancillary Data Mapping for Dual-link 12G-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.

SMPTE ST 2082-11 Document was prepared by Technology Committee 32NF.

Intellectual Property

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

Introduction

SMPTE ST 2082-11 defines the mapping of various source images and associated ancillary data into a Dual-link 12 Gb/s [nominal] SDI bit-serial interface.

The general process for creating a dual-link 12G-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.

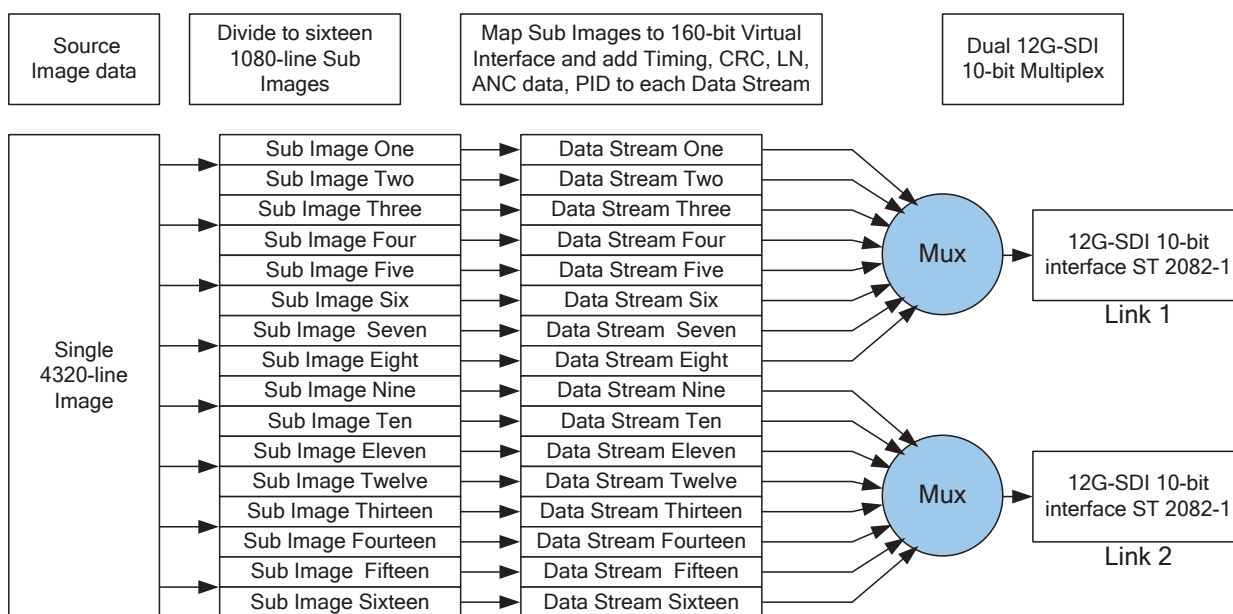


Figure 1 – Carriage of 4320-line images in a Dual-link 12G interface — generalized process as used by Mode 1

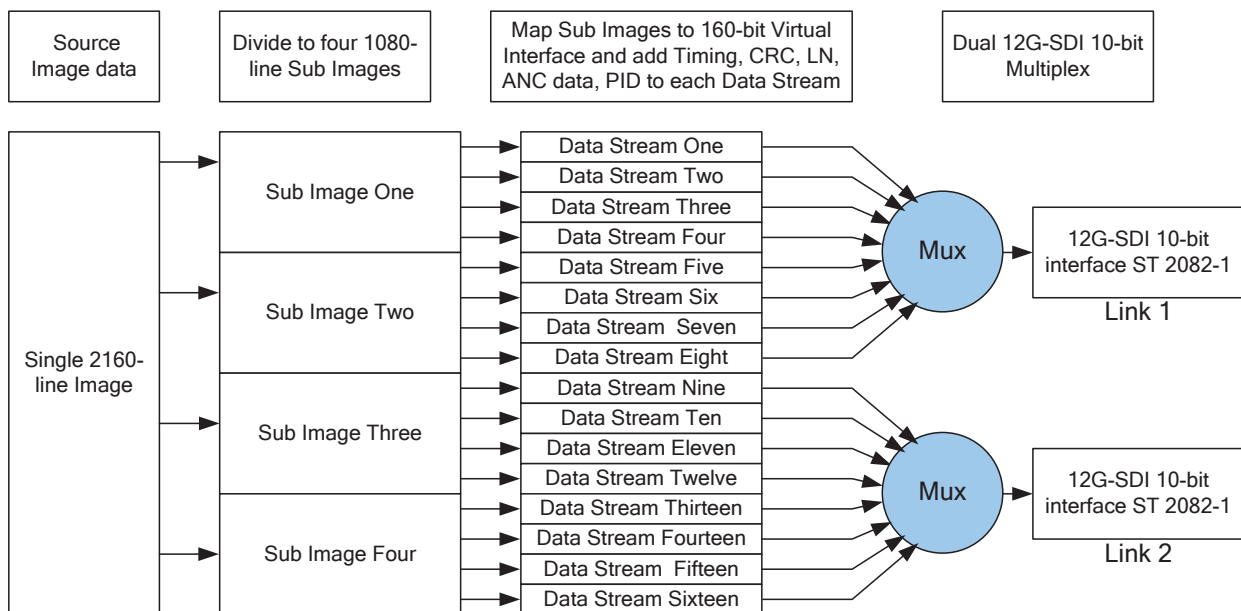


Figure 2 – Carriage of 2160-line images in a Dual-link 12G interface — generalized process as used by Mode 2 and Mode 3

Formatting

The source images are divided 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 multiplexed onto two 12G-SDI 10-bit interfaces.

The first eight data streams are multiplexed in the order data stream eight, data stream four, data stream six, data stream two, data stream seven, data stream three, data stream five, data stream one ...onto 12G-SDI Link 1.

The second eight data streams are multiplexed in the order data stream sixteen, data stream twelve, data stream fourteen, data stream ten, data stream fifteen, data stream eleven, data stream thirteen, data stream nine ...onto 12G-SDI Link 2.

1 Scope

This Standard defines the mapping of:

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

This Standard also defines the carriage of the SMPTE ST 352 payload ID's for the Dual-link 12Gb/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 _B C _R), 4:2:0 (Y'C _B C _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.

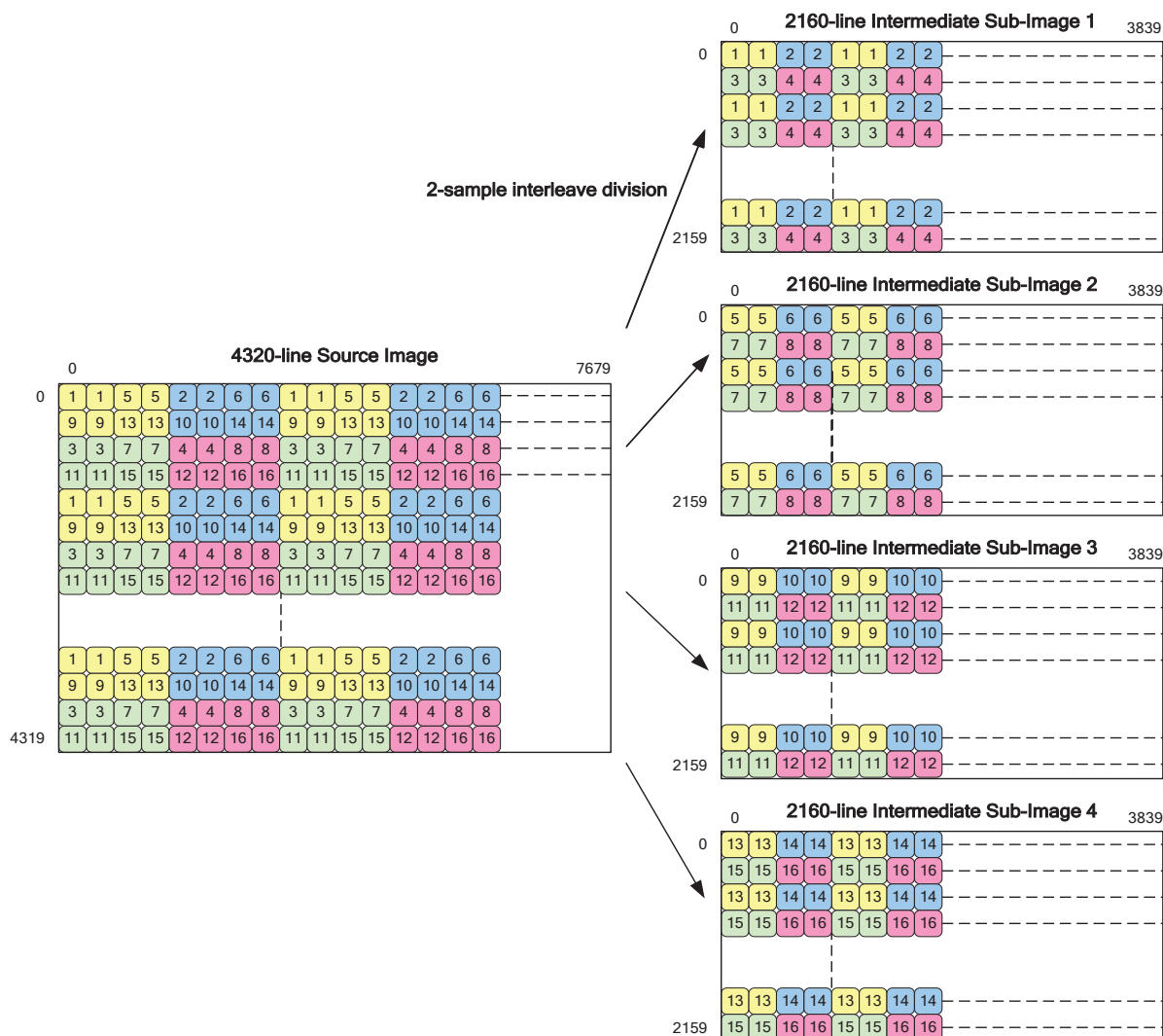


Figure 3 – Two sample division of a 4320-line image to four 2160-line intermediate sub images

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.

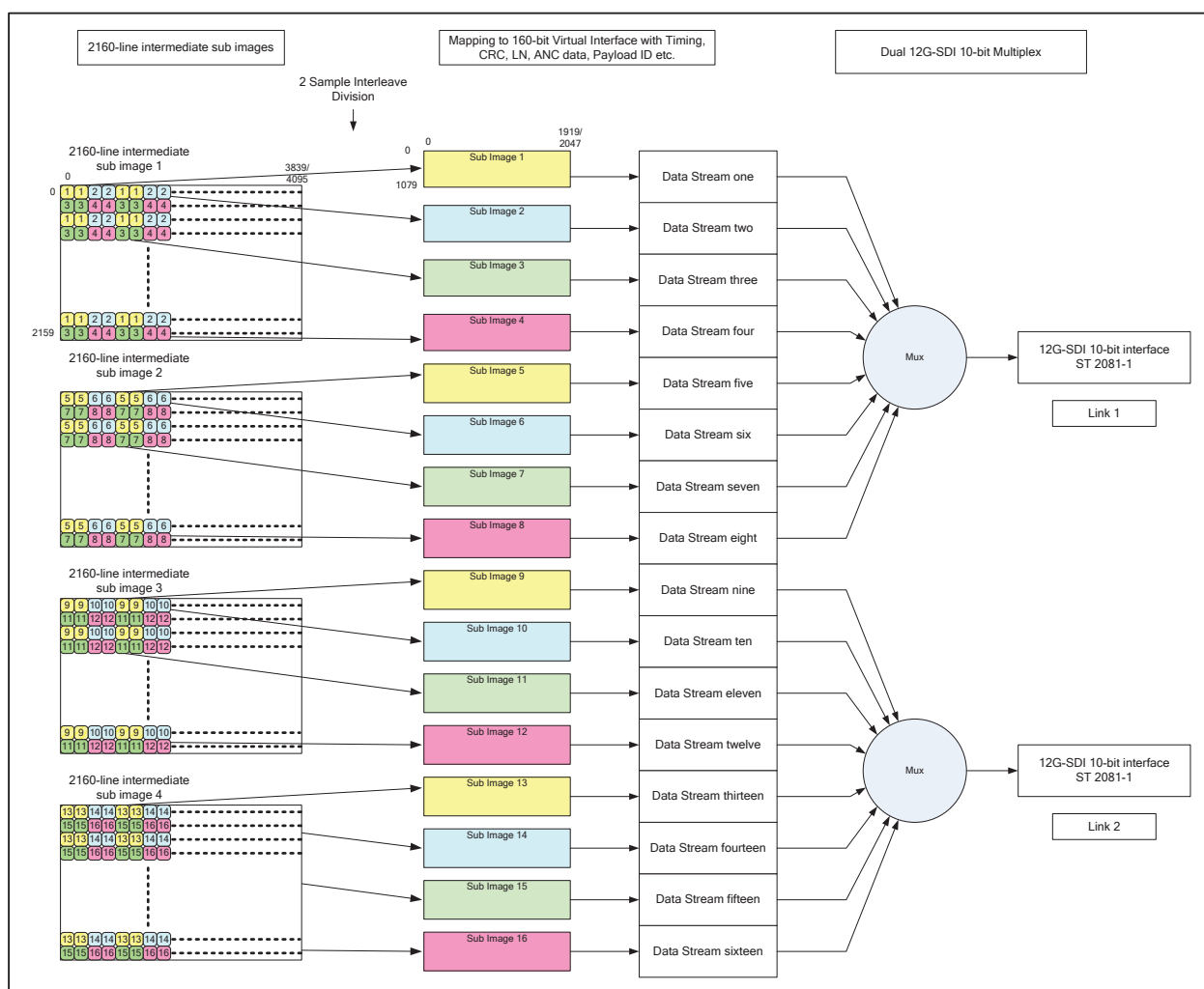


Figure 4 – 2 sample division of the four 2160-line intermediate sub images to sixteen 1080-line sub images, and mapping into a Dual-link 12G-SDI interface

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 _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 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 12G-SDI Link Multiplex Structure (Informative)

Following multiplexing onto a dual-link 12G-SDI 10-bit interface according to Section 7 the 12G-SDI data streams are conveyed in the following order:

{n} indicates the number of the sub image

12G-SDI Link 1:

Sub images 1 through 8: {8} C'_{B0}, {4} C'_{B0}, {6} C'_{B0}, {2} C'_{B0}, {7} C'_{B0}, {3} C'_{B0}, {5} C'_{B0}, {1} C'_{B0}, {8} Y'₀, {4} Y'₀, {6} Y'₀, {2} Y'₀, {7} Y'₀, {3} Y'₀, {5} Y'₀, {1} Y'₀, {8} C'_{R0}, {4} C'_{R0}, {6} C'_{R0}, {2} C'_{R0}, {7} C'_{R0}, {3} C'_{R0}, {5} C'_{R0}, {1} C'_{R0}, {8} Y'₁, {4} Y'₁, {6} Y'₁, {2} Y'₁, {7} Y'₁, {3} Y'₁, {5} Y'₁, {1} Y'₁, {8} C'_{B1}, {4} C'_{B1}, {6} C'_{B1}, {2} C'_{B1}, {7} C'_{B1}, {3} C'_{B1}, {5} C'_{B1}, {1} C'_{B1}, {8} Y'₂, {4} Y'₂, {6} Y'₂, {2} Y'₂, {7} Y'₂, {3} Y'₂, {5} Y'₂, {1} Y'₂, {8} C'_{R1}, {4} C'_{R1}, {6} C'_{R1}, {2} C'_{R1}, {7} C'_{R1}, {3} C'_{R1}, {5} C'_{R1}, {1} C'_{R1}, {8} Y'₃, {4} Y'₃, {6} Y'₃, {2} Y'₃, {7} Y'₃, {3} Y'₃, {5} Y'₃, {1} Y'₃...

12G-SDI Link 2:

Sub images 9 through 16: {16} C'_{B0}, {12} C'_{B0}, {14} C'_{B0}, {10} C'_{B0}, {15} C'_{B0}, {11} C'_{B0}, {13} C'_{B0}, {9} C'_{B0}, {16} Y'₀, {12} Y'₀, {14} Y'₀, {10} Y'₀, {15} Y'₀, {11} Y'₀, {13} Y'₀, {9} Y'₀, {16} C'_{R0}, {12} C'_{R0}, {14} C'_{R0}, {10} C'_{R0}, {15} C'_{R0}, {11} C'_{R0}, {13} C'_{R0}, {9} C'_{R0}, {16} Y'₁, {12} Y'₁, {14} Y'₁, {10} Y'₁, {15} Y'₁, {11} Y'₁, {13} Y'₁, {9} Y'₁, {16} C'_{B1}, {12} C'_{B1}, {14} C'_{B1}, {10} C'_{B1}, {15} C'_{B1}, {11} C'_{B1}, {13} C'_{B1}, {9} C'_{B1}, {16} Y'₂, {12} Y'₂, {14} Y'₂, {10} Y'₂, {15} Y'₂, {11} Y'₂, {13} Y'₂, {9} Y'₂, {16} C'_{R1}, {12} C'_{R1}, {14} C'_{R1}, {10} C'_{R1}, {15} C'_{R1}, {11} C'_{R1}, {13} C'_{R1}, {9} C'_{R1}, {16} Y'₃, {12} Y'₃, {14} Y'₃, {10} Y'₃, {15} Y'₃, {11} Y'₃, {13} Y'₃, {9} 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 Link 2 to carry a copy of

the audio on Link 1, or to facilitate audio copy from 6G-SDI Link 1 to 6G-SDI Links 2, 3 and 4 if this dual 12G-SDI signal is mapped onto quad-link 6G-SDI .

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 4.6.

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 Dual-link 12Gb/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 12G-SDI Link 1 (0h) 12G-SDI Link 2 (1h)
Bit 6	1	Progressive picture (1)	Sub image horizontal sampling 1920 (0) or 2048 (1)	
Bit 5	0	Reserved (0)	Colorimetry Rec 709* ¹ (0h) Color VANC Packet (1h) UHDTV* ² (2h) Unknown (3h)	
Bit 4	1	Reserved (0)		Reserved (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 or audio not present (0) Audio in this data stream is copied (1)
Bit 1	0			Bit depth 10-bit (1h) Other values shall be reserved
Bit 0	0			

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 [D0h] for 4320-line image formats listed in Table 1 transported via dual-link 12G-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)