SMPTE STANDARD

4096×2160 Digital Cinematography Production Image Formats FS/709 — Mapping into Multi-link 10 Gb/s Serial Signal/Data Interface

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Foreword

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SMPTE ST 2048-3 was prepared by Technology Committee 10E.

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1 Scope

This document references 4096 × 2160 Digital Cinematography Production Image Formats FS/709 — Mapping into a Multi-link 10G-SDI Mode B defined in SMPTE ST 435-2. This document also defines locations within the bit stream for Audio Data, payload ID and other ancillary data in conformance with SMPTE ST 291. The “Basic Stream” as defined in SMPTE ST 292-1 is utilized as the input source streams for the 10G-SDI.

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.

3 Normative References

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 435-1:2009) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 435-1-2009). Documents with the same root number (e.g. 435-1) and publication year (e.g. 2009) are functionally identical.

The following standards contain provisions which, 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 291:2011, Ancillary Data Packet and Space Formatting

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

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

SMPTE ST 352:2011, Payload Identification Codes for Serial Digital Interfaces

SMPTE ST 372:2011, Dual Link 1.5 Gb/s Digital Interface for 1920 × 1080 and 2048 × 1080 Picture Formats

SMPTE ST 435-1:2012, 10 Gb/s Serial Signal/Data Interface — Part 1: Basic Stream Distribution

SMPTE ST 435-2:2012, 10 Gb/s Serial Signal/Data Interface — Part 2: 10.692 Gb/s Stream — Basic Stream Data Mapping

SMPTE ST 435-3:2012, 10 Gb/s Serial Signal/Data Interface — Part 3: 10.692 Gb/s Optical Fiber Interface

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

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

4 System Overview

Input image formats shall be 4096×2160 images defined in SMPTE ST 2048-1 (2048×1080 and 4096×2160 Digital Cinematography Production Image Formats FS/709), which have 4096 maximum horizontal pixels and 2160 maximum vertical pixels as shown in Table 1. This document defines the mapping of these 4096×2160 images into Dual-link and Triple-link 10G-SDI Mode B defined with SMPTE ST 435-2 through Basic Streams that comply with the 1.5 Gb/s Signal/Data Serial Interface defined in SMPTE ST 292-1 as shown in Figure 1.

When embedding optional ancillary data, the ancillary data packet format shall be in conformance with SMPTE ST 291. Ancillary audio data shall be as defined in SMPTE ST 299-1. If Basic Stream 1 of the 10G-SDI cannot carry all the ancillary data, Basic Stream 2 of the 10G-SDI Link shall be used. Any overflow data shall be mapped to the next Basic Stream in ascending order. Audio data shall be treated in the same way.

The payload identifier shall be mapped into each Basic Stream of 10G-SDIs in conformance with SMPTE ST 352.

Table 1 – Source 4096×2160 Image Formats

System Number	Reference SMPTE Standard	Signal Format Sampling Structure/Pixel Depth	Frame Rates	Sub-Image System No. defined in SMPTE ST 435-1
8.2	SMPTE ST 2048-1	4:2:2 (Y'C'$_B$C'$_R$)/10-bit	24, 25 and 30 Frames/s Progressive	1.1
			23.98 and 29.97 Frames/s Progressive	
8.3		4:4:4 (R'G'B'[1]), 4:4:4:4 (R'G'B'[1]+A)/10-bit	24, 25 and 30 Frames/s Progressive	2.2
			23.98 and 29.97 Frames/s Progressive	
8.4		4:4:4 (Y'C'$_B$C'$_R$)/10-bit	24, 25 and 30 Frames/s Progressive	2.4
			23.98 and 29.97 Frames/s Progressive	
8.5		4:2:2 (Y'C'$_B$C'$_R$)/12-bit	24, 25 and 30 Frames/s Progressive	2.5
			23.98 and 29.97 Frames/s Progressive	
8.6		4:4:4 (R'G'B'[1])/12-bit	24, 25 and 30 Frames/s Progressive	2.3
			23.98 and 29.97 Frames/s Progressive	
16.1		4:2:2 (Y'C'$_B$C'$_R$)/10-bit	48, 50 and 60 Frames/s Progressive	2.1
			47.95 and 59.94 Frames/s Progressive	
16.2		4:4:4 (R'G'B'[1]), 4:4:4:4 (R'G'B'[1]+A)/10-bit	48, 50 and 60 Frames/s Progressive	4.2
			47.95 and 59.94 Frames/s Progressive	
16.3		4:2:2 (Y'C'$_B$C'$_R$)/12-bit	48, 50 and 60 Frames/s Progressive	4.1
			47.95 and 59.94 Frames/s Progressive	
16.4		4:4:4 (R'G'B'[1])/12-bit	48, 50 and 60 Frames/s Progressive	4.3
			47.95 and 59.94 Frames/s Progressive	

NOTES:
1. R'G'B' indicates either R'G'B' or R'$_{FS}$G'$_{FS}$B'$_{FS}$.
2. System number 8.2 through 8.6 is defined in SMPTE ST 435-1.

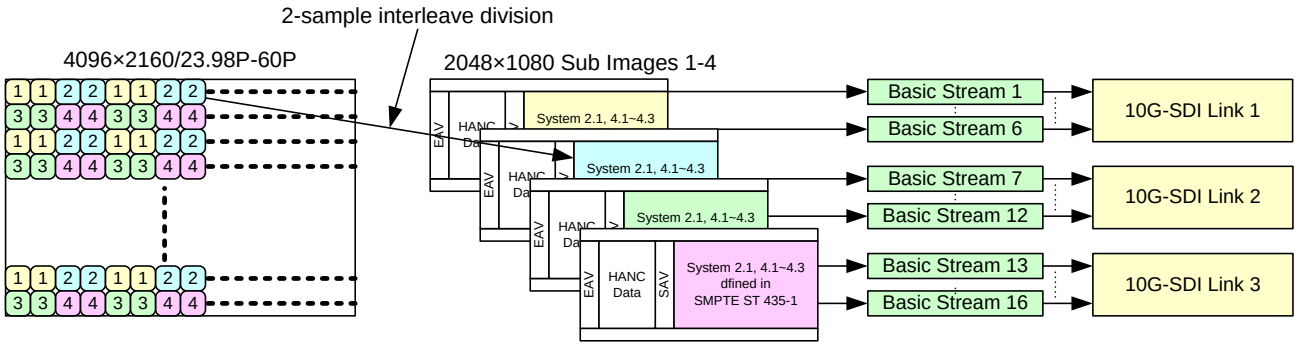

Figure 1 – 4096×2160 Image mapping overview

5 4096 × 2160/23.98P-30P Image Mapping into Dual-link 10G-SDIs

5.1 Video Payload Mapping

System Number 8.2 through 8.6 images shall be divided and mapped into the active area of Sub images 1 through 4 by 2-sample interleave division as defined by Figure 4 in SMPTE ST 435-1. Each Sub image shall have the digital sample structure as defined in Figure 1 of SMPTE ST 2048-2.

Table 5 in SMPTE ST 435-1 specifies the relation between the horizontal/vertical pixel number of the original 4096×2160 image and the sample/line number of the Sub images 1, 2, 3 and 4 (System number 1.1, 2.2~2.5 defined in SMPTE ST 435-1) by the 2-sample interleave division.

Each of Sub image data created by the 2-sample interleave division shall be System 1.1, System 2.2 through 2.5 defined in SMPTE ST 435-1. System 2.2 through 2.5 shall be divided into the dual-link streams with the same structure as the dual link 1.5 Gb/s class defined by SMPTE ST 435-1. Sub image 1 through 4 shall be divided into 8 Basic Streams as shown in Figure 2.

10G-SDI Mode B defined by SMPTE ST 435-2 can transport up to six sets of the 1.5 Gb/s-SDI or up to three sets of the dual link 1.5 Gb/s System 2.2 through 2.5 as described by SMPTE ST 435-2.

Basic Streams CH1 through CH6 in Figure 2 shall be assigned to input Basic Streams CH1 through CH6 of 10G-SDI Mode B Link 1, Basic Streams CH7 and CH8 in Figure 2 shall be assigned to input Basic Streams CH1 and CH2 of 10G-SDI Mode B Link 2. The Optical interface of Link 1 and Link 2 shall be in conformance with SMPTE ST 435-3.

System Number 8.2 can be carried with a quad link 1.5 Gb/s-SDI and shall be assigned to CH1, CH3, CH5 and CH7 in Figure 2.

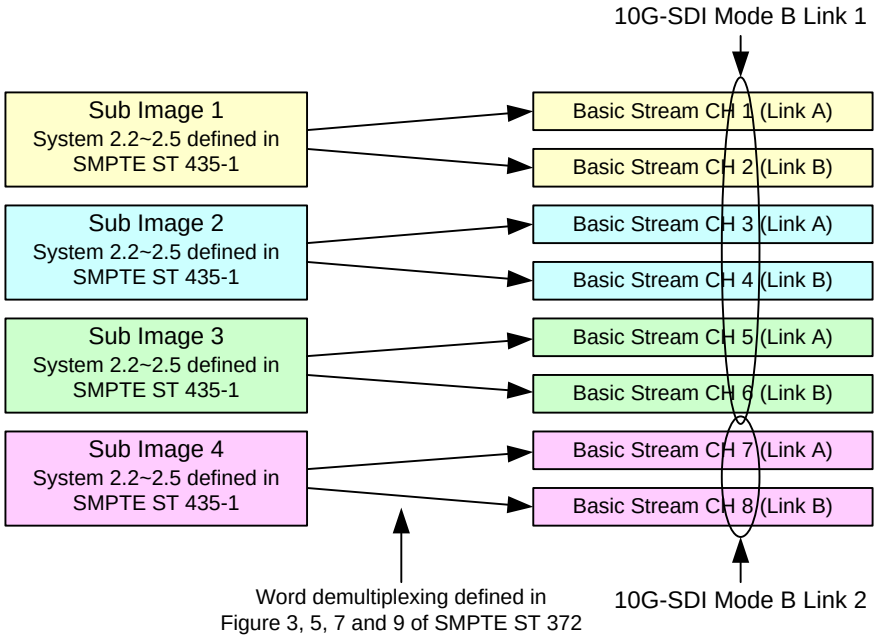

Figure 2 – 8-way division for System Number 8.2 to 8.6

5.2 ANC/Audio Data Mapping

5.2.1 ANC Data Mapping

Ancillary data if present shall be mapped into the HANC area of Basic Streams of 10G-SDI in the order CH1 Basic Stream of 10G-SDI Link 1 up to its maximum capacity, then CH2, 3, and 4 in ascending order.

If Basic Stream 1 of the 10G-SDI Link cannot carry all the ancillary data, the data overflow shall be carried in other channels in ascending order. The ancillary data format shall be in conformance with SMPTE ST 291.

In the case of 29.97P and 30P, HANC data carried through 10G-SDI Mode B is limited to CH1 and CH2.

5.2.2 Audio Data Mapping

When present, audio data shall be mapped into the C'_B/C'_R data stream of the HANC data space of CH1 Basic Stream of 10G-SDI Link 1 in conformance with SMPTE ST 299-1 If more audio data space is required, the C'_B/C'_R data stream of the HANC space of CH2 Basic Stream of the 10G-SDI Link 1, up to its maximum capacity shall be used, this same treatment shall be made to the channels in ascending order.

The maximum channel number carried by Dual-link 10G-SDI Mode B is 96 channels at a sampling frequency of 48 kHz or 48 channels at a sampling frequency of 96 kHz.

In the case of 29.97P and 30P, the maximum channel number is limited to 32 channels at a sampling frequency of 48 kHz or 16 channels at a sampling frequency of 96 kHz.

Audio control packets shall be mapped into the Y' data stream of the horizontal ancillary data space of any channel carrying audio data, and shall be in conformance with SMPTE ST 299-1.

6 4096 × 2160/47.95P-60P Image Mapping into Triple-link 10G-SDI

6.1 Video Payload Mapping

Figure 3 shows a 4 way division to Sub images 1 through 4 by the 2-sample interleave division. Even vertical pixels of System Number 16.1 through 16.4 images shall be divided and mapped into the active area of Sub images 1 and 2 as per 2 consecutive horizontal pixels and odd vertical pixels shall be divided and mapped into the active area of Sub images 3 and 4 as per 2 consecutive horizontal pixels. Each Sub image shall have the digital sample structure as defined in Figure 1 of SMPTE ST 2048-2.

Table 5 in SMPTE ST 435-1 specifies the relation between the horizontal/vertical pixel number of the original 4096 × 2160 image and the sample/line number of the mapped active area of Sub images 1, 2, 3 and 4 (system number 2.1, 4.1, 4.2 and 4.3 defined in SMPTE ST 435-1) by the 2-sample interleave division.

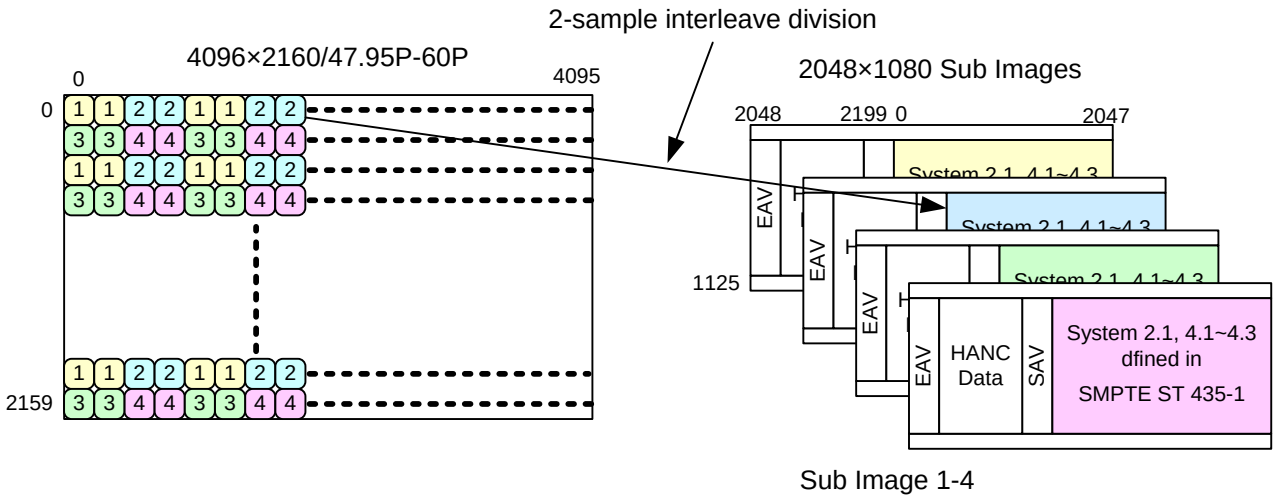

Figure 3 – 2-sample interleave division of 4096 × 2160/47.95P-60P image

Each of Sub image data created by the 2-sample interleave division shall be System 2.1, System 4.1, 4.2 or 4.3 defined in SMPTE ST 435-1. System 4.1, 4.2 or 4.3 shall be divided into the quad-link stream with the same structure as the quad link 1.5 Gb/s class defined by SMPTE ST 435-1 and shall be divided into 16 Basic Streams as shown in Figure 4.

Basic Streams CH1 through CH6 in Figure 4 shall be assigned to input Basic Streams CH1 through CH6 of 10G-SDI Mode B Link 1, Basic Streams CH7 through CH12 shall be assigned to input Basic Streams CH1 through CH6 of 10G-SDI Mode B Link 2, and Basic Streams CH13 through CH16 shall be assigned to input Basic Streams CH 1 through CH4 of 10G-SDI Mode B Link 3. Optical interface of Link 1, Link 2 and Link 3 shall be in conformance with SMPTE ST 435-3.

System Number 16.1 can be carried with an octa link 1.5 Gb/s-SDI and shall be assigned to CH1, CH3, CH5, CH7, CH9, CH11, CH13 and CH15 as shown in Figure 4.

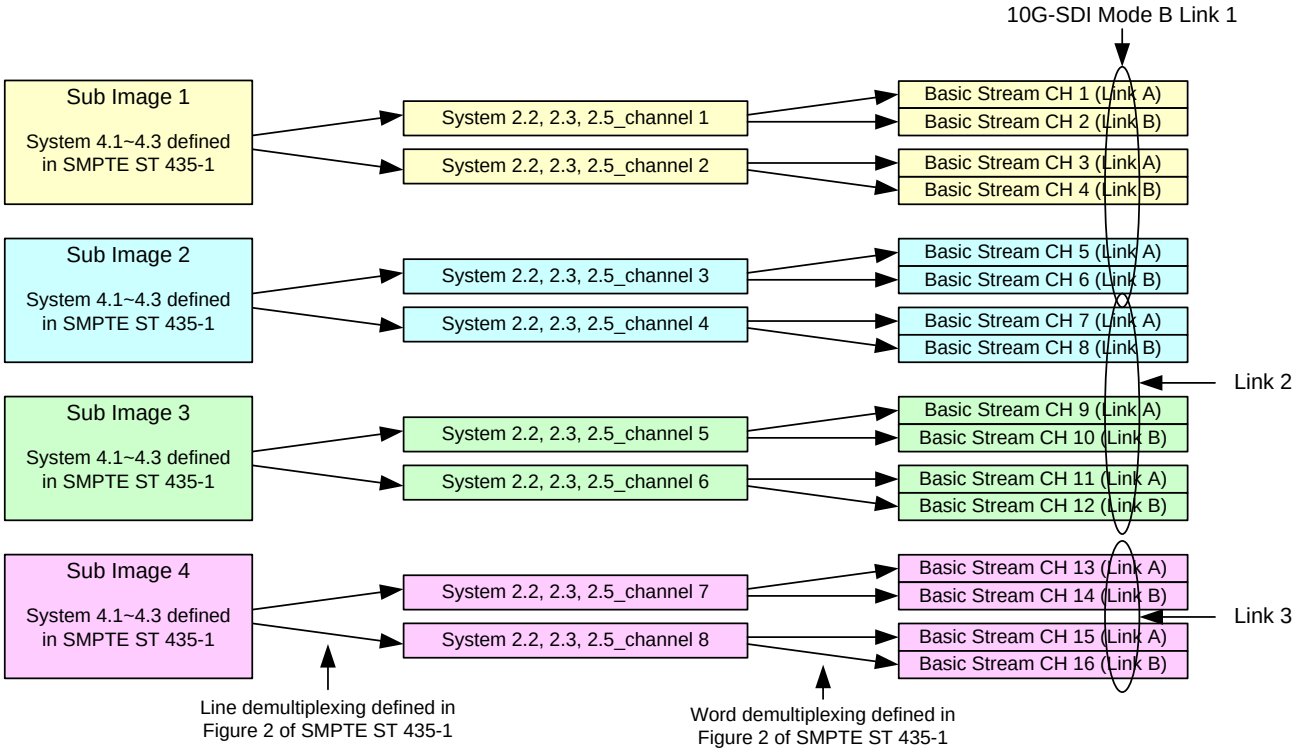

Figure 4 – 16 way division for System Number 16.1 to 16.4

6.2 ANC/Audio Data Mapping

6.2.1 ANC Data Mapping

Ancillary data if present shall be mapped into the HANC area of Basic Streams of 10G-SDI in the order of: CH1 Basic Stream Link 1 of 10G-SDI up to its maximum capacity, then CH2, CH 3, and CH4 in ascending order.

If Basic Stream link1 of 10G-SDI cannot carry all the ancillary data, the data overflow shall be carried in other channels in ascending order. The ancillary data format shall be in conformance with SMPTE ST 291.

In the case of 59.94Por 60P, H-Blank data carried through 10G-SDI Mode B is limited to CH1 and CH2.

6.2.2 Audio Data Mapping

When present, audio data shall be mapped into the C'_B/C'_R data stream of the HANC data space of CH1 Basic Stream of 10G-SDI Link 1 in conformance with SMPTE ST 299-1. If more audio data space is required, the C'_B/C'_R data stream of the HANC space of CH2 Basic Stream of the 10G-SDI Link 1, up to its maximum capacity shall be used. This same treatment shall be made to the remaining channels in ascending order.

The maximum channel number carried by Triple-link 10G-SDI Mode B is 192 channels at a sampling frequency of 48 kHz or 96 channels at a sampling frequency of 96 kHz.

In the case of 59.94P or 60P, the maximum channel number is limited to a quarter of that of 47.95P-60P frame/s signals.

Audio control packets shall be mapped into the Y' data stream of the horizontal ancillary data space of any channel carrying audio data, and shall be in conformance with SMPTE ST 299-1.

7 Payload Identifier

The payload identifier shall be mapped into each Basic Stream of 10G-SDIs in conformance with SMPTE ST 352. The definition of the 4 byte payload identifier packet shall be as defined below.

Table 2 shows the payload identifier values for the 4096 × 2160 video payload.

7.1 Payload Identifier Data Packet Specifications

The byte 1 value of $B3_h$ identifies the 4096 × 2160 video payload carried through multi-link Basic Streams. The remaining 3 bytes values shall specify the other features of the payload for 4096 × 2160 image formats.

Table 2 – Payload ID definitions for 4096 × 2160 video payloads on a Dual-link or a Triple-link 10 Gb/s (nominal) serial Signal/Data 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>Interlaced (0) or progressive (1) transport</td><td>Reserved</td><td rowspan="3">Input/Output Basic Stream channel number
Ch1 (0h), Ch2 (1h),
Ch3 (2h), Ch4 (3h),
Ch5 (4h) or Ch6 (5h),
Reserved (6h,7h)</td></tr>
<tr><td>Bit 6</td><td>0</td><td>progressive (1) picture</td><td rowspan="3">10G Link assignment
Link 1 (0h), Link 2 (1h),
Link 3 (2h),
Reserved (3h thru 7h)</td></tr>
<tr><td>Bit 5</td><td>1</td><td>Reserved</td></tr>
<tr><td>Bit 4</td><td>1</td><td>Reserved</td><td>Reserved</td></tr>
<tr><td>Bit 3</td><td>0</td><td rowspan="4">Picture rate
(see Table 2
SMPTE ST 352)</td><td rowspan="4">Sampling structure
(see Table 3 below)</td><td>Reserved</td></tr>
<tr><td>Bit 2</td><td>0</td><td>Reserved</td></tr>
<tr><td>Bit 1</td><td>1</td><td rowspan="2">Bit depth
10-bit (1h), 12-bit (2h),
Reserved (0h,3h)</td></tr>
<tr><td>Bit 0</td><td>1</td></tr>
</table>

Table 3 – Sampling Structure

Value	Sampling	Value	Sampling	Value	Sampling	Value	Sampling
0h	4:2:2 (Y'/C'$_B$/C'$_R$)	1h	4:4:4 (Y'/C'$_B$/C'$_R$)	2h	4:4:4 (G'/B'/R')	3h	4:2:0
4h	4:2:2:4 (Y'/C'$_B$/C'$_R$/A)	5h	4:4:4:4 (Y'/C'$_B$/C'$_R$/A)	6h	4:4:4:4 (G'/B'/R'/A)	7h	SMPTE ST 2048-2 FS[1]
8h	4:2:2:4 (Y'/C'$_B$/C'$_R$/D)	9h	4:4:4:4 (Y'/C'$_B$/C'$_R$/D)	Ah	4:4:4:4 (G'/B'/R'/D)	Bh	Reserved
Ch	Reserved	Dh	Reserved	Eh	4:4:4 (*X'Y'Z'*)	Fh	Reserved

[1] An additional Color VANC packet to describe the FS characteristics is defined by SMPTE ST 2048-1.

When identifying 4096 × 2160 video payloads mapped onto a Dual-link or a Triple-link 10 Gb/s serial Signal/Data interface, each bit of Table 2 shall be defined as follows:

- The interlace/progressive transport flag bit shall be set to 0 or 1 according to the digital interface transport;
- The interlaced/progressive picture flag bit shall be set to 1;
- The picture rate shall be set to the value of the 4096 × 2160 video payload;
- The sampling structure shall be set to the value of the payload being carried. The value of 7h shall be assigned when the Color VANC packet defined in SMPTE ST 2048-1 is carried;
- The assignment order of the Basic Stream channels and the 10G links for the payload IDs shall correspond to the 10 Gb/s SDI input channel and link numbers as defined in §5.1 and §6.1

  The 10G-SDI link number in bit b4, b5 and b6 of byte 3 shall be set to the following values in the case of a Dual-link and a Triple-Link:

  - 0h shall identify Link 1;
  - 1h shall identify Link 2;
  - 2h shall identify Link 3;
  - 3h thru 7h shall be reserved;

  The input/output Basic Stream channel number of each 10G-SDI link in bit b5, b6 and b7 of byte 4 shall be set to the following values:

  - 0h shall identify CH1;
  - 1h shall identify CH2;
  - 2h shall identify CH3;
  - 3h shall identify CH4;
  - 4h shall identify CH5;
  - 5h shall identify CH6;
  - 6h and 7h shall be reserved;

- The bit depth of the sample shall be identified by bits b1 and b0 of byte 4 having the following values:
  - 1h shall identify quantization using 10 bits per sample;
  - 2h shall identify quantization using 12 bits per sample.
  - 0h and 3h shall be reserved.

7.2 Placement of Payload Identifier

The recommended placement of the payload identifier for each Basic Stream of 10G-SDIs shall be immediately after the SAV in the lines defined in SMPTE ST 292-1.