

SMPTE STANDARD

**Source Image Format and
Ancillary Data Mapping for the
3 Gb/s Serial Interface**



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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 425-1 was prepared by Technology Committee 32NF.

Intellectual Property

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

Introduction

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

SMPTE ST 292-1 was originally developed to provide a serial digital connection between HDTV equipment operating largely with 10-bit Y'C_BC_R 4:2:2 signals to a maximum frame rate of 30 frames per second. Over time, SMPTE ST 292-1 applications were expanded to include larger picture formats, higher refresh rates and to provide support for R'G'B' and 12-bit source signal formats and the carriage of packetized data.

The total data rate required to support these additional applications is 2.970 Gb/s or 2.970/1.001 Gb/s and the digital interface used to carry these payloads has been realized using a dual-link structure as defined in SMPTE ST 372.

This standard defines the mapping of various source image formats onto a single link serial digital interface operating at a nominal rate of 3 Gb/s.

1 Scope

This standard defines three mapping formats: Level A, Level B Dual-Link mapping and Level B Dual-Stream mapping as described below;

Level A specifies:

The direct mapping of various uncompressed video image formats as defined in Table 1;

The direct mapping of packetized data;

The carriage of ancillary data such as the audio data, the audio control packets, the payload ID, the time code, etc.; into a serial digital interface operating at a nominal rate of 3 Gb/s.

Level B Dual-Link mapping specifies:

The mapping of the SMPTE ST 372 Dual Link interface (Dual-Link mapping) as defined in Table 13 into a serial digital interface operating at a nominal rate of 3 Gb/s.

Level B Dual-Stream mapping specifies:

The mapping of 2 x SMPTE ST 292-1 (HD-SDI) interfaces (Dual-Stream mapping) as defined in Table 14 into a serial digital interface operating at a nominal rate of 3 Gb/s.

Informative Annex A provides further details on the differences between Level A and Level B mapping.

Uncompressed video image formats or packetized data, and all applicable ancillary data such as the audio data, the audio control packets, the payload ID, the time code, etc. are mapped into SMPTE ST 372 Dual Link and 2 x SMPTE ST 292-1 interfaces prior to mapping into the virtual interfaces.

It is not necessary for implementations to include support for all formats defined in Table 1, Table 13 and Table 14 to conform to this standard. Implementers are encouraged to 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

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 RP 2077:2013, Full Range Image Mapping

SMPTE ST 12-2:2014, Transmission of Time Code 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 291-1:2011, Ancillary Data Packet and Space Formatting

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

SMPTE ST 296:2012, Television — 1280 x 720 Progressive Image 4:2:2 and 4:4:4 Sample Structure — Analog and Digital Representation and Analog Interface

SMPTE ST 299-1:2009, 24-Bit Digital Audio Format for SMPTE ST 292-1 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 372:2017, Dual Link 1.5 Gb/s Digital Interface for 1920 x 1080 and 2048 × 1080 Picture Formats

SMPTE ST 428-9:2008, D-Cinema Distribution Master — Image Pixel Structure Level 3 — Serial Digital Interface Signal Formatting

SMPTE ST 428-19:2010, D-Cinema Distribution Master — Additional Frame Rates Level AFR2 and Level AFR4 — Serial Digital Interface Signal Formatting

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

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

4 Level A — Direct Mapping of Source Image Formats

For this interface, the source data shall be an uncompressed 10-bit or 12-bit video signal corresponding to the source image formats identified in Table 1.

Note that this interface might carry packetized data as defined by other application documents providing the constraints defined in this standard and that of the source image formats are observed.

An auxiliary component signal designated A or Alpha may optionally accompany the R'G'B', R'_{FS}G'_{FS}B'_{FS} (hereafter R'G'B' indicates both R'G'B' and R'_{FS}G'_{FS}B'_{FS}) or Y'C_BC_R or IC_{TCP} video signal. If present it shall have the same characteristics as the Y' or G' or I channel as defined for the source image formatting interface. Interfaces containing the auxiliary component are denoted as R'G'B'+A, Y'C_BC_R+A and IC_{TCP}+A.

Table 1 – Source Image Formats

Mapping Structure	Reference Standard	Image Format	Signal Format Sampling Structure/Pixel Depth	Frame/Field Rates	Transport
1	ST 274 Recommendation ITU-R BT.2100	1920 × 1080	4:2:2 (Y'C _B C _R)/10-bit 4:2:2 (IC _T CP)/10-bit	60, 60/1.001 and 50 Frames Progressive	Progressive
	ST 2048-2	2048 x 1080 ^{*6}	4:2:2 (Y'C _B C _R)/10-bit	60, 60/1.001, 50, 48 and 48/1.001 Frames Progressive	Progressive
2	ST 296	1280 x 720	4:4:4 (R'G'B'), 4:4:4:4 (R'G'B' +A)/10-bit ^{*4}	60, 60/1.001 and 50 Frames Progressive	Progressive
			4:4:4 (Y'C _B C _R), 4:4:4:4 (Y'C _B C _R +A)/10-bit ^{*4}	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive
	ST 274	1920 x 1080	4:4:4 (R'G'B'), 4:4:4:4 (R'G'B' +A)/10-bit ^{*4} 4:4:4 (Y'C _B C _R), 4:4:4:4 (Y'C _B C _R +A)/10-bit ^{*4}	60, 60/1.001 and 50 Fields Interlaced	Interlaced
	ST 274 Recommendation ITU-R BT.2100		4:4:4 (R'G'B'), 4:4:4:4 (R'G'B'+A)/10-bit ^{*4}	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive
			4:4:4 (Y'C _B C _R), 4:4:4:4 (Y'C _B C _R +A)/10-bit ^{*4} 4:4:4 (IC _T CP) 4:4:4:4 (IC _T CP+A)/10-bit ^{*4}	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	P _S F ^{*1}
	ST 2048-2	2048 x 1080 ^{*6}	4:4:4 (R'G'B') ^{*7} , 4:4:4:4 (R'G'B' +A)/10-bit ^{*4}	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive
			4:4:4 (Y'C _B C _R), 4:4:4:4 (Y'C _B C _R +A)/10-bit ^{*4}	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	P _S F ^{*1}
3	ST 274	1920 x 1080	4:4:4 (R'G'B')/12-bit 4:4:4 (Y'C _B C _R)/12-bit	60, 60/1.001 and 50 Fields Interlaced	Interlaced
	ST 274		4:4:4 (R'G'B')/12-bit 4:4:4 (Y'C _B C _R)/12-bit	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive

4	Recommendation ITU-R BT.2100		4:4:4 (IC _{TCP})/12-bit		
	ST 2048-2	2048 x 1080 ⁶	4:4:4 (R'G'B') ^{*7} /12-bit	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive
			4:4:4 (Y'C _B C _R)/12-bit	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	P _s F ^{*1}
	ST 428-9	2048 x 1080 ⁵	4:4:4 (X'Y'Z')/12-bit	24 Frames Progressive	Progressive
				24 Frames Progressive	P _s F ^{*2}
	ST 428-19	2048 x 1080 ⁵	4:4:4 (X'Y'Z')/12-bit	25 and 30 Frames Progressive	Progressive
				25 and 30 Frames Progressive	P _s F ^{*3}
	ST 274	1920 x 1080	4:2:2 (Y'C _B C _R)/12-bit	60, 60/1.001 and 50 Fields Interlaced	Interlaced
4	ST 274 Recommendation ITU-R BT.2100		4:2:2 (Y'C _B C _R)/12-bit 4:2:2 (IC _{TCP})/12-bit	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive 30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive P _s F ^{*1}
	ST 2048-2	2048 x 1080 ⁶	4:2:2 (Y'C _B C _R)/12-bit	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive
			4:2:2:4 (Y'C _B C _R +A)/12-bit ^{*8}	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	P _s F ^{*1}

NOTE: In accordance with Recommendation ITU-R BT.2100, IC_{TCP} sampling is only applied to High Dynamic Range (HDR) progressive image formats.

*1 PsF structure as defined in SMPTE ST 274.

*2 PsF structure as defined in SMPTE ST 428-9.

*3 PsF structure as defined in SMPTE ST 428-19.

*4 Definition of the A channel is application dependent for mapping of these 10-bit signal structures:

- when used for non-picture data, the payload is constrained to 8-bit maximum, B8 is even parity for B7 through B0, and B9 is the complement of B8.
- when used for picture data, code words 000h to 003h and 3FCh to 3FFh are used exclusively for synchronization.

*5 This is the image container size, the active image does not always fill the container.

*6 This is the maximum pixel array, the active image does not always fill the maximum array.

*7 In this image format R'G'B' indicates either R'G'B' or R'_{FS}G'_{FS}B'_{FS}.

*8 Definition of the A channel is application dependent for mapping of this 12-bit signal structure:

- when the A channel is used for non-picture data, the payload is constrained to 8-bit words maximum, B10 is even parity for data word B9 through B2, B11 is the complement of B10, and B1 through B0 are zero.
- when used for picture data, the raster format and frame rate are the same as the Y' signal carried on the virtual interface.

4.1 20-Bit Virtual Interface

R', G', B',/ Y', C_B, C_R,/ X', Y', Z' / IC_{TCP} and A components shall be mapped into a virtual interface consisting of two parallel 10-bit data streams – data stream one and data stream two, as shown in Figures 1 through 4.

Each data stream shall have an interface frequency of 148.5 MHz or 148.5/1.001 MHz.

Mapping of the data created by the signal format, sampling structure and pixel depth shall be in accordance with § 4.2.1 through § 4.2.4 of this standard.

4.1.1 Timing Reference Signals

EAV (End of Active Video) and SAV (Start of Active Video) timing references shall be inserted into data stream one and data stream two of the virtual interface on a line-by-line basis as shown in Figures 1 through 4.

The EAV and SAV sequence, F (field/ frame), V (vertical), H (horizontal) and parity bits P3 through P1 shall be as defined in the source image formatting document.

Mapping of the timing reference signals into the virtual interface shall be in accordance with § 4.2.1 through § 4.2.4 of this standard.

4.1.2 Line Numbers

Line numbers shall be inserted into data stream one and data stream two of the virtual interface starting at the first data word (of the virtual interface) following the EAV XYZ word, as shown in Figures 1 through 4.

For Progressive and Interlaced structures, the interface line numbers shall be in accordance with the picture source line numbers as defined in the source image formatting document. The exception to this rule applies to the image formats of SMPTE ST 428-9 and SMPTE ST 428-19, for which the interface line numbers shall be in accordance with the container frame structure.

Line number data are composed of two words, LN0 and LN1, and shall be as shown in Table 2.

Table 2 – Line Number Data

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

4.1.3 Line CRC Codes

CRC (Cyclic Redundancy Check) codes shall be inserted into data stream one and data stream two of the virtual interface starting at the first data word (of the virtual interface) following the final word of the line number – LN1, as shown in Figures 1 through 4.

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:

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

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 data stream one and data stream two of the virtual interface.

The two words of the CRC code shall be as shown in Table 3.

Table 3 – 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

4.1.4 Vertical Ancillary Data Space (VANC) and Horizontal Ancillary Data Space (HANC)

Ancillary data in VANC or HANC, if present, shall be mapped into the corresponding blanking areas of both data stream one and data stream two of the virtual interface and shall be in conformance with SMPTE ST 291-1.

Unless otherwise stated, the ancillary data in VANC or HANC shall be mapped into data stream one first. Data space requirements and locations for each data service are defined by their respective application documents. When the successive concatenation of ancillary data packets into a particular data space in HANC or VANC leaves an insufficient number of samples for insertion of the next ancillary packet, the ancillary data for that service should be inserted into data stream two.

The ancillary data 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 as follows:

64 for 10-bit RGBYI signals
 512 for 10-bit $C_B C_R C_T C_P$ signals.
 512 for Full-Range 10-bit $C_B C_R C_T C_P$ signals.

256 for 12-bit RGBYI signals
 2048 for 12-bit $C_B C_R C_T C_P$ signals.
 2048 for Full-Range 12-bit $C_B C_R C_T C_P$ signals.

4 for 10-bit Full Range RGBYI signals
 0 for 12-bit Full Range RGBYI signals.

4.1.5 Audio Data

When present, audio data shall be mapped into the horizontal ancillary data space of data stream one and data stream two of the virtual interface.

Audio control packets and extended audio control packets shall be mapped into the horizontal ancillary data space of data stream one of the virtual interface.

Audio data packets and extended audio data packets shall be mapped into the horizontal ancillary data space of data stream two of the virtual interface.

The formatting and location of the audio data and control packets and extended audio data and control packets shall be in conformance with SMPTE ST 299-1 and SMPTE ST 299-2, respectively.

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 original interface clock frequency as defined by the source image format document.

Note: The virtual interface of this standard can operate at twice the clock rate of the source image format interface.

4.1.5.1 Number of Audio Channels

Up to 32 audio channels sampled at 32 kHz, 44.1 kHz, or 48 kHz may be mapped into the horizontal ancillary data space of data stream one and data stream two of the virtual interface. At 96-kHz sampling, 16 audio channels may be mapped.

Note: The maximum number of audio channels that can be mapped into the available horizontal ancillary data space varies in accordance with the video format and the video frame rate. Table 4 below illustrates the number of audio channels that can be supported in each case. Reference should be made to Annex B for a derivation of these audio channel number limits.

Table 4 – Number of audio channels supported for each image format frame rate and audio sampling rate (Informative)

Image Format	Frame/Field Rates	Maximum number of audio channels at 32-kHz, 44.1-kHz or 48-kHz sampling	Maximum number of audio channels at 96-kHz sampling
1920 × 1080	60, 60/1.001 and 50 Frames Progressive	Up to 32 channels	Up to 16 channels
	60, 60/1.001 and 50 Fields Interlaced		
	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive		
SMPTE ST 2048-2 2048 x 1080	60, 60/1.001, 30 and 30/1.001, Frames Progressive, 30 and 30/1.001 PsF	Up to 16 channels	Up to 8 channels
	50, 48, 48/1.001, 25, 24 and 24/1.001 Frames Progressive, 25, 24 and 24/1.001 PsF	Up to 32 channels	Up to 16 channels
SMPTE ST 428-9 2048 x 1080	24 Frames Progressive and 24 Frames PsF	Up to 32 channels	Up to 16 channels
SMPTE ST 428-19 2048 x 1080	30 Frames Progressive and 30 Frames PsF	Up to 16 channels	Up to 8 channels
	25 Frames Progressive and 25 Frames PsF	Up to 32 channels	Up to 16 channels
1280 x 720	60, 60/1.001 and 50 Frames Progressive	Up to 32 channels	Up to 16 channels
	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive		

When the number of audio channels at up to 48-kHz sampling rate is less than or equal to 16, audio control packets mapped into data stream 1 and audio data packets mapped into data stream 2 shall use the DID's for audio groups 1 to 4, as defined in SMPTE ST 299-1.

4.1.6 Payload Identifier

The payload identifier shall be mapped into the horizontal ancillary data space of data stream one and data stream two of the virtual interface and shall be in conformance with SMPTE ST 352.

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 750-line and 1125-line systems.

Note: The line numbers defined in SMPTE ST 352 for the placement of the payload identifier packet in 750-line and 1125-line interfaces 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.

4.1.6.1 Byte 1: Video Payload and Digital Interface Identification

The first byte of the payload identifier is used to identify the combination of video payload format and digital interface transport.

For 750-line video digital transport interfaces on the 3 Gb/s video payload, Byte 1 of the payload identifier shall be b7-b0 = 88h.

For 1125-line video digital transport interfaces on the 3 Gb/s video payload, Byte 1 of the payload identifier shall be b7-b0 = 89h.

4.1.6.2 Bytes 2 through 4: Picture Rate, Sampling Structure and Bit Depth, etc

Bytes 2 through 4 of the payload identifier shall be set in accordance with the picture rate, sampling structure and bit-depth etc of the image format being carried on the interface as shown in Tables 5 and 5a.

Table 5 – Payload Identifier Definitions, Bytes 2 to 4

Bits	Byte 2	Byte 3	Byte 4
Bit 7	Interlaced (0) or Progressive (1) transport	Aspect ratio 16:9 (1), unknown (0)	Reserved
Bit 6	Interlaced (0) or Progressive (1) picture	Horizontal Pixel Array Size 1920 (0) or 2048 (1)	Reserved
Bit 5	Transfer characteristics	Colorimetry	Reserved
Bit 4	SDR-TV (0h) HLG (1h) PQ (2h) Unspecified (3h)	Rec 709*1 (0h) Reserved (1h) UHDTV*2 (2h) Unknown (3h)	Luminance and color difference signal Y'C'B'C'R (0) IC _T CP (1)
Bit 3	Picture Rate (Refer to SMPTE ST 352 Table 2)	Sampling structure (Refer to Table 5a)	Reserved
Bit 2			Reserved
Bit 1			Bit depth 10-bit Full Range (0h), 10-bit (1h), 12-bit (2h), 12-bit Full Range (3h)
Bit 0			
*1 Rec 709 indicates Conventional System Colorimetry as defined in Recommendation ITU-R BT.709 and referenced in SMPTE ST 274.			
*2 UHDTV indicates Recommendation ITU-R BT2020 Reference Primaries and reference white as referenced in Recommendation ITU-R BT.2100			

Reserved bits shall be set to 0.

Note: Reserved status is an indication that SMPTE could in the future define a use for these bits. To ensure interoperability and future compatibility, it is recommended that decoders designed to conform to this revision of SMPTE ST 425-1 ignore reserved bits.

4.1.6.2.1 Byte 2: Picture rate and scanning method

The second byte shall be used to identify the picture rate and the picture and transport scanning methods.

Bit b7 shall be used to identify whether the digital interface uses a progressive or interlaced transport structure such that:

- b7 = 0 identifies an interlaced transport
- b7 = 1 identifies a progressive transport

Bit b6 shall be used to identify whether the image has a progressive or interlaced structure such that:

- b6 = 0 identifies an interlaced structure
- b6 = 1 identifies a progressive structure

PsF video payloads are identified by a progressive structure carried on an interlaced transport.

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

- b5:b4 = 0h identifies SDR-TV in accordance with Recommendation ITU-R BT.709 as referenced by SMPTE ST 274 and ST 296.
- b5:b4 = 1h identifies HLG HDR-TV in accordance with Recommendation ITU-R BT.2100
- b5:b4 = 2h identifies PQ HDR-TV in accordance with Recommendation ITU-R BT.2100
- b5:b4 = 3h identifies Unspecified Transfer Characteristics.

In the case where Bits b3 to b0 of byte 3 indicates 'SMPTE ST 2048-2 FS', if the Transfer Characteristic signaled in the Color VANC packet referenced in SMPTE ST 2048-2 is active, then it takes precedence over the Transfer Characteristic signaled in b5,b4.

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

Bits b3 to b0 shall be used to identify the picture rate in Hz in accordance with the default assignment of picture rate values defined in SMPTE ST 352.

4.1.6.2.2 Byte 3: Sampling structure identification

The third byte 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 image aspect ratio such that:

- b7 = 0 indicates unknown aspect ratio
- b7 = 1 indicates a 16:9 aspect ratio.

For SMPTE ST 428-9 and SMPTE ST 428-19 the image aspect ratio shall be set to "unknown."

Bit b6 shall be used to identify the horizontal pixel array size such that:

b6 = 0 indicates 1920 samples
b6 = 1 indicates 2048 samples

For 750-line formats, b6 of Byte 3 shall be reserved.

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

b5:b4 = 0h identifies Rec 709 colorimetry in accordance with Recommendation ITU-R BT.709 as referenced by SMPTE ST 274 and ST 296

b5:b4 = 2h identifies UHDTV colorimetry in accordance with the Reference Primaries and reference white as defined in Recommendation ITU-R BT.2100

b5:b4 = 3h identifies unknown colorimetry

Other values are reserved

In the case where Bits b3 to b0 of byte 3 indicates 'SMPTE ST 2048-2 FS', if the colorimetry signaled in the Color VANC packet referenced in SMPTE ST 2048-2 is active, then it takes precedence over the colorimetry signaled in b7,b4 / b5,b4.

Bits b3 to b0 of byte 3 shall be used to identify the horizontal sampling structure in accordance with Table 5a.

Table 5a – Default assignment of sampling structure values

Value	Sampling	Value	Sampling	Value	Sampling	Value	Sampling
0h	4:2:2 (Y'C _B C _R) or (IC _{TCp})	1h	4:4:4 (Y'C _B C _R) or (IC _{TCp})	2h	4:4:4 (R'G'B')	3h	4:2:0 (Y'C _B C _R) or (IC _{TCp})
4h	4:2:2:4 (Y'C _B C _R +A) or (IC _{TCp} +A)	5h	4:4:4:4 (Y'C _B C _R +A) or (IC _{TCp} +A)	6h	4:4:4:4 (R'G'B'+A)	7h	SMPTE 2048-2 FS ^{*1}
8h	4:2:2:4 (Y'C _B C _R +D) (Y'C _B C _R) or (IC _{TCp} +D)	9h	4:4:4:4 (Y'C _B C _R +D) (Y'C _B C _R) or (IC _{TCp} +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
<p>Note 1: The term 4:4:4 identifies the ratio of component sampling independently of the resolution. These values apply to all picture sampling definitions including high definition pictures.</p> <p>Note 2: In the 4:2:2:4 and 4:4:4:4 fields, the A nomenclature refers to a picture channel, whereas the D nomenclature refers to a non-picture (i.e., data) channel.</p> <p>^{*1}Indicates 4:4:4 R_{FS} G_{FS} B_{FS} Sampling when the Color VANC packet referenced in SMPTE ST 2048-2 is present</p>							

4.1.6.2.3 Byte 4: Special options

Byte 4 shall be used to identify extended aspects of the video payload.

Bits b7 to b5 shall be reserved and set to 0

Bit b4 shall be used to indicate the interpretation of the Luminance and color difference signal such that:

b4 = 0 indicates that the $Y'C'_B C'_R$ sampling structure defined in Byte 3 bits b3:b0, is interpreted as $Y'C'_B C'_R$.

b4 = 1 indicates that the $Y'C'_B C'_R$ sampling structure defined in Byte 3 bits b3:b0, is interpreted as $IC_T C_P$ in accordance with Recommendation ITU-R BT.2100.

NOTE: In the case where Byte 3 bits b3:b0 indicate $R'G'B'$, $X'Y'Z'$ or SMPTE 2048-2 FS, Bit 4 can be ignored.

NOTE: Non Constant Luminance (NCL) $Y'C'_B C'_R$ sampling as referenced by Recommendation ITU-R BT.2100 is equivalent to $Y'C'_B C'_R$ sampling in this document.

Bit b3 and b2 shall be reserved and set to 0

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

(0h) identifies quantization using Full Range 10-bit per sample as defined in Recommendation ITU-R BT.2100.

The prohibited code values shall be protected in accordance with RP 2077 - Mapping to Interfaces and Formats that Rely upon Protected Code Values with $CV_{LOW} = 4$ and $CV_{HIGH} = 1019$

1h identifies quantization using 10 bits per sample;

2h identifies quantization using 12 bits per sample.

3h identifies quantization using Full Range 12-bit per sample as defined Recommendation ITU-R BT.2100.

NOTE: In the case where the bit depth field indicates 12-bits per sample, these bits have been mapped into a 10-bit interface.

4.1.7 Time Code Data

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

The vertical placement of the packet shall be in accordance with the recommendations given in SMPTE ST 12-2.

4.2 Virtual Interface — Data Stream Mappings

4.2.1 Mapping Structure 1: SMPTE 274M – 4:2:2 ($Y'C'_B C'_R$) or ($IC_T C_P$)/10-Bit Signals at 60, 60/1.001 and 50 Progressive Frames/Sec, or SMPTE 2048-2 – 4:2:2 ($Y'C'_B C'_R$)/10-Bit Signals at 60, 60/1.001, 50, 48 and 48/1.001 Progressive Frames/Sec

Mapping of the data created by either of these two 4:2:2 picture sampling structures into the virtual interface shall be as shown in Figure 1.

Data stream one shall contain all of the Y' sample data and data stream two shall contain a multiplex of the C'_B and C'_R sample data, conveyed in the following order:

Data stream one	=	$Y'0$,	$Y'1$,	$Y'2$,	$Y'3$
Data stream two	=	C'_B0 ,	C'_R0 ,	C'_B1 ,	C'_R1

For $IC_T C_P$ formats, Y' shall be replaced with I , C'_B shall be replaced with C_T and C'_R shall be replaced with C_P .

4.2.1.1 Timing reference signals

The EAV timing reference signal shall be inserted into the virtual interface starting at the first data word (of the virtual interface) following the last active Y' sample (data stream one) and C'_R sample (data stream two), in accordance with § 4.1.1.

The SAV timing reference signal shall be inserted into the virtual interface starting 4 data words (of the virtual interface) prior to the first active Y' sample (data stream one) and C'_B sample (data stream two), in accordance with § 4.1.1.

The locations of the last sample number 'n' of the total line and of the first and last active sample numbers of the original digital interface, as defined in the image formatting document, are repeated in Table 6 for convenience.

Table 6 – Locations of the First and Last Active Samples for 4:2:2 (Y'C'_BC'_R)/10-Bit Signals at 60, 60/1.001, 50, 48 and 48/1.001 Progressive Frames/Sec

Reference SMPTE Standard	Frame Rate	First active sample number	Last Y' active sample number	Last C' _B / C' _R active sample number	Last Y' sample number '2n+1' (total line)	Last C' _B / C' _R sample number 'n' (total line)
ST 274 system 1 and 2	60 or 60/1.001	0	1919	959	2199	1099
ST 274 system 3	50	0	1919	959	2639	1319
ST 2048-2 system 1 and 2	60 or 60/1.001	0	2047	1023	2199	1099
ST 2048-2 system 3	50	0	2047	1023	2639	1319
ST 2048-2 system 4 and 5	48 or 48/1.001	0	2047	1023	2749	1374

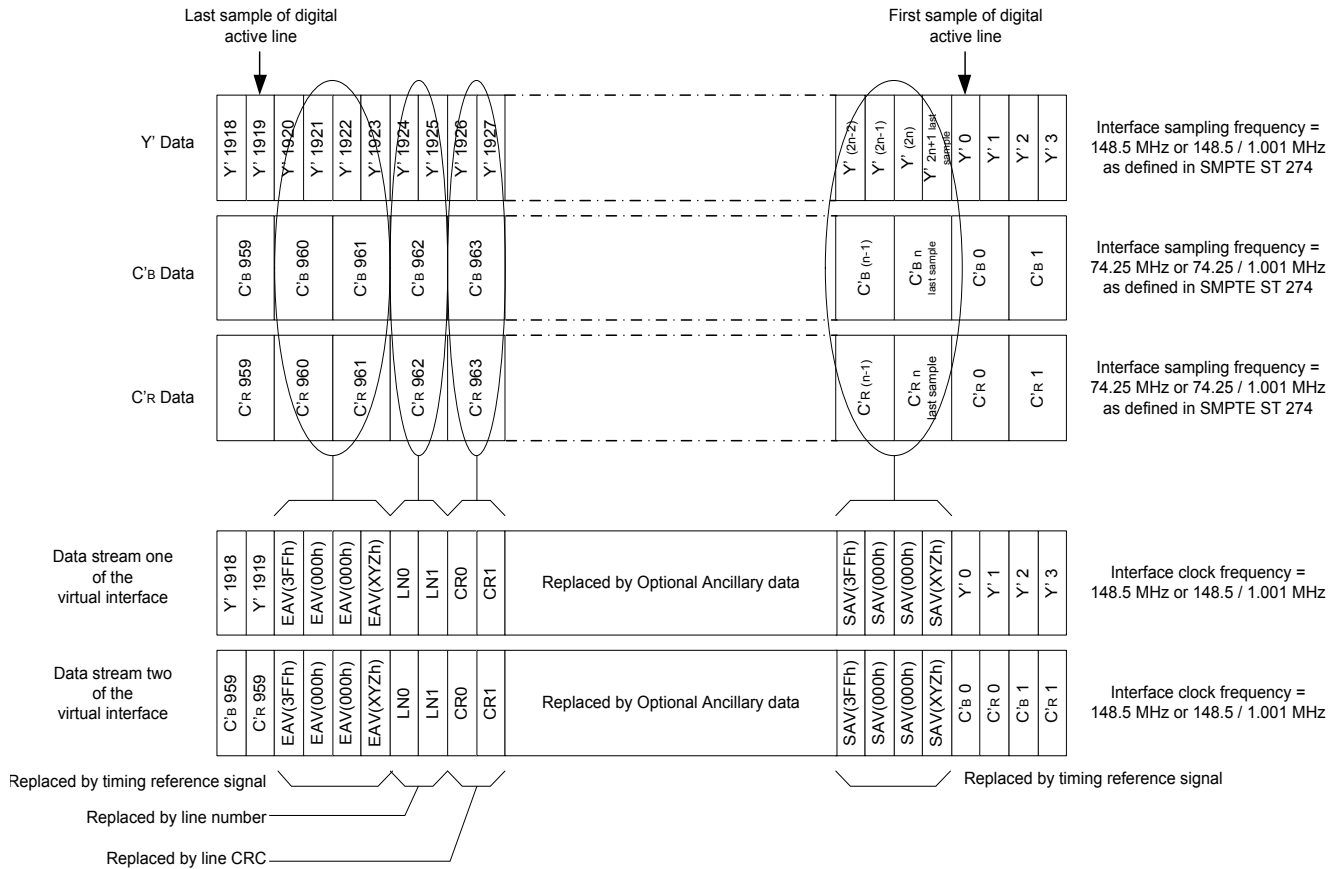


Figure 1 – Mapping Structure 1 – 4:2:2 (Y'C'B'C'R)/10-Bit Signals at 60, 60/1.001, 50, 48 and 48/1.001 Progressive Frames/Sec

4.2.2 Mapping Structure 2: 4:4:4 (R'G'B')/ (Y'C'B'C'R) / (IC_{TC_P}) or 4:4:4:4 (R'G'B'+A)/ (Y'C'B'C'R+A) / (IC_{TC_P}+A) /10-Bit Signals

Mapping of the data created by the 4:4:4 (R'G'B')/10-bit or the 4:4:4:4 (R'G'B'+A)/10-bit image sampling structure into the virtual interface shall be as shown in Figure 2.

Data stream one shall contain a multiplex of the R' and G' sample data and data stream two shall contain a multiplex of the A (where present) and B' sample data, conveyed in the following order:

Data stream one = G'0, R'0, G'1, R'1.....

Data stream two = A0, B'0, A1, B'1.....

Mapping of the data created by the 4:4:4 (Y'C'B'C'R) / (IC_{TC_P}) or the 4:4:4:4 (Y'C'B'C'R+A) / (IC_{TC_P}+A) /10-bit image sampling structure into the virtual interface shall be as shown in Figure 2, except that:

The R' samples shall be replaced with C'_R samples or the C_P samples;

The G' samples shall be replaced with Y' or the I samples;

The B' samples shall be replaced with C'_B or the C_T samples;

4.2.2.1 Timing reference signals

The EAV timing reference signal shall be inserted into the virtual interface starting at the first data word (of the virtual interface) following the last active R' sample (data stream one) and B' sample (data stream two), in accordance with § 4.1.1.

The SAV timing reference signal shall be inserted into the virtual interface starting 4 data words (of the virtual interface) prior to the first active G' sample (data stream one) and A sample (data stream two), in accordance with § 4.1.1.

The locations of the last sample number 'n' of the total line and of the first and last active sample numbers of the original digital interface, as defined in the image formatting document, are repeated in Table 7 for convenience.

Table 7 – Locations of the First and Last Active Samples for 4:4:4 (R'G'B')/10-bit and 4:4:4:4 (R'G'B'+A)/10-Bit Signals

Reference SMPTE Standard	Frame Rate	First active sample number	Last active sample number 'a'	Last sample number 'n' (total line)
ST 296 System 1 and 2	60 or 60/1.001	0	1279	1649
ST 296 System 3	50	0	1279	1979
ST 274 System 4 and 5, System 7 and 8	30 or 30/1.001	0	1919	2199
ST 296 System 4 and 5	30 or 30/1.001	0	1279	3299
ST 274 System 6 and 9	25	0	1919	2639
ST 296 system 6	25	0	1279	3959
ST 274 System 10 and 11	24 or 24/1.001	0	1919	2749
ST 296 System 7 and 8	24 or 24/1.001	0	1279	4124
ST 2048-2 Systems 6 and 7	30 or 30/1.001	0	2047	2199
ST 2048-2 System 8	25	0	2047	2639
ST 2048-2 Systems 9 and 10	24 or 24/1.001	0	2047	2749

4.2.2.2 Alpha channel

If the alpha channel is not used, the values of the alpha channel samples shall be set to 040h. Use of the alpha channel is application dependent.

4.2.2.2.1 Alpha Channel for Picture Information

If the alpha channel is used for conveying picture information, the raster format and frame rate shall be the same as the R'G'B' / Y'C'B'C_R or IC_{TCP} signals carried on the virtual interface.

4.2.2.2.2 Alpha Channel for Data

If the alpha channel is used to carry data, the data words shall be 8-bit maximum. As this is a 10-bit signal format, B8 is even parity for B7 through B0, and B9 is the complement of B8.

4.2.2.2.3 Alpha Channel – Prohibited Data Values

Data values 000h to 003h and 3FCh to 3FFh shall be used exclusively for synchronization.

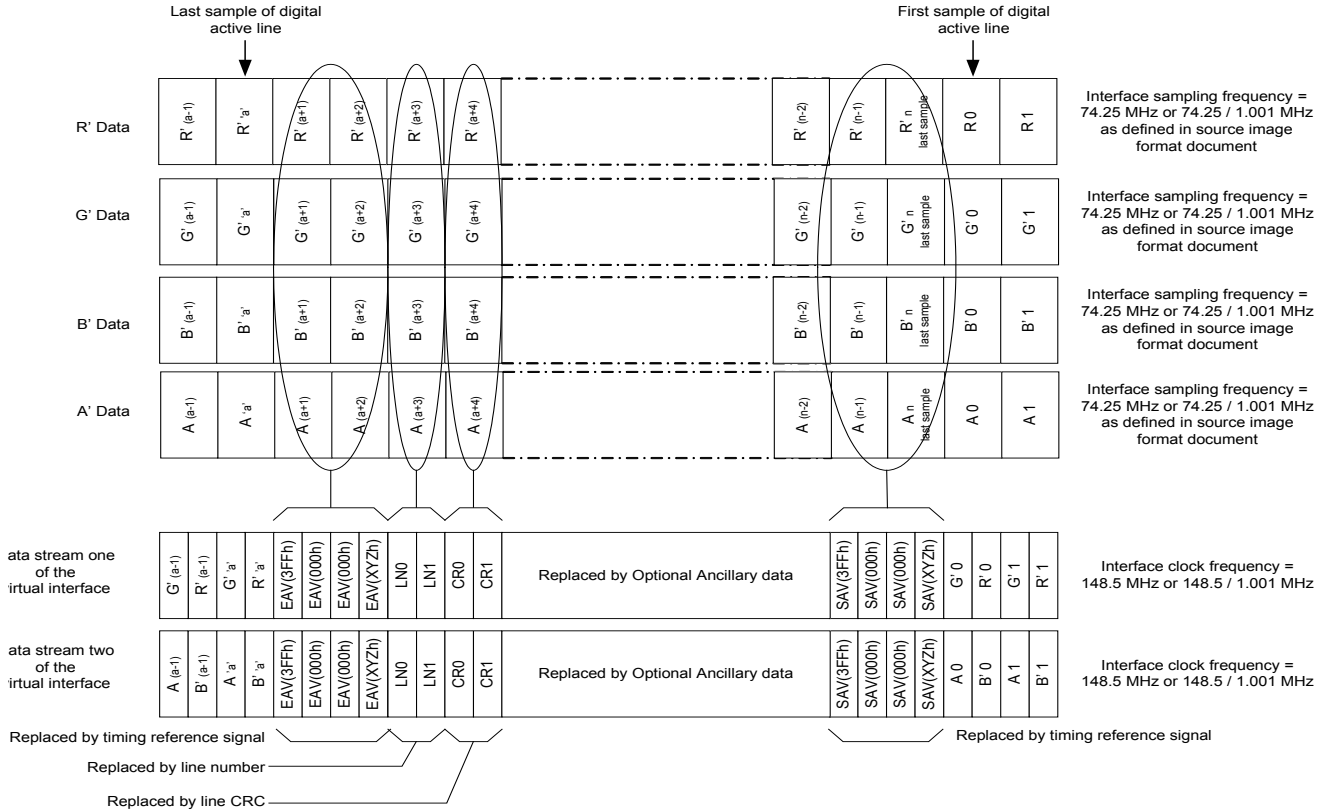


Figure 2 – Mapping Structure 2 – 4:4:4 (R'G'B') and 4:4:4:4 (R'G'B'+A)/10-Bit Signals

4.2.3 Mapping Structure 3: 4:4:4 (R'G'B') / (Y'C_BC_R) / (IC_TC_P) / (X'Y'Z')/12-Bit Signals

Mapping of the data created by the 4:4:4 (R'G'B') /12-bit picture sampling structure into the virtual interface shall be as shown in Figure 3.

The 12-bit quantized samples — represented as R'G'B' (i) [11:0] — shall be subdivided and conveyed across two data words of data stream one and data stream two of the virtual interface in the following order:

Data stream one = R'G'B' (i) [11:9], R'G'B' (i) [5:3], R'G'B' (i+1) [11:9].....

Data stream two = R'G'B' (i) [8:6], R'G'B' (i) [2:0], R'G'B' (i+1) [8:6].....

The individual samples are designated with suffix (0 ≤ i ≤ n) to indicate the sample number and [x:y] to represent specific bits within the sample.

Note: The colon symbol indicates a range; e.g., “5:3” means bits 5, 4, and 3.

Table 8 shows the bit structure of the subdivided samples.

Table 8 – R'G'B' (i) [x:y] Bit Structure Mapping into Data Words of the Virtual Interface

	Bit Number									
Data Stream	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Data stream one first word of sample (i)	$\overline{\text{B8}}$	R' (i) [11:9]			G' (i) [11:9]			B' (i) [11:9]		
Data stream one second word of sample (i)	B8	R' (i) [5:3]			G' (i) [5:3]			B' (i) [5:3]		
Data stream two first word of sample (i)	$\overline{\text{B8}}$	R' (i) [8:6]			G' (i) [8:6]			B' (i) [8:6]		
Data stream two second word of sample (i)	B8	R' (i) [2:0]			G' (i) [2:0]			B' (i) [2:0]		

The Mapping and sub-divided bit structure of the data created by the 4:4:4 (Y'C_BC_R)/12-bit picture sampling structure shall be as shown in Table 8 and Figure 3 respectively, except that:

The R' samples shall be replaced with C'_R samples;

The G' samples shall be replaced with Y' samples;

The B' samples shall be replaced with C'_B samples.

The Mapping and sub-divided bit structure of the data created by the 4:4:4 (X'Y'Z')/12-bit picture sampling structure shall be as shown in Table 8 and Figure 3 respectively, except that:

The R' samples shall be replaced with X' samples;

The G' samples shall be replaced with Y' samples;

The B' samples shall be replaced with Z' samples.

4:4:4 (X'Y'Z')/12-bit operational level 3 as defined in SMPTE ST 428-1 and AFR levels 2 and 4 as defined in SMPTE ST 428-11 are further constrained for serial digital interface signal formatting by SMPTE ST 428-9 and SMPTE ST 428-19 respectively. SMPTE ST 428-9 and SMPTE ST 428-19 shall therefore be used as the source for mapping this data into the virtual interface of this standard.

The Mapping and sub-divided bit structure of the data created by the 4:4:4 (I_C C_P)/12-bit picture sampling structure shall be as shown in Table 8 and Figure 3 respectively, except that:

The R' samples shall be replaced with C_P samples;

The G' samples shall be replaced with I samples;

The B' samples shall be replaced with C_T samples;

4.2.3.1 Timing reference signals

The EAV timing reference signal shall be inserted into the virtual interface starting at the first data word (of the virtual interface) following the last word of the last active R'G'B' sample in data stream one and data stream two, in accordance with § 4.1.1.

The SAV timing reference signal shall be inserted into the virtual interface starting 4 data words (of the virtual interface) prior to the first word of the first active R'G'B' sample in data stream one and data stream two, in accordance with § 4.1.1.

The locations of the last sample number 'n' of the total line and of the first and last active sample numbers of the original digital interface, as defined in the image formatting document, are repeated in Table 9 for convenience.

**Table 9 – Location of the First and Last Active Samples for
4:4:4 (R'G'B') / (Y'C'_BC'_R) / (I'C_TC_P) / (X'Y'Z') /12-Bit Signals**

Reference SMPTE Standard	Frame Rate	First active sample number	Last active sample number 'a'	Last sample number 'n' (total line)
ST 274 System 4 and 5, System 7 and 8	30 or 30/1.001	0	1919	2199
ST 274 System 6 and 9	25	0	1919	2639
ST 274 System 10 and 11	24 or 24/1.001	0	1919	2749
ST 428-9 DCDM Level 3	24	0	2047	2749
ST 428-19 AFR Level 4	30	0	2047	2199
ST 428-19 AFR Level 2	25	0	2047	2639
ST 2048-2 System 6 and 7	30 or 30/1.001	0	2047	2199
ST 2048-2 System 8	25	0	2047	2639
ST 2048-2 System 9 and 10	24 or 24/1.001	0	2047	2749

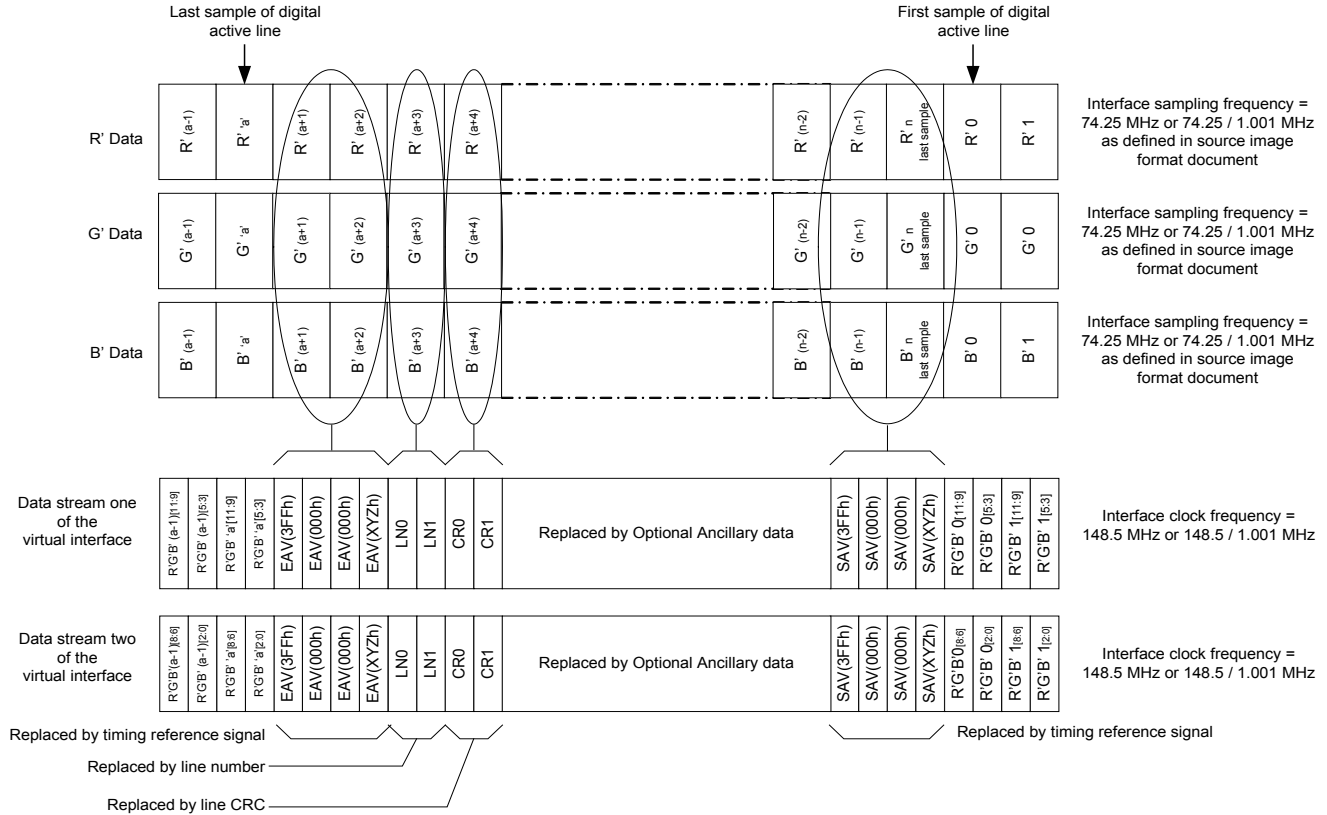


Figure 3 – Mapping Structure 3 – 4:4:4 (R'G'B')/12-Bit Signals

4.2.4 Mapping Structure 4: 4:2:2 (Y'C_BC_R) or (IC_TC_P)/12-Bit and 4:2:2:4 (Y'C_BC_R+A) or (IC_TC_P+A)/12-Bit Signals at 30, 30/1.001, 25, 24 and 24/1.001 Frame Rates, 4:2:2 (Y'C_BC_R)/12-Bit and 4:2:2:4 (Y'C_BC_R) 60, 60/1.001 and 50 Field Rates

Mapping of the data created by the 4:2:2 (Y'C_BC_R) or (IC_TC_P) /12-bit and 4:2:2:4 (Y'C_BC_R+A) or (IC_TC_P+A)/12-bit picture sampling structures into the virtual interface shall be as shown in Figure 4.

The 12-bit quantized samples — represented as Y' (2i+r)[11:0], where 0 ≤ i ≤ n, 0 ≤ r ≤ 1, — shall be subdivided and conveyed across two data words of data stream one of the virtual interface.

The 12-bit Alpha channel — represented as A (2i+r)[11:0] — shall be subdivided and conveyed across two data words of data stream one and two data words of data stream two of the virtual interface.

The 12-bit quantized samples — represented as C_BC_R (i)[11:0] — shall be subdivided and conveyed across four data words of data stream two of the virtual interface in the following order:

Data stream one	=	Y'(2i) [11:6],	Y'(2i) [5:0]	Y'(2i+1) [11:6],	Y'(2i+1) [5:0].....
		A(2i) [11:9],	A(2i) [5:3]	A(2i+1) [11:9],	A(2i+1) [5:3].....
Data stream two	=	C _B (i) [11:6],	C _B (i) [5:0],	C _R (i) [11:6],	C _R (i) [5:0].....
		A(2i) [8:6],	A(2i) [2:0]	A(2i+1) [8:6],	A(2i+1) [2:0].....

The individual samples are designated suffix (0 ≤ i ≤ n) and (0 ≤ 2i+r ≤ 2n+1) to indicate the sample number and [x:y] to represent specific bits within the sample.

The bit structure of the subdivided samples shall be as shown in Table 10 and Table 11.

Table 10 – $Y'(2i+r)$ [x:y] and $A(2i+r)$ [x:y] Bit Structure Mapping into Data Words of the Virtual Interface

	Bit Number									
Data Stream	9	8	7	6	5	4	3	2	1	0
Data stream one first word of sample (2i)	$\overline{B[8]}$	$A(2i) [11:9]$			$Y'(2i) [11:6]$					
Data stream one second word of sample (2i)	$\overline{B[8]}$	$A(2i) [5:3]$			$Y'(2i) [5:0]$					
Data stream one first word of sample (2i+1)	$\overline{B[8]}$	$A(2i+1) [11:9]$			$Y'(2i+1) [11:6]$					
Data stream one second word of sample (2i+1)	$\overline{B[8]}$	$A(2i+1) [5:3]$			$Y'(2i+1) [5:0]$					

Table 11 – $C'_B C'_R(i)$ [x:y] and $A(2i+r)$ [x:y] Bit Structure Mapping into Data Words of the Virtual Interface

	Bit Number									
Data Stream	9	8	7	6	5	4	3	2	1	0
Data stream two first word of sample (i)	$\overline{B[8]}$	$A(2i) [8:6]$			$C'_B(i) [11:6]$					
Data stream two second word of sample (i)	$\overline{B[8]}$	$A(2i) [2:0]$			$C'_B(i) [5:0]$					
Data stream two third word of sample (i)	$\overline{B[8]}$	$A(2i+1) [8:6]$			$C'_R(i) [11:6]$					
Data stream two fourth word of sample (i)	$\overline{B[8]}$	$A(2i+1) [2:0]$			$C'_R(i) [5:0]$					

For $IC_T C_P$ formats, Y' shall be replaced with I , C'_B shall be replaced with C_T and C'_R shall be replaced with C_P .

4.2.4.1 Timing reference signals

The EAV timing reference signal shall be inserted into the virtual interface starting at the first data word (of the virtual interface) following the last word of the last active Y' sample in data stream one and C'_R sample in data stream two, in accordance with § 4.1.1.

The SAV timing reference signal shall be inserted into the virtual interface starting 4 data words (of the virtual interface) prior to the first word of the first active Y' sample in data stream one and C'_B sample in data stream two, in accordance with § 4.1.1.

The locations of the last sample number 'n' of the total line and of the first and last active sample numbers of the original digital interface, as defined in the image formatting document, are repeated in Table 12 for convenience.

Table 12 – Location of the First and Last Active Samples for 4:2:2 (Y'C'_BC'_R) OR (IC_TC_P)/12-Bit and 4:2:2:4 (Y'C'_BC'_R+A) or (IC_TC_P+A)/12-Bit Signals

Reference SMPTE Standard	Frame Rate	First active sample number	Last active Y' or A sample number '2a+1'	Last active C' _B / C' _R sample number 'a'	Last Y' or A sample number '2n+1' (total line)	Last C' _B / C' _R sample number 'n' (total line)
ST 274 System 4 and 5, System 7 and 8	30 or 30/1.001	0	1919	959	2199	1099
ST 274 System 6 and 9	25	0	1919	959	2639	1319
ST 274 System 10 and 11	24 or 24/1.001	0	1919	959	2749	1374
ST 2048-2 System 6 and 7	30 or 30/1.001	0	2047	1023	2199	1099
ST 2048-2 System 8	25	0	2047	1023	2639	1319
ST 2048-2 Systems 9 and 10	24 or 24/1.001	0	2047	1023	2749	1374

4.2.4.2 Alpha channel

The 10-bit alpha samples shall use bits B11 through B2 of each 12-bit word. Bits B1 through B0 are zero. If the alpha channel is not used, the values of the 10-bit alpha channel samples shall be set to 040h. Use of the alpha channel is application dependent.

4.2.4.2.1 Alpha Channel for Picture Information

If the alpha channel is used for conveying picture information, the raster format and frame rate shall be the same as the Y' or I signal carried on the virtual interface.

4.2.4.2.2 Alpha Channel for Data

If the alpha channel is used to carry data, the data words shall be 8-bit maximum, B10 is even parity for data word B9 through B2, B11 is the complement of B10. B1 through B0 are zero.

4.2.4.2.3 Alpha Channel – Prohibited Data Values

Data values 000h to 003h and 3FCh to 3FFh for the 10-bit alpha samples shall be used exclusively for synchronization.

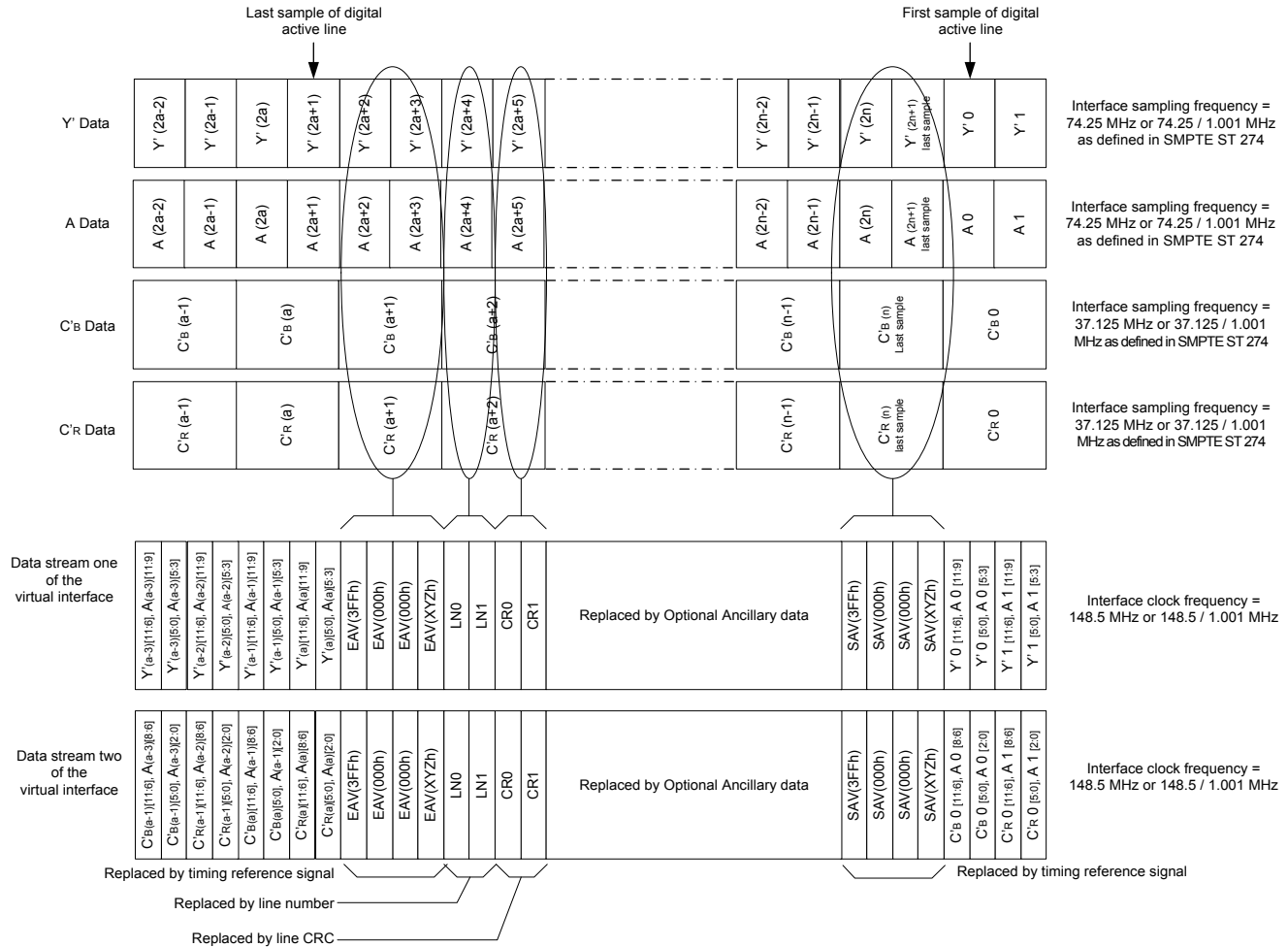


Figure 4 – Mapping Structure 4 – 4:2:2 (Y'C'B'C'R)/12-Bit and 4:2:2:4 (Y'C'B'C'R+A)/12-Bit Signals

5 Level B — Mapping of SMPTE ST 372 Dual-Link

Level B Dual-Link mapping provides a method of carrying SMPTE ST 372 Dual-Link interfaces over a single 3 Gb/s SDI link.

The Level B Dual-Link mappings are described in the following sections.

When present, the ancillary data shall be mapped into the HANC or the VANC space of data streams one and two. Ancillary data mapping rules are defined in SMPTE ST 372. The ancillary data packet shall be in conformance with SMPTE ST 291-1.

Up to 32 audio channels sampled at 32 kHz, 44.1 kHz, or 48 kHz may be mapped into the horizontal ancillary data space of data stream one and data stream two of the virtual interface. At 96-kHz sampling, 16 audio channels may be mapped.

Note: The maximum number of audio channels that can be mapped into the available horizontal ancillary data space varies in accordance with the video format and the video frame rate. Table 4 illustrates the number of audio channels that can be supported in each case.

5.1 SMPTE ST 372 Dual Link Mapping

R', G', B',/ Y', C'B, C'R, / IC_TCP / X', Y', Z' and A components shall be mapped into a 20-bit Virtual Interface consisting of two data streams — data stream one and data stream two. The data mapping rules are defined in SMPTE ST 372.

Data-stream one shall contain all of the 10-bit data words of the Link A interface and data stream two shall contain all of the data words of the Link B interface as shown in Figure 5.

The 10-bit interfaces so constructed shall contain timing reference code words (SAV/EAV) and line numbers as defined SMPTE ST 372, and line based CRC's as defined in SMPTE ST 292-1.

Each parallel 10-bit interface shall be line and word aligned, having an interface frequency of 148.5 MHz or 148.5/1.001 MHz.

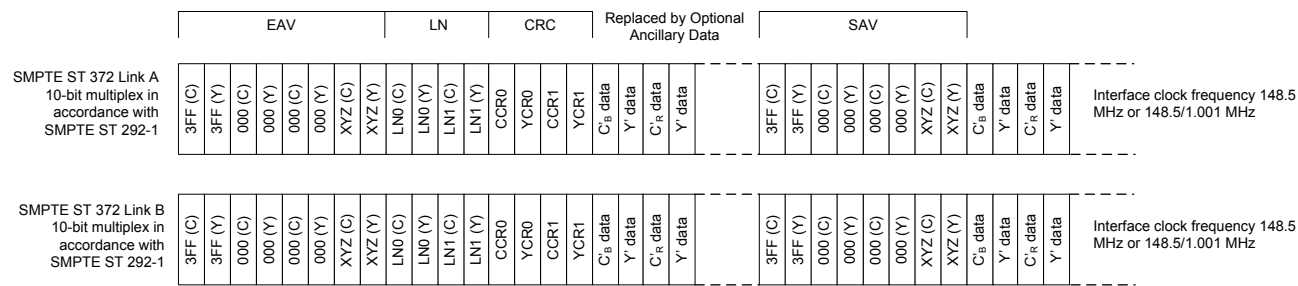


Figure 5 – Example of SMPTE ST 372 Link A 10-bit multiplex and Link B 10-bit multiplex

Table 13 shows the image formats carried over the SMPTE ST 372 Dual Link interface.

Table 13 – Source Image Formats carried by the SMPTE ST 372 Dual Link interface

SMPTE ST 372 Mapping Structure	Reference Standard	Image Format	Signal Format Sampling Structure/Pixel Depth	Frame/Field Rates	Transport	
I §5.1	ST 274 Recommendation ITU-R BT.2100	1920 × 1080	4:2:2 (Y'C _B C _R)/10-bit 4:2:2 (IC _T C _P)/10-bit	60, 60/1.001 and 50 Frames Progressive	Interlaced	
	ST 2048-2	2048 × 1080 ⁶	4:2:2 (Y'C _B C _R)/10-bit	60, 60/1.001, 50, 48 and 48/1.001 Frames Progressive	Interlaced	
II §5.2, §5.4	ST 274	1920 × 1080	4:4:4 (R'G'B'), 4:4:4:4 (R'G'B' +A)/10-bit ⁴ 4:4:4 (Y'C _B C _R), 4:4:4:4 (Y'C _B C _R +A)/10-bit ⁴	60, 60/1.001 and 50 Fields Interlaced	Interlaced	
	ST 274 Recommendation ITU-R BT.2100		4:4:4 (R'G'B'), 4:4:4:4 (R'G'B' +A)/10-bit ⁴ 4:4:4 (Y'C _B C _R), 4:4:4:4 (Y'C _B C _R +A)/10-bit ⁴ 4:4:4 (IC _T C _P), 4:4:4:4 (IC _T C _P +A)/10-bit ⁴	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive	
			ST 2048-2	2048 × 1080 ⁶	4:4:4 (R'G'B') ^{*7} , 4:4:4:4 (R'G'B' +A) /10-bit ⁴ 4:4:4 (Y'C _B C _R), 4:4:4:4 (Y'C _B C _R +A) /10-bit ⁴	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive
	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	P _S F ^{*1}				
	III §5.3, §5.4	ST 274	1920 × 1080	4:4:4 (R'G'B')/12-bit 4:4:4 (Y'C _B C _R)/12-bit	60, 60/1.001 and 50 Fields Interlaced	Interlaced
		ST 274 Recommendation ITU-R BT.2100		4:4:4 (R'G'B')/12-bit 4:4:4 (Y'C _B C _R)/12-bit 4:4:4 (IC _T C _P)/12-bit	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive
ST 2048-2		2048 × 1080 ⁶	4:4:4 (R'G'B') ^{*7} /12-bit 4:4:4 (Y'C _B C _R)/12-bit	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive	
			30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	P _S F ^{*1}		
ST 428-9		2048 x 1080 ⁵	4:4:4 (X'Y'Z')/12-bit	24 Frames Progressive	Progressive	
				24 Frames Progressive	P _S F ^{*2}	
ST 428-19	2048 × 1080 ⁵	4:4:4 (X'Y'Z')/12-bit	25 and 30 Frames Progressive	Progressive		
			25 and 30 Frames Progressive	P _S F ^{*3}		
IV §5.5	ST 274	1920 × 1080	4:2:2 (Y'C _B C _R)/12-bit	60, 60/1.001 and 50 Fields Interlaced	Interlaced	
	ST 274 Recommendation ITU-R BT.2100		4:2:2 (Y'C _B C _R)/12-bit	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive	
			4:2:2 (IC _T C _P)/12-bit	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	P _S F ^{*1}	
	ST 2048-2	2048 × 1080 ⁶	4:2:2 (Y'C _B C _R)/12-bit, 4:2:2:4 (Y'C _B C _R)/12-bit + A ⁴	30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive	
			30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	P _S F ^{*1}		

NOTE: In accordance with Recommendation ITU-R BT.2100, IC_TCP sampling is only applied to High Dynamic Range (HDR) progressive image formats.

- *1 PsF structure as defined in SMPTE ST 274.
- *2 PsF structure as defined in SMPTE ST 428-9.
- *3 PsF structure as defined in SMPTE ST 428-19.
- *4 Definition of the A channel is application dependent for mapping of these 10-bit signal structures.
- *5 This is the image container size, the active image does not always fill the container.
- *6 This is the maximum pixel array, the active image does not always fill the maximum array.
- *7 In this image format R'G'B' indicates either R'G'B' or R'_{FS}G'_{FS}B'_{FS}.

For IC_TC_P mapping, Y' is replaced with I, C'_B with C_T and C'_R with C_P.

5.1.1 Payload Identifier

The payload identifier shall be mapped into the horizontal ancillary data space of the “Y” or “I” channel of Link A and Link B as defined in SMPTE ST 372 and shall be in conformance with SMPTE ST 352.

The horizontal placement of the packet should be immediately following the last CRC code word (YCR1), of the line(s) specified in SMPTE ST 372.

Byte 1 of the payload shall be set to 8Ah in both Link A and Link B.

The video payload identification code assignment for bytes 2 through 4 of SMPTE ST 372 Dual Link payloads shall be as defined in SMPTE ST 372.

Link A (Ch1) and Link B (Ch2) identification shall be provided in the payload identifier mapped into data stream one and data stream two, respectively.

6 Level B — 2 x SMPTE ST 292-1 (HD-SDI) Dual-Stream Mapping

Level B Dual-Stream mapping provides a method of carrying 2 x SMPTE ST 292-1 dual-stream interfaces over a single 3Gb/s SDI link.

The Level B Dual-Stream mappings are described in the following sections.

All applicable ancillary data shall be mapped into each SMPTE ST 292-1 stream of the dual-stream interface prior to final mapping into the Virtual Interface of this standard. The correct construction of this data is defined in the applicable source image format document, and/or in any other applicable mapping document.

6.1 2 x SMPTE ST 292-1 (HD-SDI) Dual Stream Mapping

Two parallel 10-bit interfaces of the same line and frame structure, having bit synchronization and constructed in conformance with SMPTE ST 292-1, shall be mapped into a 20-bit Virtual Interface consisting of two data streams — data stream one and data stream two.

The 10-bit interfaces so constructed shall contain timing reference code words (SAV/EAV), line numbers and line based CRC's as defined in SMPTE ST 292-1 and/or the source image format document.

Each parallel 10-bit interface shall be line and word aligned, having an interface frequency of 148.5 MHz or 148.5/1.001 MHz as shown in Figure 6.

Note: The two streams might not be frame aligned, and video switching could then be adversely affected in this case.

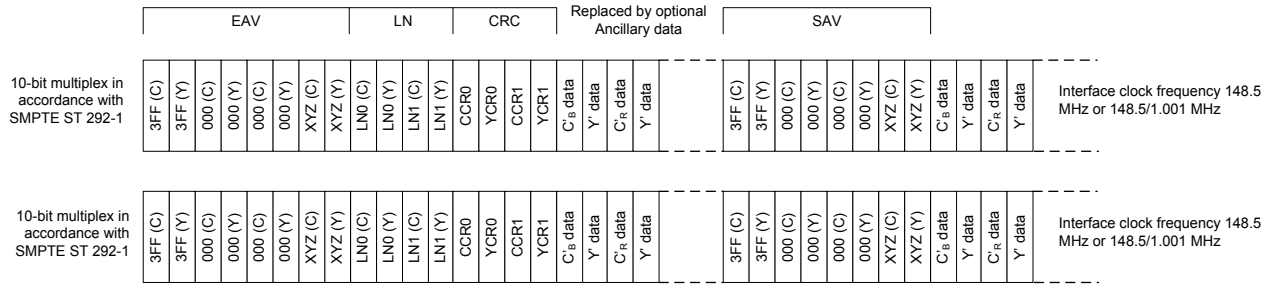


Figure 6 – Example of 2 x SMPTE ST 292-1 dual-stream 10-bit multiplex

The source data for each 10-bit parallel interface may be packetized data, or an uncompressed video source.

Table 14 shows the image formats defined in SMPTE ST 274, SMPTE ST 296, and SMPTE ST 2048-2 that can be transported through Single-link SMPTE ST 292-1.

Note: SMPTE ST 348 (High Data-Rate Serial Data Transport Interface (HD-SDTI)) and SMPTE ST 349 (Transport of Alternate Source Image Formats through SMPTE ST 292-1) can also be applied to 2 x SMPTE ST 292-1 (HD-SDI) dual-stream mapping mode.

Reference should be made to these reference standards for further details of the capabilities of these interfaces.

Table 14 – Source Image Formats carried by SMPTE ST 292-1

Reference SMPTE Standard	Image Format	Signal Format Sampling Structure/Pixel Depth	Frame/Field Rates	Transport
ST 274	1920 × 1080	4:2:2 (Y'C _b C _r)/10-bit	60, 60/1.001 and 50 Fields Interlaced	Interlaced
			30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive
			30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Psf ^{*1}
ST 2048-2	2048 x 1080 ^{*2}	4:2:2 (Y'C _b C _r)/10-bit	60, 60/1.001 and 50 Fields Interlaced	Interlaced
			30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive
			30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Psf ^{*1}
ST 296	1280 x 720	4:2:2 (Y'C _b C _r)/10-bit	60, 60/1.001, 50, 30, 30/1.001, 25, 24 and 24/1.001 Frames Progressive	Progressive
*1 PsF structure as defined in SMPTE ST 274				
*2 This is the maximum pixel array, the active image might not fill the maximum array.				

6.1.1 Payload Identifier

The payload identifier shall be mapped into the horizontal ancillary data space of the “Y” channel of each SMPTE ST 292-1 stream and shall be in conformance with SMPTE ST 352.

The horizontal placement of the packet should be immediately following the last CRC code word (YCR1), of the line(s) specified in SMPTE ST 292-1.

Byte 1 of the payload identifier shall be set in accordance with Table 15.

Bytes 2 through 4 of the payload identifier shall be set in accordance with the picture rate, sampling structure, dynamic range and bit-depth, etc., of the image format being carried on the interface as defined in SMPTE ST 292-1.

Table 15 –Video Payload and Digital Interface Identification for dual stream mapping of 2 x HD SDI Mapped on the 3 Gb/s Serial Digital Interface

Mapping Nomenclature	Byte 1: Video Payload and Digital Interface
2 x (SMPTE ST 292-1) 720-line video payloads on a 3 Gb/s serial digital interface	8Bh
2 x (SMPTE ST 292-1) 1080-line video payloads on a 3 Gb/s serial digital interface	8Ch
2 x (SMPTE ST 349) 483/576-line video payloads on a 3 Gb/s serial digital interface	8Dh

The Payload Identifier shall not be mapped into the ancillary data space when the data format is HD-SDTI as defined in SMPTE ST 348. A stream identifier is already provided in the form of the HD-SDTI header in SMPTE ST 348. This information may be used by receiver equipment to identify the payload data.

7 Levels of Operation (Informative)

To define the level of support for this standard, manufacturers are encouraged to indicate in publications which mapping format is supported. For example:

- Level A – Direct image format mapping
- Level B-DL – SMPTE ST 372 Dual Link mapping
- Level B-DS – 2 x SMPTE ST 292-1 (HD-SDI) dual-stream mapping

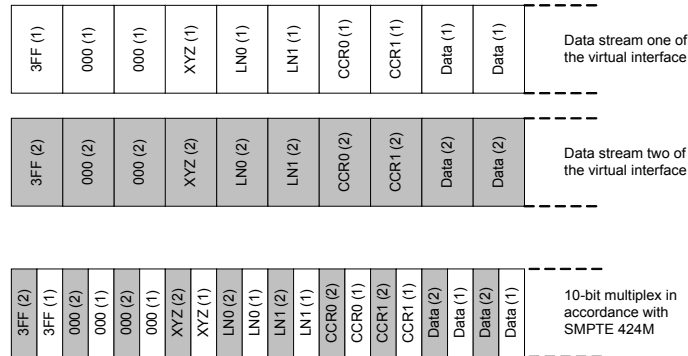
Manufacturers are also encouraged to indicate in publications supported audio and video formats.

Annex A Level A Mapping Compared to Level B Mapping (Informative)

A.1 Level A 10-bit Multiplex to a SMPTE ST 424 Interface

For Level A mapping support as defined in § 4 of this standard, data stream one and data stream two of the virtual interface will each contain one set of TRS, Line Number and line CRC code words.

SMPTE ST 424 defines a 10-bit multiplex of the virtual interface prior to scrambling and serialization. The result of this multiplex is that the SMPTE ST 424 data stream carries two word interleaved sets of TRS, Line Number and line CRC code words as shown in the Figure A.1.

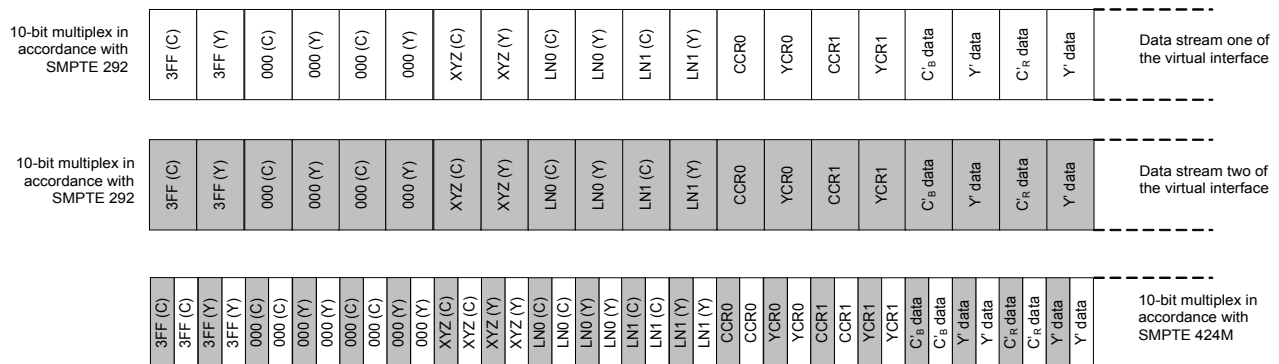


**Figure A.1 – 10-Bit Multiplex of Data Stream One and Two (Level A Mapping)
in accordance with SMPTE ST 424**

A.2 Level B 10-bit Multiplex to a SMPTE ST 424 Interface

For Level B mapping as defined in § 5 or § 6 of this standard, supporting SMPTE ST 372 Dual Link or 2 x SMPTE ST 292-1 (HD-SDI) mapping modes, data stream one and data stream two of the virtual interface will each contain two sets of TRS, Line Number, and line CRC code words.

When the virtual interface containing the 10-bit 292 multiplex is further multiplexed in accordance with SMPTE ST 424, the resultant interleaved data stream will contain four complete sets of TRS, Line Number, and CRC code words as shown in Figure A.2.



**Figure A.2 – 10-Bit Multiplex of Data Stream One and Two (Level B Mapping)
in accordance with SMPTE ST 424**

Annex B Derivation of 32-Channel Audio Multiplexing Restrictions for Level A Direct Mappings (Informative)

For audio groups 1 to 4, Na is defined in the SMPTE ST 299-1 section on Audio Data Packet Multiplexing as the maximum number of audio samples for a given audio channel to be embedded into each horizontal ancillary data space. Na applies equally to extended audio groups 5 to 8 as defined in SMPTE ST 299-2. Na is calculated for multiplexing 48-kHz audio into each Level A mapping, and is shown in Table B.1 below, along with the number of HANC words required by this multiplexing method for up to 8 audio groups. The Na value is doubled for 96-kHz audio, but the maximum number of packets per horizontal ancillary data space for each of the eight groups remains the same as it is for 48-kHz audio, with only half the number of channels. The maximum number of audio channels that can be multiplexed into each Level A video mapping is listed in the far-right column of Table B.1. In cases where this maximum number is 16, only audio groups 1 to 4 are multiplexed.

Table B.1 – Derivation of 32-Channel Audio Multiplexing Restrictions for SMPTE ST 425-1 Level A Direct Mappings

Mapping Structure	Video Format	Available Stream #2 HANC Words (Ref. Note 1)	Sample Rate (48kHz) divided by Video Line Rate	Maximum Words per Video Line for 32 Channels (Na*31*8)	Maximum Number of Embedded Audio Channels
1	1080p/50	697	0.8533	1*248=248	32
	1080p/59.94,60	257	0.7118, 0.7111	1*248=248	32
	2048x1080p/50	569	0.8533	1*248=248	32
	2048x1080p/59.94,60	129	0.7118, 0.7111	1*248=248	16
	2048x1080p/47.95,48	679	0.8898, 0.8889	1*248=248	32
2	720p/50	1354	1.280	2*248=496	32
	720p/59.94,60	694	1.068, 1.067	2*248=496	32
	720p/25	5337	2.560	3*248=744	32
	720p/23.98,24	5667	2.669, 2.667	3*248=744	32
	720p/29.97,30	4017	2.135, 2.133	3*248=744	32
	1080i/50	1417	1.707	2*248=496	32
	1080i/59.94,60	537	1.424, 1.422	2*248=496	32
	1080p,psf/25	1417	1.707	2*248=496	32
	1080p,psf/23.98,24	1637	1.780, 1.778	2*248=496	32
	1080p,psf/29.97,30	537	1.424, 1.422	2*248=496	32
	2048x1080p/25	1161	1.707	2*248=496	32
	2048x1080p/29.97,30	281	1.424, 1.422	2*248=496	16
	2048x1080p/23.98/24	1381	1.780, 1.778	2*248=496	32
	1080i/50	1417	1.707	2*248=496	32
3	1080i/59.94,60	537	1.424, 1.422	2*248=496	32
	1080p/25	1417	1.707	2*248=496	32
	1080p/23.98,24	1637	1.780, 1.778	2*248=496	32
	1080p/29.97,30	537	1.424, 1.422	2*248=496	32
	2048x1080p,psf/24	1381	1.780, 1.778	2*248=496	32
	2048x1080p/25	1161	1.707	2*248=496	32
	2048x1080p/29.97,30	281	1.424, 1.422	2*248=496	16
	2048x1080p/25	1161	1.707	2*248=496	32
	2048x1080p/29.97,30	281	1.424, 1.422	2*248=496	16
	2048x1080p/23.98/24	1381	1.780, 1.778	2*248=496	32
4	1080i/50	1417	1.707	2*248=496	32
	1080i/59.94,60	537	1.424, 1.422	2*248=496	32
	1080p,psf/25	1417	1.707	2*248=496	32
	1080p,psf/23.98,24	1637	1.780, 1.778	2*248=496	32
	1080p,psf/29.97,30	537	1.424, 1.422	2*248=496	32

Note for Table B.1:

The number of available Stream#2 HANC words equals Stream#2 Words per Line minus Stream#2 Active Video Words per Line minus Stream#2 EAV (4 words) minus Stream#2 SAV (4 words) minus Stream#2 LN (2 words) minus Stream#2 CRC (2 words) minus Stream#2 S352M Packet (11 words).

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