SMPTE STANDARD

Ultra High Definition Television — Multi-link 10 Gb/s Signal/Data Interface Using 12-Bit Width Container

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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 2036-4 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

SMPTE ST 2036 Ultra High Definition Television suite of documents is in multiple parts.

This document is Part 4 of SMPTE ST 2036 and describes UHDTV (Ultra High Definition Television) video payload mapping into a Multi-link 10-Gb/s Signal/Data Interface. This interface is capable of transferring signals up to about 250 Gb/s.

The source UHDTV image sample structures for the interface are defined in SMPTE ST 2036-1. UHDTV has an image format (sample structure) of 3840 × 2160 (UHDTV1) or 7680 × 4320 (UHDTV2).

1 Scope

This document defines UHDTV video payload mapping of formats as shown in Table 1 into Multi-link 10Gb/s [nominal] Signal/Data Interface. This document also defines mapping of ANC, payload ID and other ancillary data[1] as well as optical characteristics and a connector.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or text that contains the conformance language keywords: "shall," "should," or "may." Informative text is text that is potentially helpful to the user, but not indispensable, and that 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.

[1] Audio essence using ancillary space and ancillary packets will be covered in a separate document.

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

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

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

SMPTE RP 184:2004, Specification of Jitter in Bit-Serial Digital Systems

ANSI INCITS 230-1994 (R1999), Information Technology — Fibre Channel — Physical and Signaling Interface (FC-PH)

IEC 61754-7:2008, Fibre Optic Interconnecting Devices and Passive Components — Fibre Optic Connector Interfaces — Part 7: Type MPO Connector Family

IEEE 802.3ae-2002 and Amendment, Media Access Control (MAC) Parameters, Physical Layers, and Management Parameters for 10 Gb/s Operation

4 Definition of Terms

For the purposes of this standard, the following definitions shall apply:

4.1 Active frame

1080 active lines that constitute one frame of a basic image.

4.2 Active line

1920 words of data that constitute one line of a basic image.

4.3 Basic image

1920 × 1080 pixel image of each color component obtained by sub-sampling of a UHDTV1 image or UHDTV1 Sub-image.

4.4 Basic Stream

A 12-bit-word multiplexed data stream which consists of a four-word EAV (End of Active Video) timing reference code, a two-word line number (LN), a two-word CRCC (Cyclic Redundancy Check Code) error detection code, ancillary data or blanking data, a four-word SAV (Start of Active Video) timing reference code, and video data.

4.5 Frame blanking

The lines between an active frame and the next active frame.

4.6 Running disparity

A binary parameter indicating the cumulative disparity (positive or negative) of all previously issued transmission characters.

4.7 UHDTV

Ultra High Definition Television, having an image format (sample structure) of 3840 × 2160 or 7680 × 4320.

4.8 UHDTV1

Class of UHDTV having an image format (sample structure) of 3840 × 2160.

4.9 UHDTV2

Class of UHDTV having an image format (sample structure) of 7680 × 4320.

4.10 4K Sub-Image

Class of UHDTV having an image format (sample structure) of 3840 × 2160 of each color component obtained by sub-sampling of a UHDTV2 image.

4.11 8K/Fr

UHDTV2 image with frame frequency of Fr (Fr = 120, 120/1.001, 100, 60, 60/1.001, 50, 30, 30/1.001, 25, 24, 24/1.001).

4.12 4K/Fr

UHDTV1 image with frame frequency of Fr (Fr = 120, 120/1.001, 100, 60, 60/1.001, 50, 30, 30/1.001, 25, 24, 24/1.001).

4.13 4Ks/Fr

4K Sub-Image with frame frequency of Fr (Fr = 120, 120/1.001, 100, 60, 60/1.001, 50, 30, 30/1.001, 25, 24, 24/1.001).

4.14 2K/Fr

Basic image with frame frequency of Fr (Fr = 120, 120/1.001, 100, 60, 60/1.001, 50, 30, 30/1.001, 25, 24, 24/1.001).

5 Video Data Signals

5.1 Overview of Mapping from UHDTV2 or UHDTV1 Images to 10G Link Signals

5.1.1 Mapping of UHDTV2 or UHDTV1 images with 120-Hz, 120/1.001-Hz or 100-Hz frame frequency

The mapping of UHDTV2 images with 120-Hz, 120/1.001-Hz or 100-Hz frame frequency to multiple 10G link signals shall be as illustrated in Figure 1, and the mapping of UHDTV1 images with 120-Hz, 120/1.001-Hz or 100-Hz frame frequency shall be as illustrated in Figure 2. The color components, C1, C2, and C3 of each figure shall be represented as Y′, C'_B, and C'_R or G′, B′, and R′.

For 8K/Fr (Fr = 120, 120/1.001, 100), the three color components that constitute the image shall be divided into four to produce N (N=6, 8, or 12) 4K Sub-Images, each of which is then further divided to produce 4N basic images. Those 4N basic images shall be converted to 4N basic streams, each two of which are mapped to one 10G link signal to generate 2N 10G link signals.

For 4K/Fr (Fr = 120, 120/1.001, 100), the three color components that constitute the image shall be divided into four to produce M (M=6, 8, or 12) basic images. The M basic images shall be converted to M basic streams, each two of which are mapped to one 10G link signal to generate 4 or 6 10G link signals. The reason for there being no M/2 is that 10G link signals are generated for each color component. Detailed specifications are in Section 7.2.4.

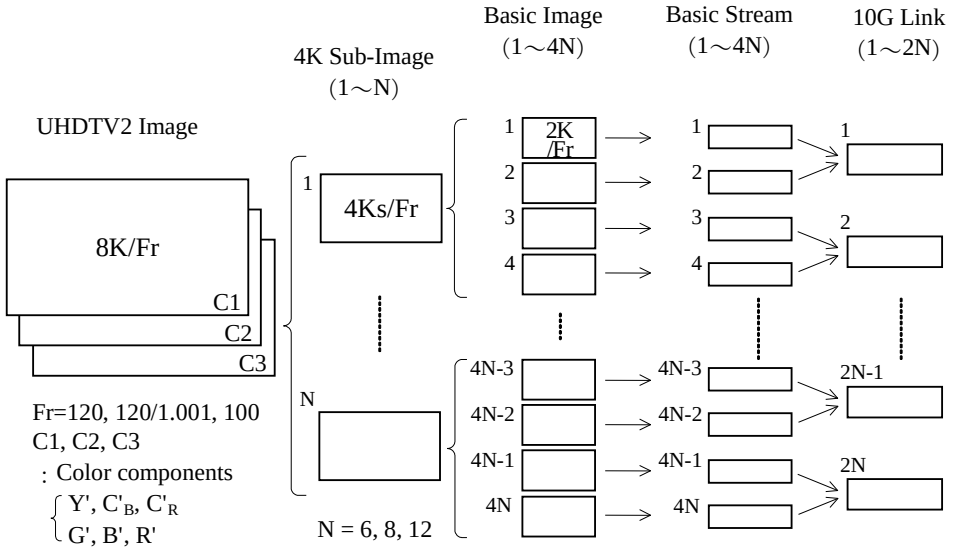

Figure 1 – Mapping overview of UHDTV2 images with 120-Hz, 120/1.001-Hz or 100-Hz frame frequency

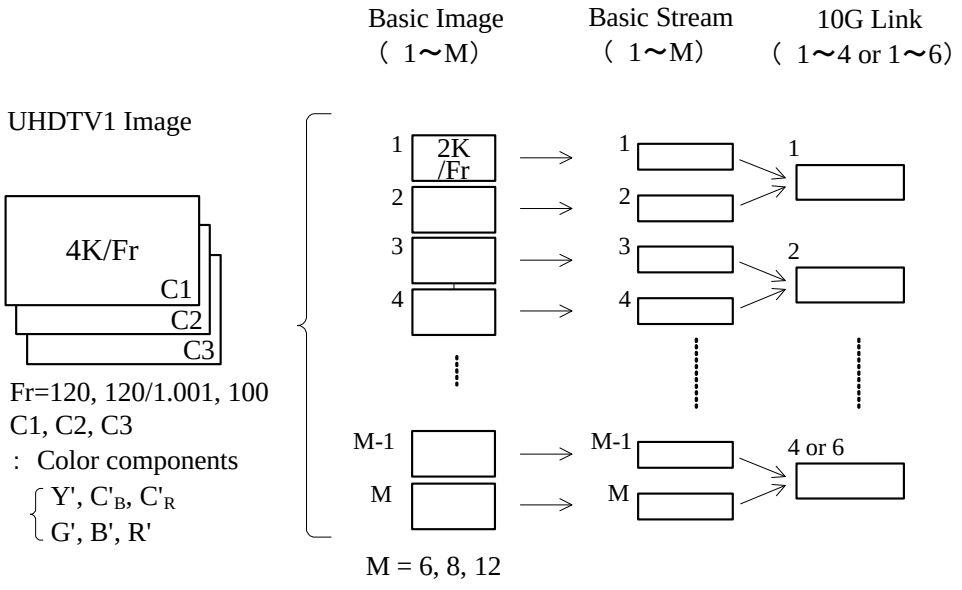

Figure 2 – Mapping overview of UHDTV1 images with 120-Hz, 120/1.001-Hz or 100-Hz frame frequency

5.1.2 Mapping of UHDTV2 or UHDTV1 images with 60-Hz, 60/1.001-Hz or 50-Hz frame frequency

The mapping of UHDTV2 images with 60-Hz, 60/1.001-Hz or 50-Hz frame frequency to multiple 10G link signals shall be as illustrated in Figure 3, and the mapping of UHDTV1 images with 60-Hz, 60/1.001-Hz or 50-Hz frame frequency shall be as illustrated in Figure 4.

For 8K/Fr (Fr = 60, 60/1.001, 50), the three color components that constitute the image shall be divided into four to produce N (N=6, 8, or 12) 4K Sub-Images, and then 4N basic images shall be generated. Next, the 4N basic images are converted to 4N basic streams, each four of which shall be mapped to one 10G link signal to generate N 10G link signals.

For 4K/Fr (Fr = 60, 60/1.001, 50), the three color components that constitute the image shall be divided into four to produce M (M=6, 8, or 12) basic images. The M basic images shall be converted to M basic streams, each four of which shall be mapped to one 10G link signal to generate three 10G link signals. The reason for there being no M/4 is that 10G link signals are generated for each color component. Detailed specifications are in Section 7.2.5.

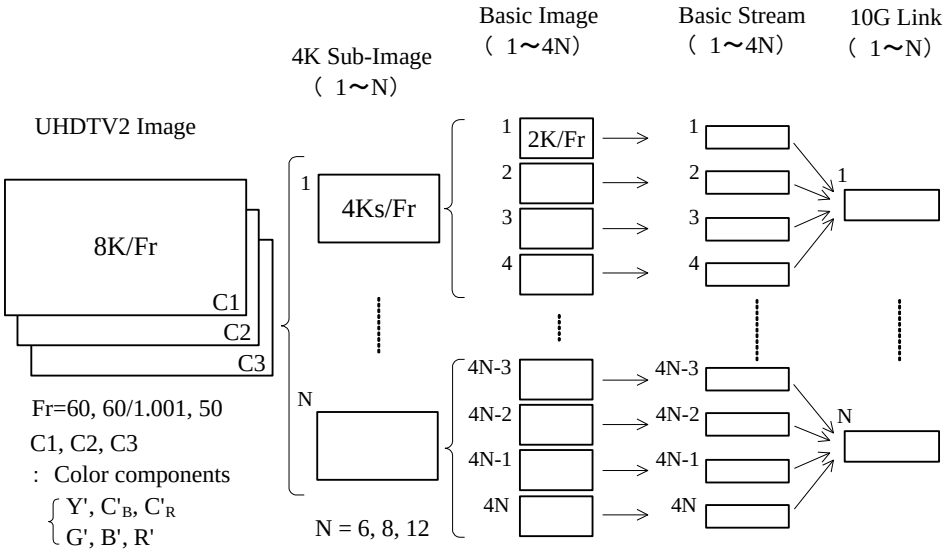

Figure 3 – Mapping overview of UHDTV2 images with 60-Hz, 60/1.001-Hz or 50-Hz frame frequency

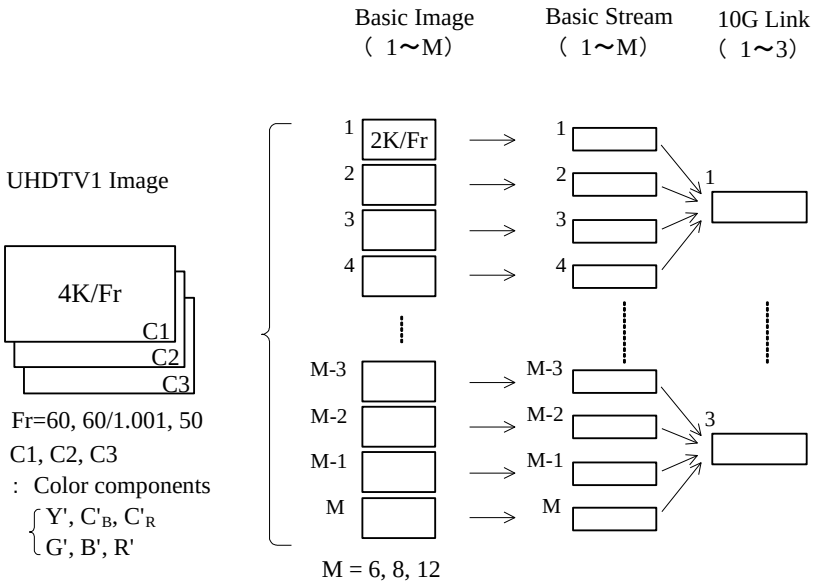

Figure 4 – Mapping overview of UHDTV1 images with 60-Hz, 60/1.001-Hz or 50-Hz frame frequency

5.1.3 Mapping of UHDTV2 or UHDTV1 images with 30-Hz, 30/1.001-Hz, 25-Hz, 24-Hz or 24/1.001-Hz frame frequency

The mapping of UHDTV2 images with 30-Hz, 30/1.001-Hz, 25-Hz, 24-Hz or 24/1.001-Hz frame frequency to multiple 10G link signals shall be as illustrated in Figure 5, and the mapping of UHDTV1 images with 30-Hz, 30/1.001-Hz, 25-Hz, 24-Hz or 24/1.001-Hz frame frequency shall be as illustrated in Figure 6.

For 8K/Fr (Fr = 30, 30/1.001, 25, 24, 24/1.001), the three color components that constitute the image shall be divided into four to produce N (N=6, 8, or 12) 4K Sub-Images, and then 4N basic images shall be generated. Next, the 4N basic images shall be converted to 4N basic streams, each eight of which shall be mapped to one 10G link signal to generate 4 or 6 10G link signals. The reason for there being no N/2 is that 10G link signals are generated for each color component. Detailed specifications are in Section 7.2.3.

For 4K/Fr (Fr = 30, 30/1.001, 25, 24, 24/1.001), the three color components that constitute the image shall be divided into four to produce M (M=6, 8, or 12) basic images. The M basic images shall be converted to M basic streams, each eight of which shall be mapped to one 10G link signal to generate three 10G link signals. The reason for there being no M/8 is that 10G link signals are generated for each color component. Detailed specifications are in Section 7.2.6.

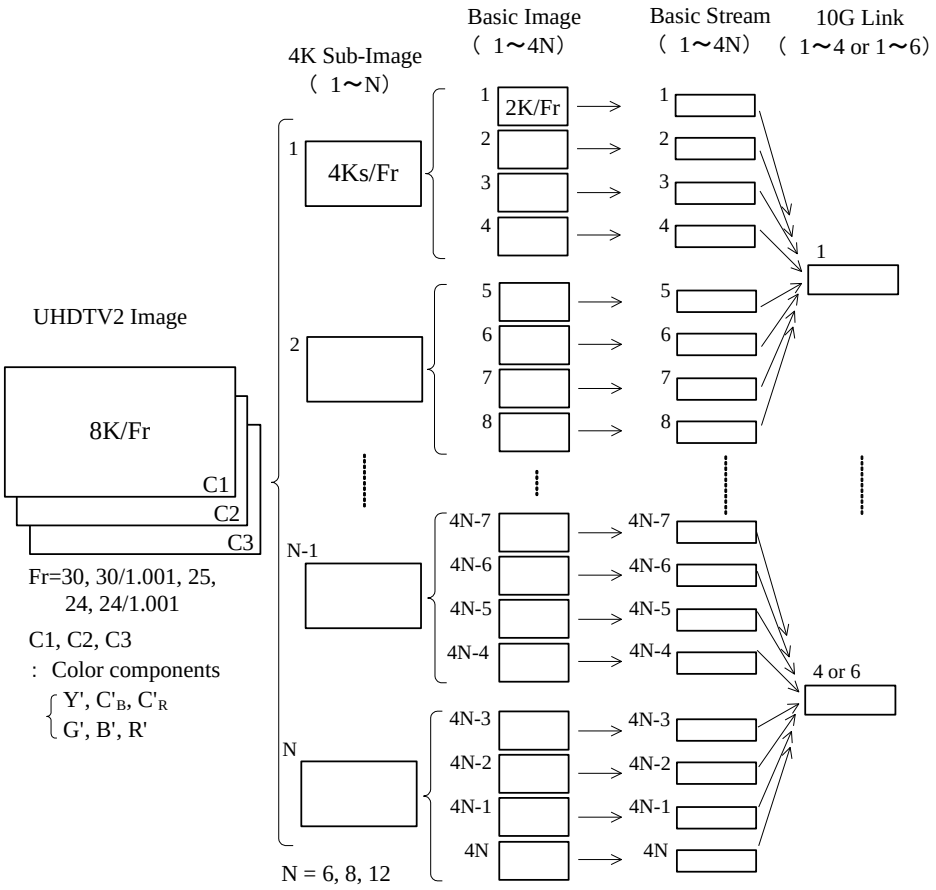

Figure 5 – Mapping overview of UHDTV2 images with 30-Hz, 30/1.001-Hz, 25-Hz, 24-Hz or 24/1.001-Hz frame frequency

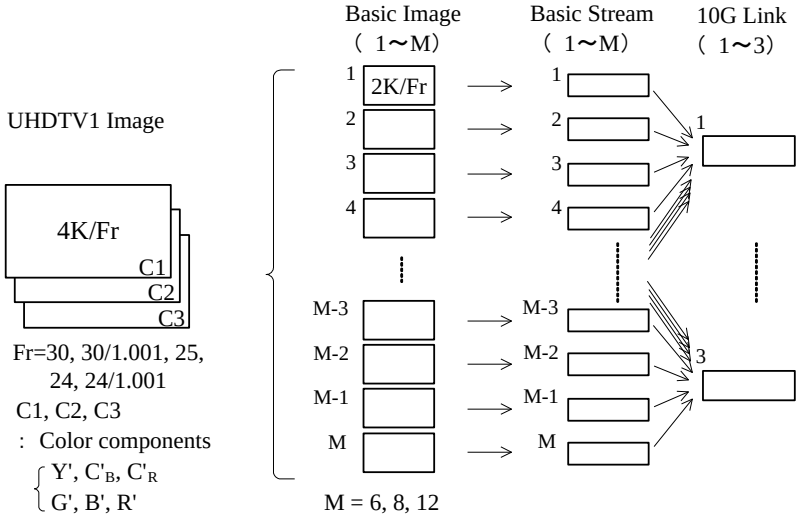

Figure 6 – Mapping overview of UHDTV1 images with 30-Hz, 30/1.001-Hz, 25-Hz, 24-Hz or 24/1.001-Hz frame frequency

5.1.4 Configuration of color signal component and system ID

Figure 7 illustrates the image division of UHDTV2 images into 4K Sub-Images and UHDTV1 images into basic images when the sampling structures for UHDTV2 images and UHDTV1 images are 4:2:2 ($Y'C'_BC'_R$) or 4:2:0 ($Y'C'_BC'_R$).

For the 4:2:2 ($Y'C'_BC'_R$) sampling structure, the color components of the 4K Sub-Images generated from the UHDTV2 images shall be limited to Y1, Y2, Y3, Y4, C_B1, C_B3, C_R1, and C_R3 and the color components of the basic images generated from the UHDTV1 image shall be limited to y1, y2, y3, y4, c_B1, c_B3, c_R1, and c_R3.

For the sampling structure 4:2:0 ($Y'C'_BC'_R$), the color components of the 4K Sub-Images generated from the UHDTV2 images shall be limited to Y1, Y2, Y3, Y4, C_B1, C_R1 and the color components of the basic images generated from the UHDTV1 image shall be limited to y1, y2, y3, y4, c_B1, and c_R1.

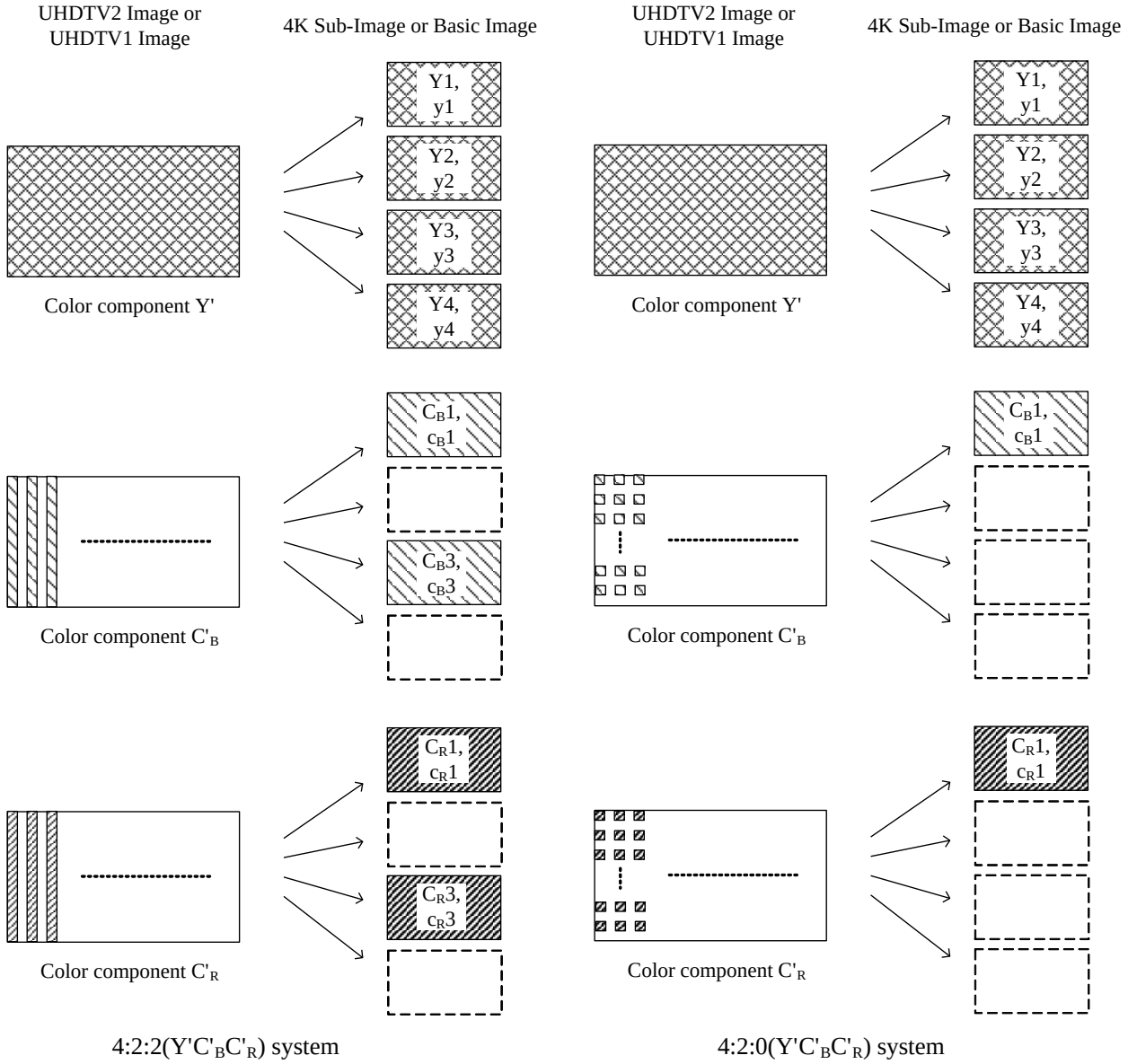

Figure 7 – Image division of 4:2:2 ($Y'C'_BC'_R$) and 4:2:0 ($Y'C'_BC'_R$) systems

The system numbers for identifying the image format are defined in Table 1 for UHDTV1 images and in Table 2 for UHDTV2 images.

Table 1 – UHDTV1 image formats

UHDTV1 Image Sampling Structure	Basic Image		Frame Frequency (Hz)	Number of 10G Links	System Number
	Number of Basic Images (M)	Elements of Color Components			
UHDTV1, 4:4:4(G′B′R′)	12	g1, g2, b1, b2, r1, r2, g3, g4, b3, b4, r3, r4	120, 120/1.001	6	U1.1
			100	6	U1.2
			60, 60/1.001	3	U1.3
			50	3	U1.4
			30, 30/1.001	3	U1.5
			25	3	U1.6
			24, 24/1.001	3	U1.7
UHDTV1, 4:4:4(Y′C′$_B$C′$_R$)	12	y1, y2, c_B1, c_B2, c_R1, c_R2, y3, y4, c_B3, c_B4, c_R3, c_R4	120, 120/1.001	6	U1.8
			100	6	U1.9
			60, 60/1.001	3	U1.10
			50	3	U1.11
			30, 30/1.001	3	U1.12
			25	3	U1.13
			24, 24/1.001	3	U1.14
UHDTV1, 4:2:2(Y′C′$_B$C′$_R$)	8	y1, y2, c_B1, c_R1, y3, y4, c_B3, c_R3	120, 120/1.001	4	U1.15
			100	4	U1.16
			60, 60/1.001	3	U1.17
			50	3	U1.18
			30, 30/1.001	3	U1.19
			25	3	U1.20
			24, 24/1.001	3	U1.21
UHDTV1, 4:2:0(Y′C′$_B$C′$_R$)	6	y1, y2, c_R1, c_R1, y3, y4	120, 120/1.001	4	U1.22
			100	4	U1.23
			60, 60/1.001	3	U1.24
			50	3	U1.25
			30, 30/1.001	3	U1.26
			25	3	U1.27
			24, 24/1.001	3	U1.28

Table 2 – UHDTV2 Image formats

UHDTV2 Image Sampling Structure	4K Sub-Image		Frame Frequency (Hz)	Number of 10G Links	System Number
	Number of Sub-Images (N)	Elements of Color Components			
UHDTV2, 4:4:4(G′B′R′)	12	G1, G2, B1, B2, R1, R2, G3, G4, B3, B4, R3, R4	120, 120/1.001	24	U2.1
			100	24	U2.2
			60, 60/1.001	12	U2.3
			50	12	U2.4
			30, 30/1.001	6	U2.5
			25	6	U2.6
			24, 24/1.001	6	U2.7
UHDTV2, 4:4:4(Y′$C'_B$$C'_R$)	12	Y1, Y2, C_B1, C_B2, C_R1, C_R2, Y3, Y4, C_B3, C_B4, C_R3, C_R4	120, 120/1.001	24	U2.8
			100	24	U.2.9
			60, 60/1.001	12	U2.10
			50	12	U2.11
			30, 30/1.001	6	U2.12
			25	6	U2.13
			24, 24/1.001	6	U2.14
UHDTV2, 4:2:2(Y′$C'_B$$C'_R$)	8	Y1, Y2, C_B1, C_R1, Y3, Y4, C_B3, C_R3	120, 120/1.001	16	U2.15
			100	16	U2.16
			60, 60/1.001	8	U2.17
			50	8	U2.18
			30, 30/1.001	4	U2.19
			25	4	U2.20
			24, 24/1.001	4	U2.21
UHDTV2, 4:2:0(Y′$C'_B$$C'_R$)	6	Y1, Y2, C_B1, C_R1, Y3, Y4	120, 120/1.001	12	U2.22
			100	12	U2.23
			60, 60/1.001	6	U2.24
			50	6	U2.25
			30, 30/1.001	4	U2.26
			25	4	U2.27
			24, 24/1.001	4	U2.28

5.2 Division of UHDTV2 Images into 4K Sub-Images

The division of UHDTV2 images into 4K Sub-Images shall be as illustrated in Figure 8. In the line numbering for each UHDTV2 image sample, the uppermost line in the vertical direction shall be line number 1 and the lowermost line shall be line number 4320; the leftmost sample in the horizontal direction shall be sample number 0 and the rightmost sample shall be sample number 7679. The numbering for each sample of the 4K Sub-Images shall be done similarly, with the uppermost line in the vertical direction as line number 1 and the lowest line as line number 2160, and the leftmost sample in the horizontal direction as sample number 0 and the rightmost sample as sample number 3839.

The even-numbered samples of the odd lines of the UHDTV2 images shall be mapped to 4K Sub-Image 1, and the odd-numbered samples of the odd lines of the UHDTV2 images shall be mapped to 4K Sub-Image 2. The even-numbered samples of the even lines of the UHDTV2 images shall be mapped to 4K Sub-Image 3, and the odd-numbered samples of the even lines of the UHDTV2 images shall be mapped to 4K Sub-Image 4.

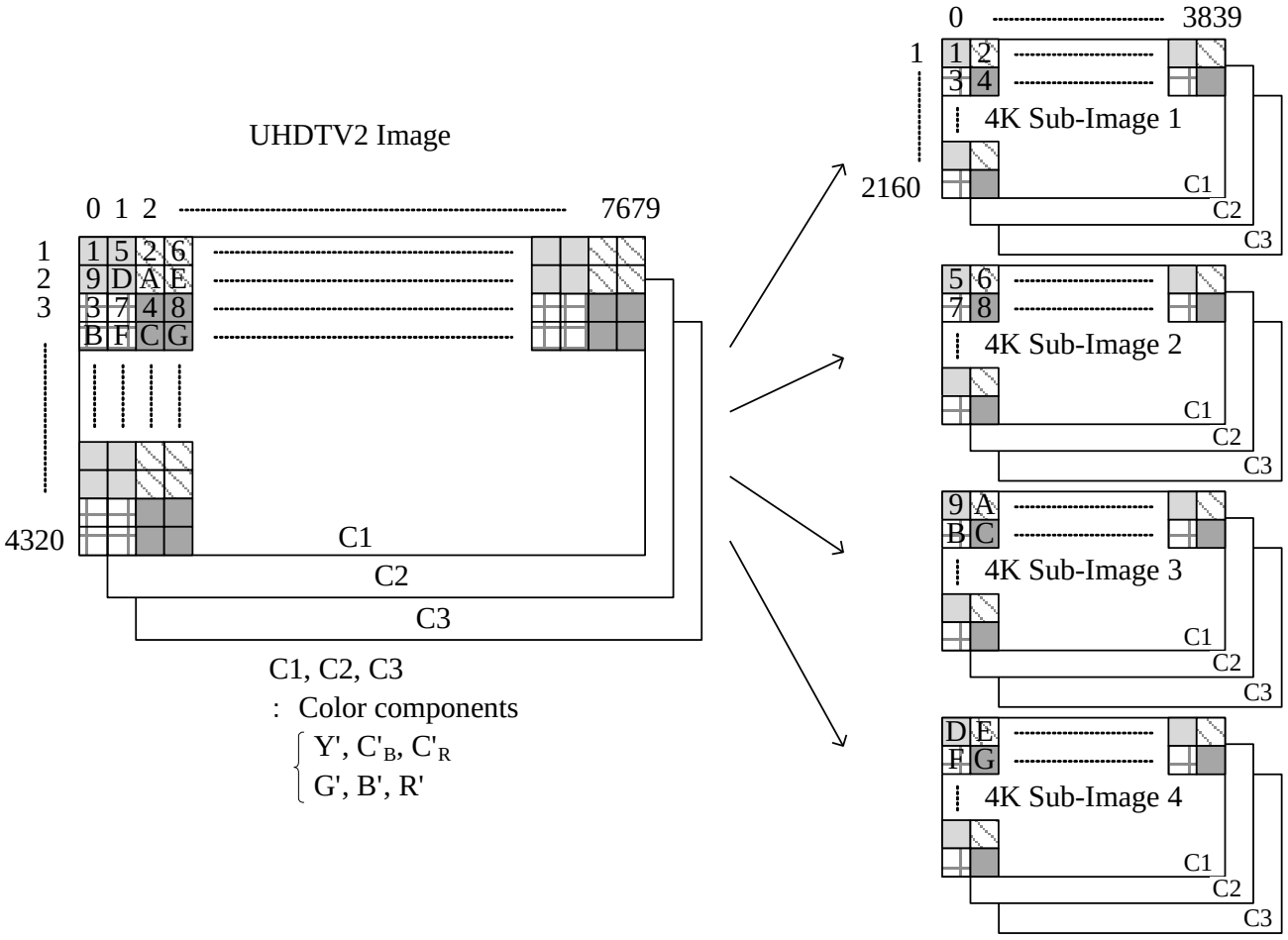

Figure 8 – Image division from UHDTV2 Images to 4K Sub-Images

5.3 Division of UHDTV1 Images and 4K Sub-Images into Basic Images

The division of UHDTV1 images and 4K Sub-Images into basic images shall be as illustrated in Figure 9. The numbering for each sample of the 4K Sub-Images shall be done in the same way as for the 4K Sub-Images, with the uppermost line in the vertical direction as line number 1 and the lowest line as line number 2160, and the leftmost sample in the horizontal direction as sample number 0 and the rightmost sample as sample number 3839. The numbering for each sample of the basic images shall be done similarly, with the uppermost line in the vertical direction as line number 1 and the lowest line as line number 1080, and the leftmost sample in the horizontal direction as sample number 0 and the rightmost sample as sample number 1919.

The even-numbered samples of the odd lines of the UHDTV1 images and 4K Sub-Images shall be mapped to basic image 1 and the odd-numbered samples of the odd lines of the UHDTV1 images and 4K Sub-Images shall be mapped to basic image 2; the even-numbered samples of the even lines of the UHDTV1 images and 4K Sub-Images shall be mapped to basic image 3 and the odd-numbered samples of the even lines of the UHDTV1 images and 4K Sub-Images shall be mapped to basic image 4.

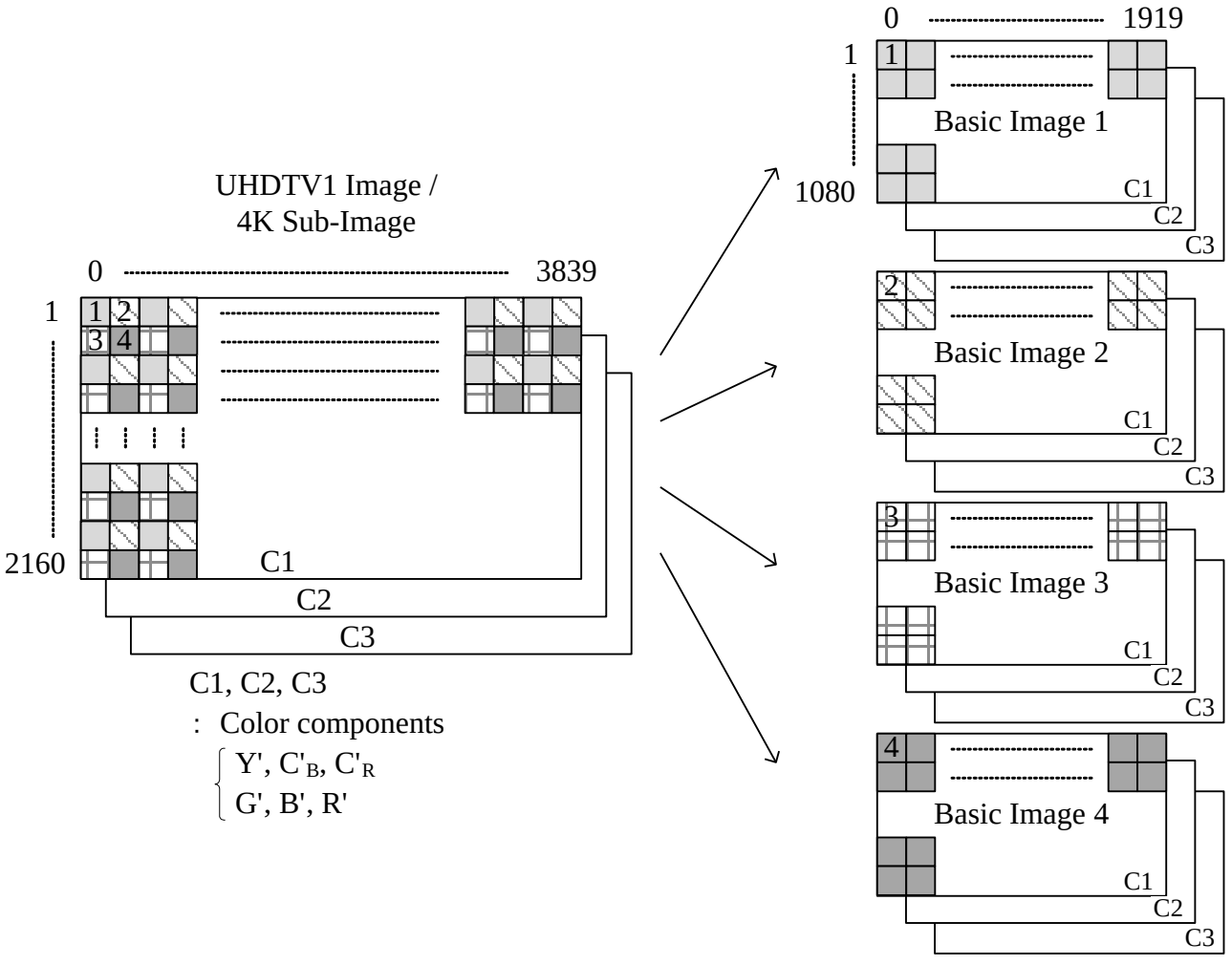

Figure 9 – Image division of UHDTV1 images or 4K Sub-Image into Basic Images

6 Basic Stream

6.1 Conversion from Basic Images to Basic Streams

The method for converting each line when converting basic images to basic streams shall be as shown in Figure 10. Each sample of the basic image is either 10 bits or 12 bits. For the 10 bit case, a two-bit shift shall be done to fill the least significant two bits with “00” to produce a 12-bit word so that the word for all of the basic streams is 12 bits.

As shown in Figure 10, the one line period of basic stream shall consist of a four-word EAV (End of Active Video) timing reference code, a two-word line number (LN), a two-word CRCC (Cyclic Redundancy Check Code) error detection code, ancillary data or blanking data, a four-word SAV (Start of Active Video) timing reference code, and video data. The sample numbers of a basic stream shall be determined as shown in Table 3.

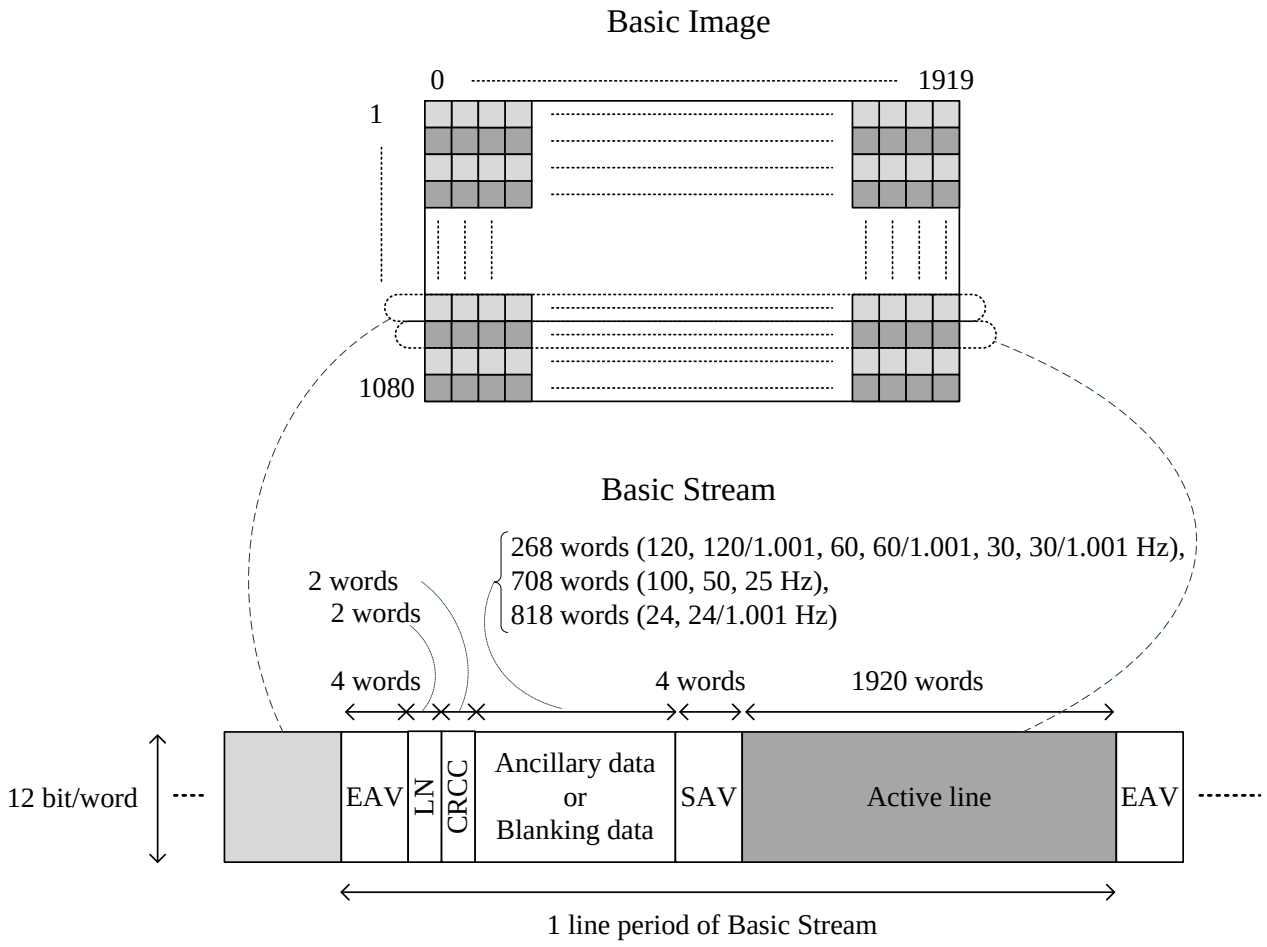

Figure 10 – Line structure of Basic Stream

Table 3 – Sample numbers of Basic Stream

Item	Symbol		Sample number		
			120, 120/1.001, 60, 60/1.001, 30 or 30/1.001-Hz frame frequency	100, 50 or 25-Hz frame frequency	24 or 24/1.001-Hz frame frequency
Active line (video data)	D		0-1919		
Timing reference code (EAV)	EAV		1920, 1921, 1922, 1923		
Line number data	LN	LN0	1924		
		LN1	1925		
Cyclic redundancy check codes	CRCC	CRCC0	1926		
		CRCC1	1927		
Ancillary data or Blanking data	ANC		1928-2195	1928-2635	1928-2745
Timing reference code (SAV)	SAV		2196, 2197, 2198, 2199	2636, 2637, 2638, 2639	2746, 2747, 2748, 2749

The frame structure of a basic stream shall be as shown in Figure 11 and the basic stream line numbering as shown in Table 4. A basic stream shall comprise 1080-line active frame and 45-line frame blanking intervals. The samples from the first line of a basic image to the 1080th line shall be from line 42 to line 1121 of the basic stream. The frame blanking shall be assigned from line 1 to line 41 and from line 1122 to line 1125. The line structure of the frame blanking shall be that of the active frame shown in Figure 10, with a 1920-word region of the active line allocated to the ancillary data or blanking data.

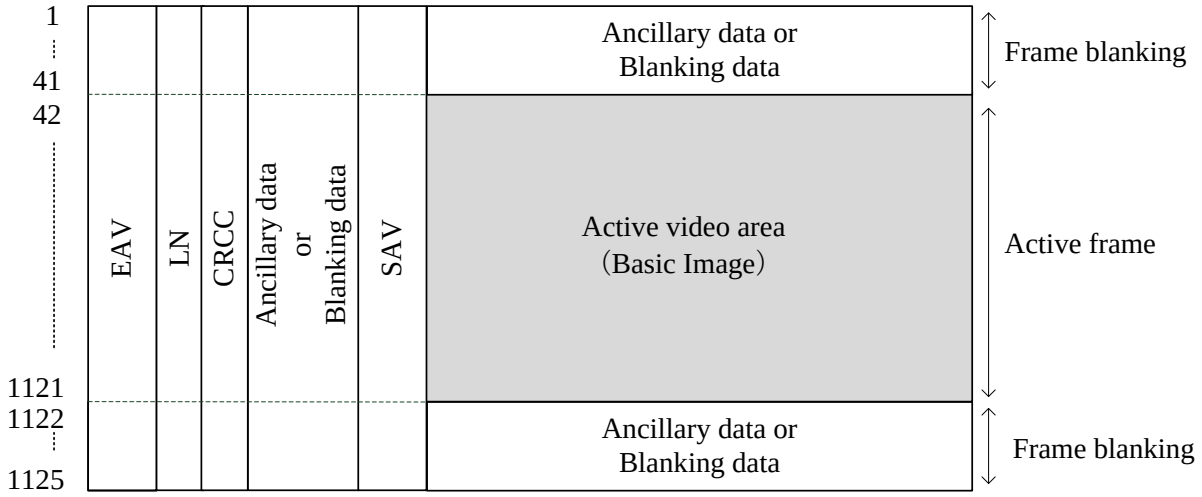

Figure 11 – Frame structure of Basic Stream

Table 4 – Line numbers of Basic Stream

Item	Line number
Frame blanking	1-41, 1122-1125
Active frame	42-1121

6.2 Timing reference codes (SAV and EAV)

The two timing reference codes are the SAV, which shall be placed immediately before the video data (active line), and the EAV, which shall be placed immediately after the video data. The bit assignments for the SAV and EAV shall be as shown in Table 5 and the protection bit assignments shall be as shown in Table 6.

In Table 5 and Table 6, F is an identification bit for progressive/interlaced (first/second field). The images in this recommendation shall be progressive, so the value of F is fixed at 0. The V is an identifier bit for the frame blanking and the active video data. The value of V shall be 1 in the frame blanking from line 1 to line 41 and from line 1122 to line 1125; the value shall be 0 in the active video data from line 42 to line 1121. The H is an identifier bit that shall have a value of 0 for SAV and 1 for EAV. The values P0 through P3 are parity bits, which are used for one bit error correction and two bits error detection on the receiving side. The assignment of those bits shall be as shown in Table 6.

Table 5 – Bit assignment for timing reference codes

Word	Value	Bit number											
		b11 (MSB)	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0 (LSB)
1	FFFh	1	1	1	1	1	1	1	1	1	1	1	1
2	000h	0	0	0	0	0	0	0	0	0	0	0	0
3	000h	0	0	0	0	0	0	0	0	0	0	0	0
4	XYZ	1	F	V	H	P_3	P_2	P_1	P_0	0	0	0	0

Table 6 – Protection bits for timing reference codes

Bit number	b10	b9	b8	b7	b6	b5	b4
Function	F	V	H	P_3	P_2	P_1	P_0
Bit pattern 0	0	0	0	0	0	0	0
Bit pattern 1	0	0	1	1	1	0	1
Bit pattern 2	0	1	0	1	0	1	1
Bit pattern 3	0	1	1	0	1	1	0

6.3 Line Number Data

The line numbering of the basic stream shall use the line numbers for the basic stream specified in Figure11 and Table 4 rather than the line numbers of the UHDTV2 or UHDTV1 image. The line number data shall be represented in binary format using the 11 bits from L0 (LSB) to L10 (MSB). The bit assignment of line number data LN0 and LN1 shall be as shown in Table 7. The reserved bits of Table 7 shall be set to "0".

Table 7 – Bit assignment for line number

Bit number	LN0	LN1
b11 (MSB)	NOT b10	NOT b10
b10	L6	Reserved
b9	L5	Reserved
b8	L4	Reserved
b7	L3	L10 (MSB)
b6	L2	L9
b5	L1	L8
b4	L0 (LSB)	L7
b3	Reserved	Reserved
b2	Reserved	Reserved
b1	Reserved	Reserved
b0 (LSB)	Reserved	Reserved

6.4 Error Detection Code Data

The basic stream error detection code data shall be represented by the 18 bits from CRCC0 to CRCC17 and is defined as follows.

(1) Error detection code: CRCC (Cyclic Redundancy Check Code)

(2) Polynomial generator equation:

$C(X) = X^{18}+X^5+X^4+1$. The initial value shall be set to 0.

(3) Error detection code generation range:

Start point: The first word after the SAV of the previous line

End point: The last word of the line number data

(4) Error detection code generation sequence:

Shall begin with the LSB of the first word of the error detection code generation range and end with the MSB of the last word in that range.

(5) Bit assignment:

Table 8 specifies the bit assignment. CRCC0 is the MSB of the error detection code.

The reserved bits of Table 8 shall be set to "0" until defined.

Table 8 – Bit assignment for CRCC

Bit number	CRC0	CRC1
b11 (MSB)	NOT b10	NOT b10
b10	CRCC8	CRCC17
b9	CRCC7	CRCC16
b8	CRCC6	CRCC15
b7	CRCC5	CRCC14
b6	CRCC4	CRCC13
b5	CRCC3	CRCC12
b4	CRCC2	CRCC11
b3	CRCC1	CRCC10
b2	CRCC0	CRCC9
b1	Reserved	Reserved
b0 (LSB)	Reserved	Reserved

6.5 Ancillary Data

The ancillary data shall be mapped into the blanking area of basic stream 1 and basic stream 2. The data format shall be in conformance with SMPTE ST 291-1.

When the ancillary data packet is specified as 10bits/word, the conversion shown in Figure 12 shall apply. In Figure 12, ADF indicates an ancillary data flag, DID indicates a data identifier word, DBN indicates a data block number word, SDID indicates second data identifier word, DC indicates a data count word, UDW indicates a user data word and CS indicates a checksum word. As shown in Figure 12, for ancillary data packets specified as 10 bits/word, excluding ADF and CS, the lowest two bits shall be filled with "00" to convert to a 12-bit word format and a two bit shift shall be applied to the bit assignment specified for the 10-bit words. For the three words of the ADF, "00" shall be appended to the lowest two bits of the first word and "11" shall be appended to the lowest two bits of the other two words for conversion to 12-bit words. For CS, the lower 11 bits of the sum of the lower 11 bits of the words from DID to the last UDW shall be assigned as b0 (LSB) to b10 of CS, and b11 (MSB) shall be set as the inverse of b10.

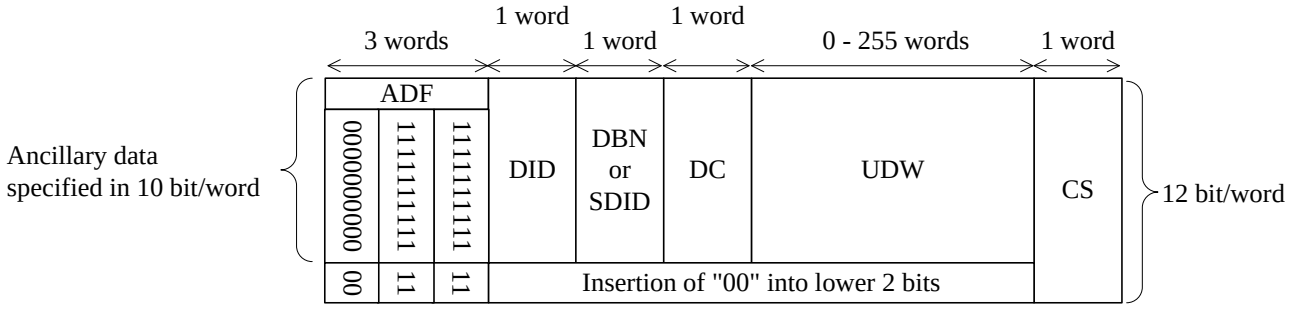

Figure 12 – Conversion of ancillary data packet from 10 bit/word to 12 bit/word

6.6 Payload ID

The payload identifier shall be in conformance with the general video payload identifier format defined in SMPTE ST 352. The specification and carriage of this video payload identifier shall also be in conformance with SMPTE ST 352.

The UDW bit assignment of Payload ID packet shall be as shown in Table 9. The Payload ID packet shall be multiplexed once per frame of the basic stream. The recommended location should be immediately after the CRCC of the basic stream in line 10.

Table 9 – Payload identifier definitions

<table>
<tr><th>Bit number</th><th>Word 1</th><th>Word 2</th><th>Word 3</th><th>Word 4</th></tr>
<tr><td>b9
(MSB)</td><td>NOT b8</td><td>NOT b8</td><td>NOT b8</td><td>NOT b8</td></tr>
<tr><td>b8</td><td>EP
(Note 1)</td><td>EP</td><td>EP</td><td>EP</td></tr>
<tr><td>b7</td><td>1</td><td>Progressive (1)</td><td rowspan="3">Channel assignment of basic stream
Ch1 (0h), Ch2 (1h),
Ch3 (2h), Ch4 (3h),
Ch5 (4h), Ch6 (5h),
Ch7 (6h) or Ch8 (7h)</td><td rowspan="4">10G link assignment
Ch1 (00h) -
Ch24 (17h)

Other values are reserved.</td></tr>
<tr><td>b6</td><td>0</td><td>Progressive (1)</td></tr>
<tr><td>b5</td><td>1</td><td>Reserved(0)</td></tr>
<tr><td>b4</td><td>0</td><td>Reserved(0)</td><td>Reserved(0)</td></tr>
<tr><td>b3</td><td>0</td><td rowspan="3">Picture rate

Undefined (0h),
Reserved (1h),
24/1.001 Hz (2h),
24 Hz (3h),
25 Hz (5h),
30/1.001 Hz (6h),
30 Hz (7h),
50 Hz (9h),
60/1.001 Hz (Ah),
60 Hz (Bh),
100 Hz (Dh)
120/1.001 Hz (Eh)
120 Hz (Fh)</td><td rowspan="3">Sampling structure identification

4:2:2 (Y′C′_BC′_R) (0h),
4:4:4 (Y′C′_BC′_R) (1h),
4:4:4 (G′B′R′) (2h),
4:2:0 (Y′C′_BC′_R) (3h),

Other values are reserved.</td><td rowspan="2">Color encoding
(Note 2)
Rec. 709 (1)
Rec. 2020 (0)</td></tr>
<tr><td>b2</td><td>1</td></tr>
<tr><td>b1</td><td rowspan="2">UHDTV1/UHDTV2
UHDTV1 (1h),
UHDTV2 (2h)

Other values are not assigned.</td><td rowspan="2">Bit depth
Reserved (0h),
10-bit (1h),
12-bit (2h),
Reserved (3h)</td></tr>
<tr><td>b0
(LSB)</td></tr>
<tr><td colspan="5">Note 1: EP = Even parity for b0 through b7.
Note 2: SMPTE ST 2036-1 allows implementers to optionally adopt the conventional reference primaries (Rec.709) for UHDTV1 up to 60 Hz.</td></tr>
</table>

6.7 Blanking Data

The blanking data words occurring during blanking intervals that are not used for the timing reference codes (SAV and EAV), line number data, error detection codes or ancillary data shall be as listed below.

(1) Basic streams for color components Y′, G′, B′, R′: 100h

(2) Basic streams for color components C'_B, C'_R: 800h

7 Generation of 10G Link Signals

7.1 Generating 10G Link Signals from Basic Streams

7.1.1 Generating 10G link signals from 120-Hz, 120/1.001-Hz or 100-Hz basic streams

The method for converting two 120-Hz, 120/1.001-Hz or 100-Hz basic stream to one 10G link signal shall be as shown in Figure 13 to Figure 16.

First, two basic streams shall be multiplexed word-by-word and converted to a multiplexed data stream. Stuffing data shall be added to the two basic streams as shown in Figure 13. This results in a data stream that has 5280 words per line period for a frame frequency of 120 Hz and 120/1.001 Hz, or 6336 words per line period for a frame frequency of 100 Hz. The stuffing data, shall have a value of 100h.

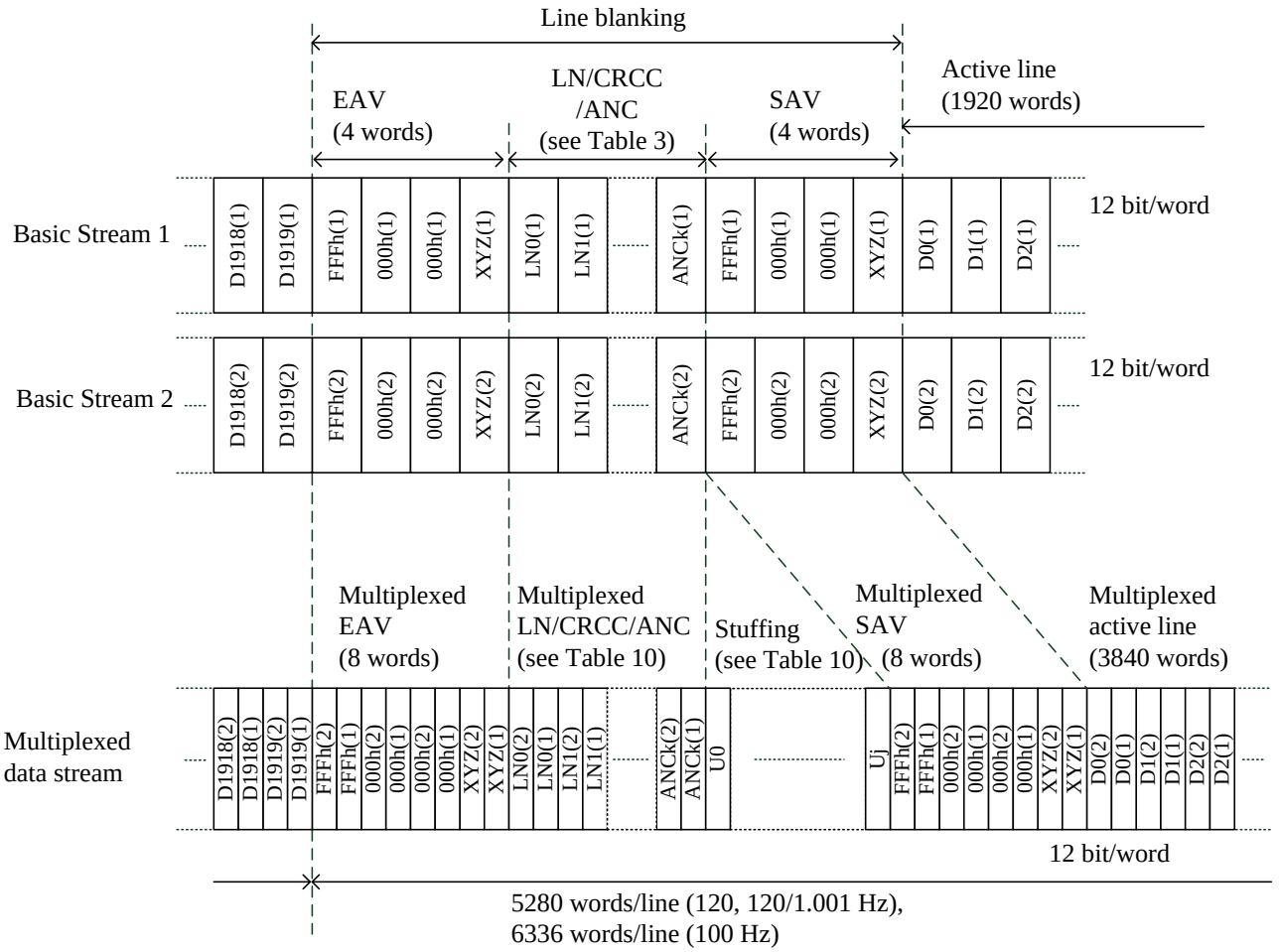

Figure 13 – Multiplexing of two 120, 120/1.001 or 100 Hz Basic Streams

Table 10 – Line structure of a 120, 120/1.001 or 100 Hz multiplexed data stream

Item	Number of data words	
	120 or 120/1.001-Hz frame frequency	100-Hz frame frequency
Multiplexed EAV	8	
Multiplexed LN/CRCC/ANC	544	1424
Stuffing data	880	1056
Multiplexed SAV	8	
Multiplexed active video	3840	
Total word for a line	5280	6336

Next, the word-multiplexed data stream shall be coded by 8B/10B encoding as specified by ANSI INCITS 230.

The multiplexed data stream consisting of 12-bit words shall be first converted to a byte series as shown in Figure 14, and then coded as 8B/10B encoded data. The conversion to byte series shall be done in order from the beginning of the active line and every two words Figure 15. The 8B/10B coding, shall result in the first four bytes of the multiplexed SAV and EAV being replaced with a synchronization block as shown in Figure16. The first two words of the multiplexed SAV shall be replaced with the K28.5 special characters and those of the multiplexed EAV shall be replaced with the K29.7 special characters defined by ANSI INCITS 230, and the successive two words shall be replaced with content IDs. The content ID bit assignment shall be as shown in Table 11 and the bit assignment of the system ID, which is part of the content ID, is shown in Table 12. The 8B/10B encoding process shall start at the first K28.5 special character with a negative running disparity.

The 8B/10B encoding converts two 12-bit words of data to three 10-bit words. The word-multiplexed data stream has 7920 words per line period (10 bit/word) for the 120-Hz and 120/1.001-Hz frame frequencies and 9504 words (10 bits/word) per line period for the 100-Hz frame frequency.

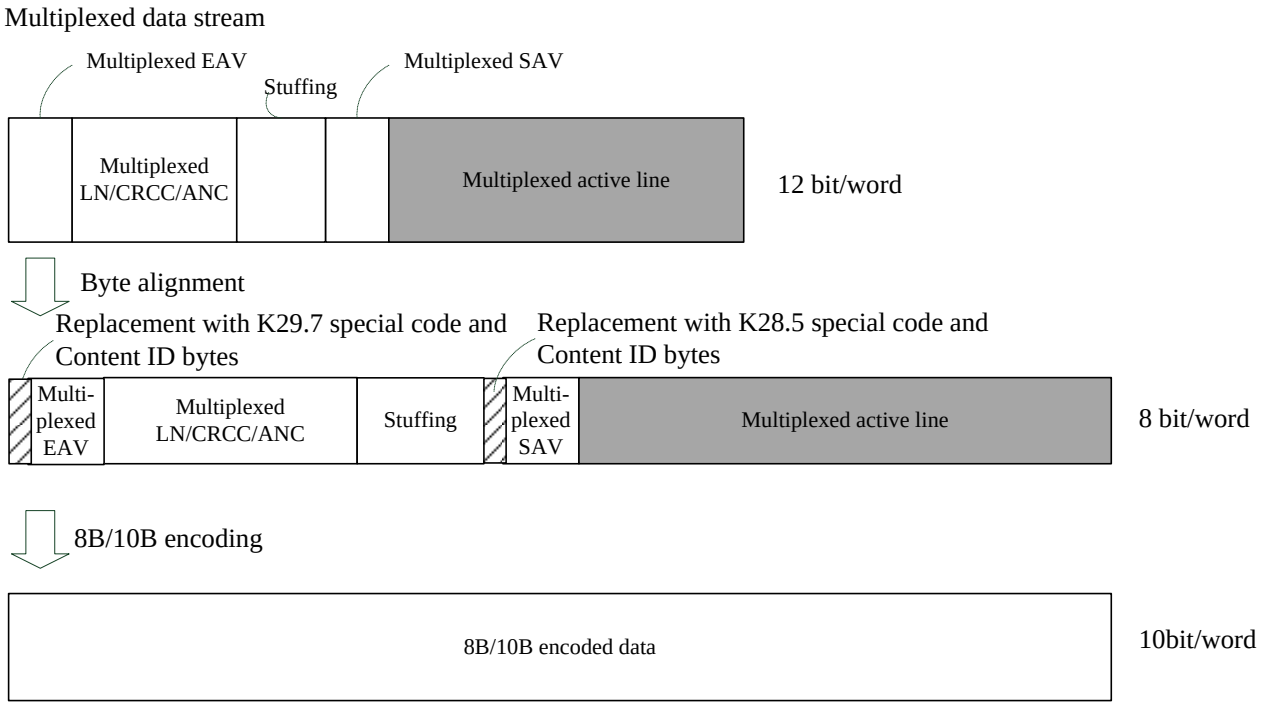

Figure 14 – 8B/10B encoding of multiplexed data stream

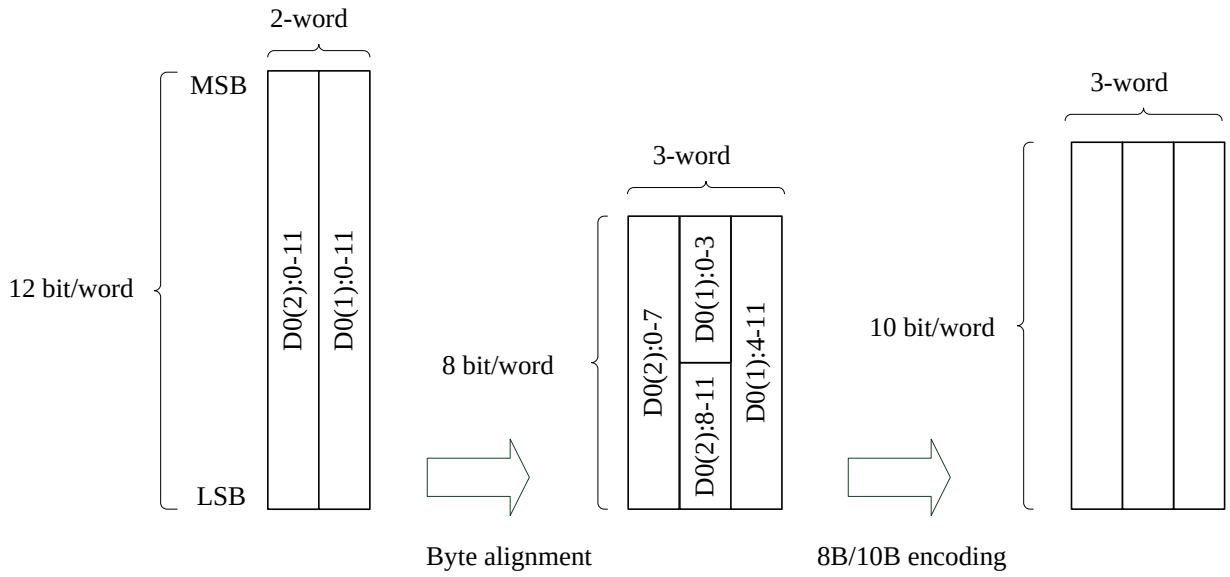

Figure 15 – Data alignment and 8B/10B encoding of 2-word data block

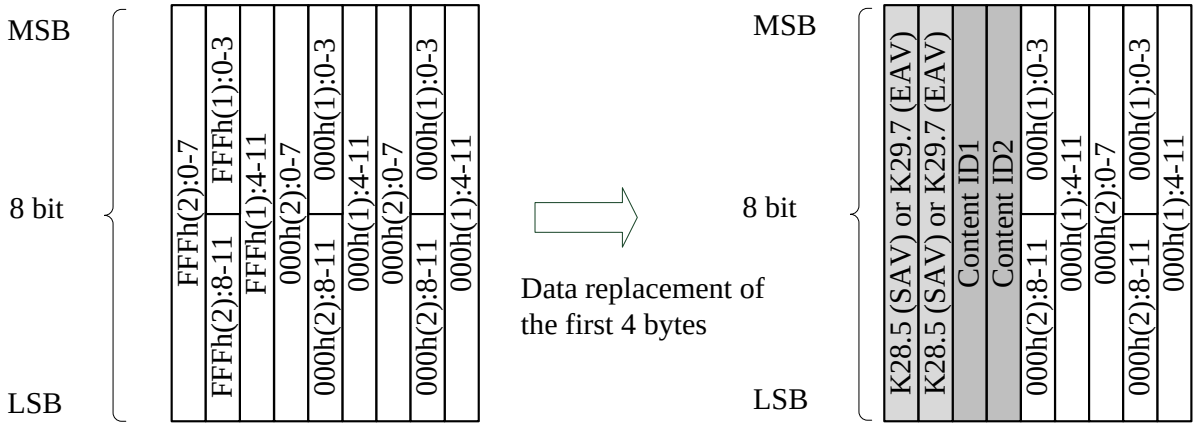

Figure 16 – Multiplexed SAV and EAV data replacement with synchronization block (120 Hz, 120/1.001 Hz or 100 Hz)

Table 11 – Content ID bit assignment

Bit	Content ID1	Content ID2
b7 (MSB)	Reserved (0h)	Reserved (0h)
b6		
b5	System ID	
b4		10G link assignment Ch1 (00h) to Ch24 (17h)
b3		
b2		
b1		
b0 (LSB)		

Table 12 – System ID bit assignment

System ID (b5 to b0)	System Number	System ID (b5 to b0)	System Number	System ID (b5 to b0)	System Number	System ID (b5 to b0)	System Number
000000	U1.1	001111	U1.16	100000	U2.1	101111	U2.16
000001	U1.2	010000	U1.17	100001	U2.2	110000	U2.17
000010	U1.3	010001	U1.18	100010	U2.3	110001	U2.18
000011	U1.4	010010	U1.19	100011	U2.4	110010	U2.19
000100	U1.5	010011	U1.20	100100	U2.5	110011	U2.20
000101	U1.6	010100	U1.21	100101	U2.6	110100	U2.21
000110	U1.7	010101	U1.22	100110	U2.7	110101	U2.22
000111	U1.8	010110	U1.23	100111	U2.8	110110	U2.23
001000	U1.9	010111	U1.24	101000	U2.9	110111	U2.24
001001	U1.10	011000	U1.25	101001	U2.10	111000	U2.25
001010	U1.11	011001	U1.26	101010	U2.11	111001	U2.26
001011	U1.12	011010	U1.27	101011	U2.12	111010	U2.27
001100	U1.13	011011	U1.28	101100	U2.13	111011	U2.28
001101	U1.14	011100 ~ 011111	Reserved	101101	U2.14	111100 ~ 111111	Reserved
001110	U1.15			101110	U2.15		

Next, the 8B/10B coded data shall be serialized from the least significant bit (LSB) into the serial stream of 10G link signal. The speed of the 10G link signals generated as described above is calculated by the following equation:

The speed of the 10G link signals (Gb/s)

=(Total words for a line described in Table 10) × 3/2 × 10 (bits/word) × 1125 (lines) × the frame frequency (1/second).

For the frame frequency of 120 Hz and 100 Hz, the speed is 10.692 Gb/s. For the frame frequency of 120/1.001 Hz, the speed is 10.692/1.001 Gb/s.

7.1.2 Generating 10G link signals from 60-Hz, 60/1.001-Hz or 50-Hz basic streams

The method for converting four 60-Hz, 60/1.001-Hz or 50-Hz basic streams to one 10G link signal shall be as shown in Figure 17 and Figure 18. First, the four basic streams shall be converted to a word-multiplexed data stream by multiplexing word by word. Stuffing data shall be added to the four basic streams as shown in Figure 17. This results in a data stream that has 10560 words per line period for a frame frequency of 60 Hz or 60/1.001 Hz, or 12672 words per line period for a frame frequency of 50 Hz. The stuffing data shall have a value of 100h.

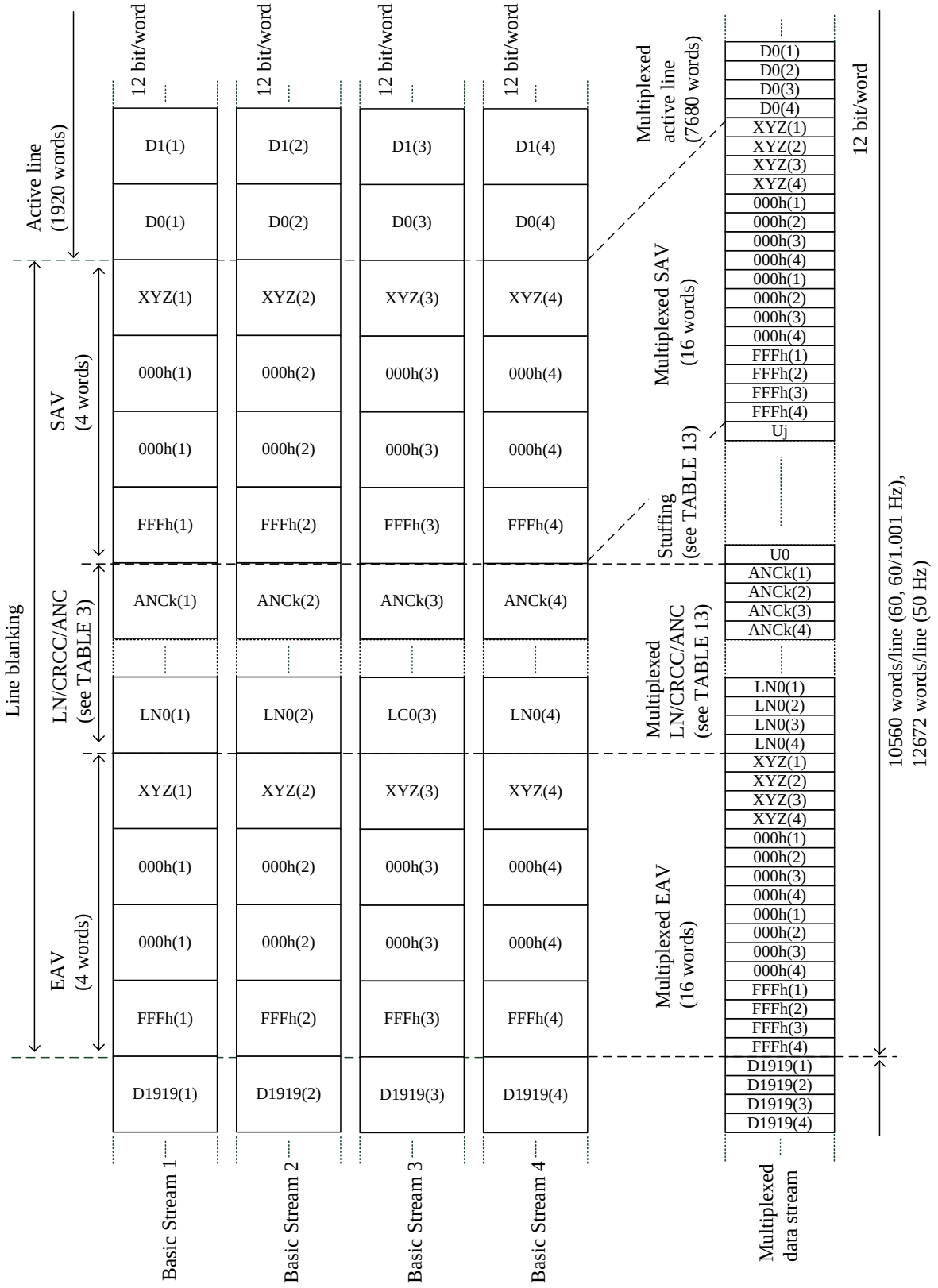

Figure 17 – Multiplexing of four 60-Hz, 60/1.001-Hz or 50-Hz Basic Streams

Table 13 – Line structure of a 60-Hz, 60/1.001-Hz or 50-Hz multiplexed data stream

Item	Number of data words	
	60 or 60/1.001-Hz frame frequency	50-Hz frame frequency
Multiplexed EAV	16	
Multiplexed LN/CRCC/ANC	1088	2848
Stuffing data	1760	2112
Multiplexed SAV	16	
Multiplexed active video	7680	
Total word for a line	10560	12672

The word-multiplexed data stream shall be coded by 8B/10B encoding as specified by ANSI INCITS 230.

The multiplexed data stream consisting of 12-bit words shall be first converted to a byte series and then coded as 8B/10B encoded data. The conversion to byte series shall be done in order from the beginning of the active data D0(4) and every two words as shown in Figure 15. When doing the 8B/10B encoding, the first four bytes of the multiplexed SAV and EAV shall be converted to a synchronization block as shown in Figure 18. The first two words of the multiplexed SAV shall be replaced with the K28.5 special characters and those of the multiplexed EAV shall be replaced with the K29.7 special characters defined by ANSI INCITS 230, and the successive two words are replaced with content IDs. The content ID bit assignment shall be as shown in Table 11 and Table 12. The 8B/10B encoding process shall start at the first K28.5 special character with a negative running disparity.

The 8B/10B encoding converts two 12-bit words of data to three 10-bit words. The word-multiplexed data stream has 15840 words (10 bits/word) per line period for the 60-Hz and 60/1.001-Hz frame frequencies and 19008 words (10 bits/word) per line period for the 50-Hz frame frequency.

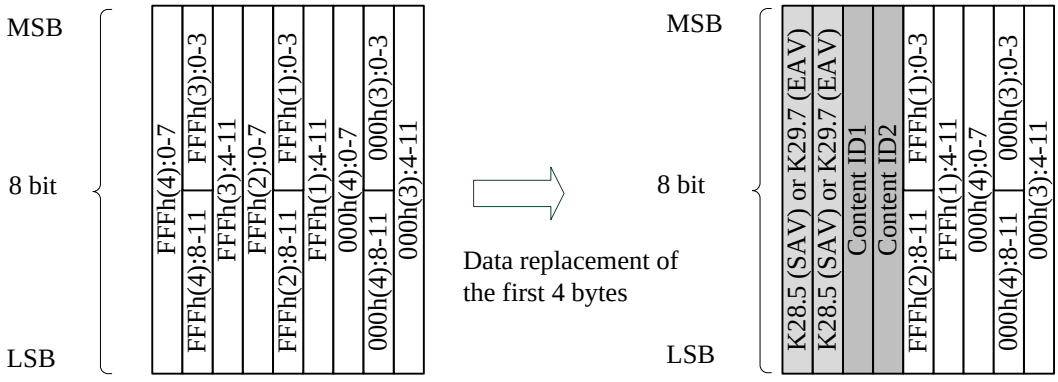

Figure 18 – Multiplexed SAV and EAV data replacement with synchronization block (60 Hz, 60/1.001 Hz or 50 Hz)

The 8B/10B coded data shall be serialized from the least significant bit (LSB) into the serial stream of 10G link signal. The speed of the 10G link signals generated as described above is calculated by the following equation:

The speed of the 10G link signals (Gb/s)

=(Total words for a line described in Table 13) × 3/2 × 10 (bits/word) × 1125 (lines) × the frame frequency (1/second).

For the frame frequency of 60 Hz and 50 Hz, the speed is 10.692 Gb/s. For the frame frequency of 60/1.001 Hz, the speed is 10.692/1.001 Gb/s.

7.1.3 Generating 10G link signals from 30-Hz, 30/1.001-Hz, 25-Hz, 24-Hz or 24/1.001-Hz basic streams

The method for converting eight 30-Hz, 30/1.001-Hz, 25-Hz, 24-Hz or 24/1.001-Hz basic streams into one 10G link signal shall be as shown in Figure 19 and Figure 20. First, the eight 30-Hz basic streams shall be converted to a word-multiplexed data stream by multiplexing word by word. Adding stuffing data to the eight basic streams shall be as shown in Figure 19 resulting in a data stream that has 21120 words for a frame frequency of 30 Hz or 30/1.001 Hz, 25344 words for a frame frequency of 25 Hz, and 26400 words for a frame frequency of 24 Hz or 24/1.001 Hz. The stuffing data shall have a value of 100h.

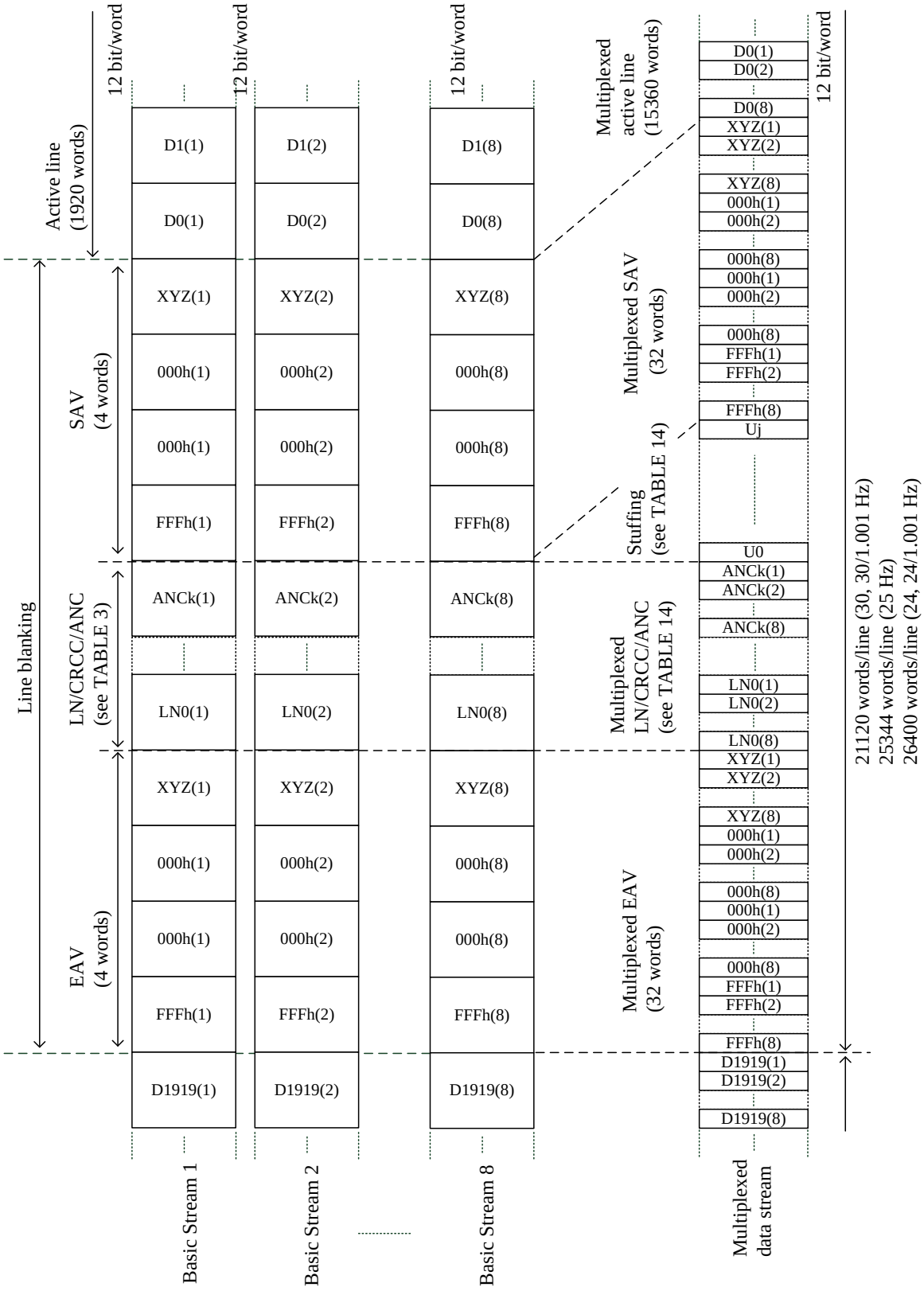

Figure 19 – Multiplexing of eight 30-Hz, 30/1.001-Hz, 24-Hz or 24/1.001-Hz Basic Streams

Table 14 – Line structure of a 30-Hz, 30/1.001-Hz, 25-Hz, 24-Hz or 24/1.001-Hz multiplexed data stream

Item	Number of data words		
	30 or 30/1.001-Hz frame frequency	25-Hz frame frequency	24 or 24/1.001-Hz frame frequency
Multiplexed EAV	32		
Multiplexed LN/CRCC/ANC	2176	5696	6576
Stuffing data	3520	4224	4400
Multiplexed SAV	32		
Multiplexed active video	15360		
Total data words per line	21120	25344	26400

The word-multiplexed data stream shall be coded by 8B/10B encoding as specified by ANSI INCITS 230.

The multiplexed data stream consisting of 12-bit words shall be first converted to a byte series and then coded as 8B/10B encoded data. The conversion to byte series shall be done in order from the beginning of the active data D0(8) and every two words, as shown in Figure 15. The 8B/10B encoding, shall result in the first four bytes of the multiplexed SAV and EAV being converted to a synchronization block as shown in Figure 20. The first two words of the multiplexed SAV shall be replaced with the K28.5 special characters and those of the multiplexed EAV shall be replaced with the K29.7 special character defined by ANSI INCITS 230, and the successive two words are replaced with content IDs. The content ID bit assignment shall be as shown in Table 11 and Table 12. The 8B/10B encoding process shall start at the first K28.5 special character with a negative running disparity.

The 8B/10B encoding converts two 12-bit words of data to three 10-bit words. The word-multiplexed data stream has 31680 words (10 bits/word) per line for frame frequencies of 30 Hz and 30/1.001 Hz, 38016 words (10 bits/word) per line for a frame frequency of 25 Hz, and 39600 words (10 bits/word) per line for frame frequencies of 24 and 24/1.001 Hz.

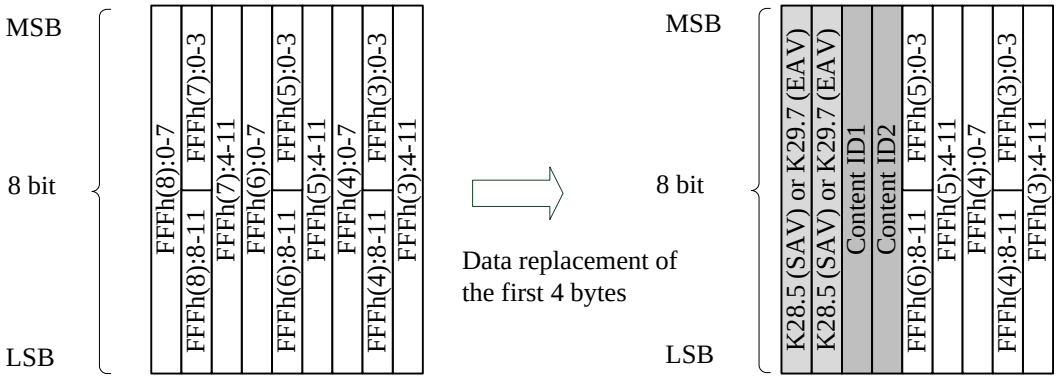

Figure 20 – Multiplexed SAV and EAV data replacement with synchronization block (30 Hz, 30/1.001 Hz, 25 Hz, 24 Hz or 24/1.001 Hz)

The 8B/10B coded data shall be serialized from the least significant bit (LSB) into the serial stream of 10G link signal. The speed of the 10G link signals generated as described above is calculated by the following equation:

The speed of the 10G link signals (Gb/s)

=(Total words for a line described in Table 14) × 3/2 × 10 (bits/word) × 1125 (lines) × the frame frequency (1/second).

For the frame frequency of 30 Hz, 25 Hz and 24 Hz, the speed is 10.692 Gb/s. For the frame frequency of 30/1.001 Hz and 24/1.001 Hz, the speed is 10.692/1.001 Gb/s.

7.2 Mapping of UHDTV2 or UHDTV1 Image to 10G Link Signals

7.2.1 8K/ Fr (Fr = 120, 120/1.001, 100)

The mapping of the 8K/Fr (Fr = 120, 120/1.001, 100) images listed below to the 10G link signals shall be as illustrated in Figure 21 and Figure 22. System numbers in this list are defined in Table 2.

System number U2.1 and U2.2 (8K/Fr, G′B′R′, 4:4:4)

System number U2.8 and U2.9 (8K/Fr, Y′C′$_B$C′$_R$, 4:4:4)

System number U2.15 and U.2.16 (8K/Fr, Y′C′$_B$C′$_R$, 4:2:2)

System number U2.22 and U2.23 (8K/Fr, Y′C′$_B$C′$_R$, 4:2:0)

The SIp.q (p is an integer greater than or equal to 1 and less than or equal to 4; q is an integer greater than or equal to 1 and less than or equal to 3) represents the 4K Sub-Image p for color component Cq generated by division of the UHDTV2 images and shall be mapped as shown in Figure 8. The BIu.p.q (u is an integer greater than or equal to 1 and less than or equal to 4) represents the basic image u generated by further division of 4Ks/Fr SIp.q and shall be mapped as shown in Figure 9. BS1/Fr and BS2/Fr represent the Fr Hz basic stream 1 and Fr Hz basic stream 2 illustrated in Figure 13. For the 8K/Fr mapping, one 10G link signal shall be generated from the two Fr Hz basic streams. As shown in Figure 7, fewer 4K Sub-Images shall be generated from the UHDTV2 image for 4:2:2 or 4:2:0 (both Y′C′$_B$C′$_R$) than for 4:4:4 (G′B′R′ or Y′C′$_B$C′$_R$). In Figure 21, the 4K Sub-Images that are appended with *1 shall be generated with 4:4:4 and 4:2:2, and those appended with *2 shall be generated with only 4:4:4.

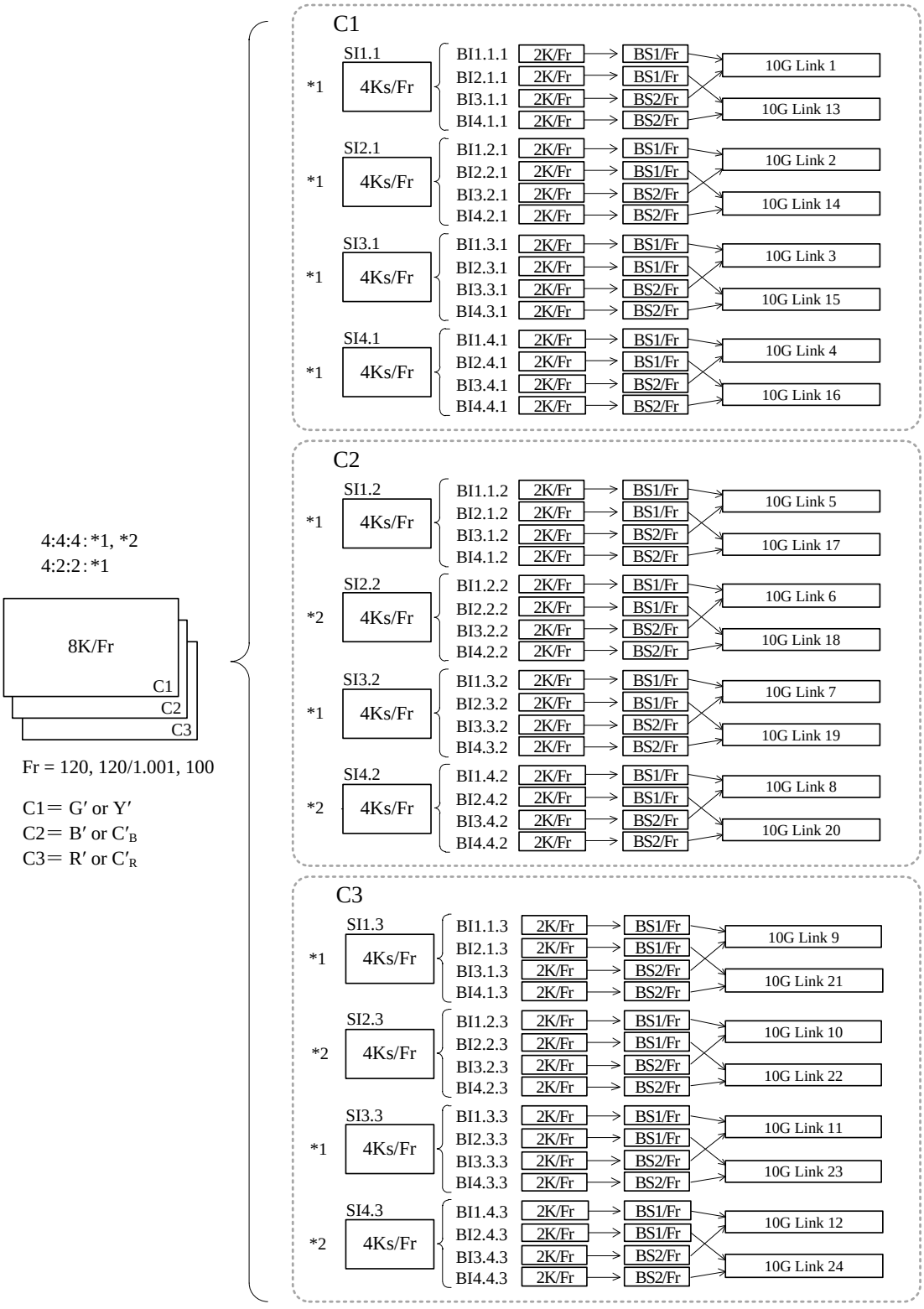

Figure 21 – Mapping to 10G links for 8K/Fr (Fr = 120. 120/1.001, 100) with 4:4:4 (G′B′R′ or Y′C′$_B$C′$_R$) or 4:2:2 (Y′C′$_B$C′$_R$)

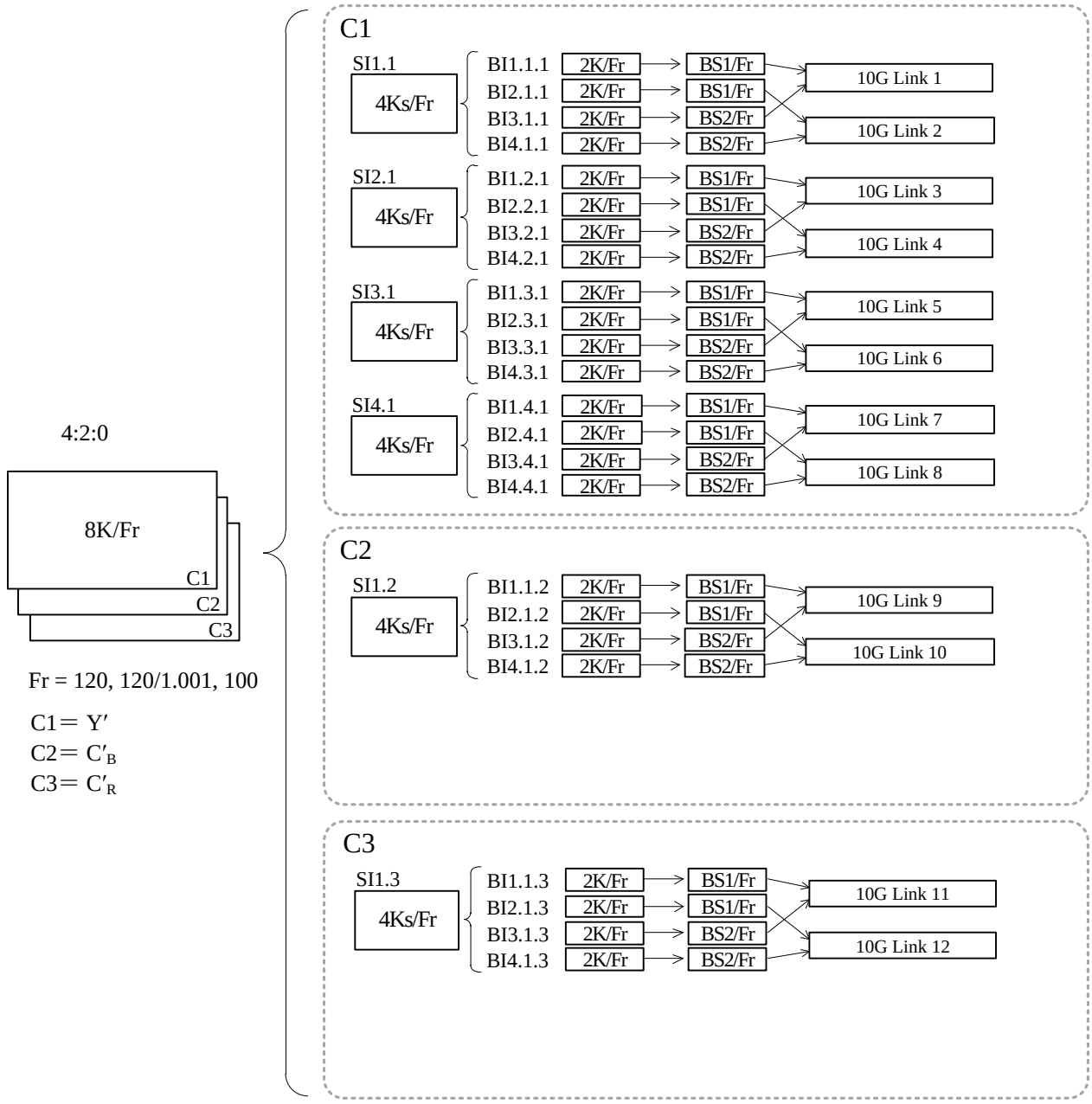

Figure 22 – Mapping to 10G links for 8K/Fr (Fr = 120. 120/1.001, 100) with 4:2:0 (Y′C′$_B$C′$_R$)

7.2.2 8K/Fr (Fr = 60, 60/1.001, 50)

The mapping of the 8K/Fr (Fr = 60, 60/1.001, 50) images listed below to the 10G link signals shall be as illustrated in Figure 23. System numbers in this list are defined in Table 2.

System number U2.3 and U2.4 (8K/Fr, G′B′R′, 4:4:4)

System number U2.10 and U.2.11 (8K/Fr, $Y'C'_BC'_R$, 4:4:4)

System number U2.17 and U2.18 (8K/Fr, $Y'C'_BC'_R$, 4:2:2)

System number U2.24 and U2.25 (8K/Fr, $Y'C'_BC'_R$, 4:2:0)

SIp.q and BIu.p.q are as defined in Section 7.2.1. BS1/Fr to BS4/Fr represents the Fr Hz basic streams 1 to 4illustrated in Figure 17. For the UHDTV2 mapping, one 10 G link signal shall be generated for each four basic streams. In Figure 23, the 10G link signals that are appended with *1 shall be generated with the entire UHDTV2 sampling structure, those appended with *2 shall be generated with only 4:4:4 and 4:2:2, and those appended with *3 shall be generated with only 4:4:4.

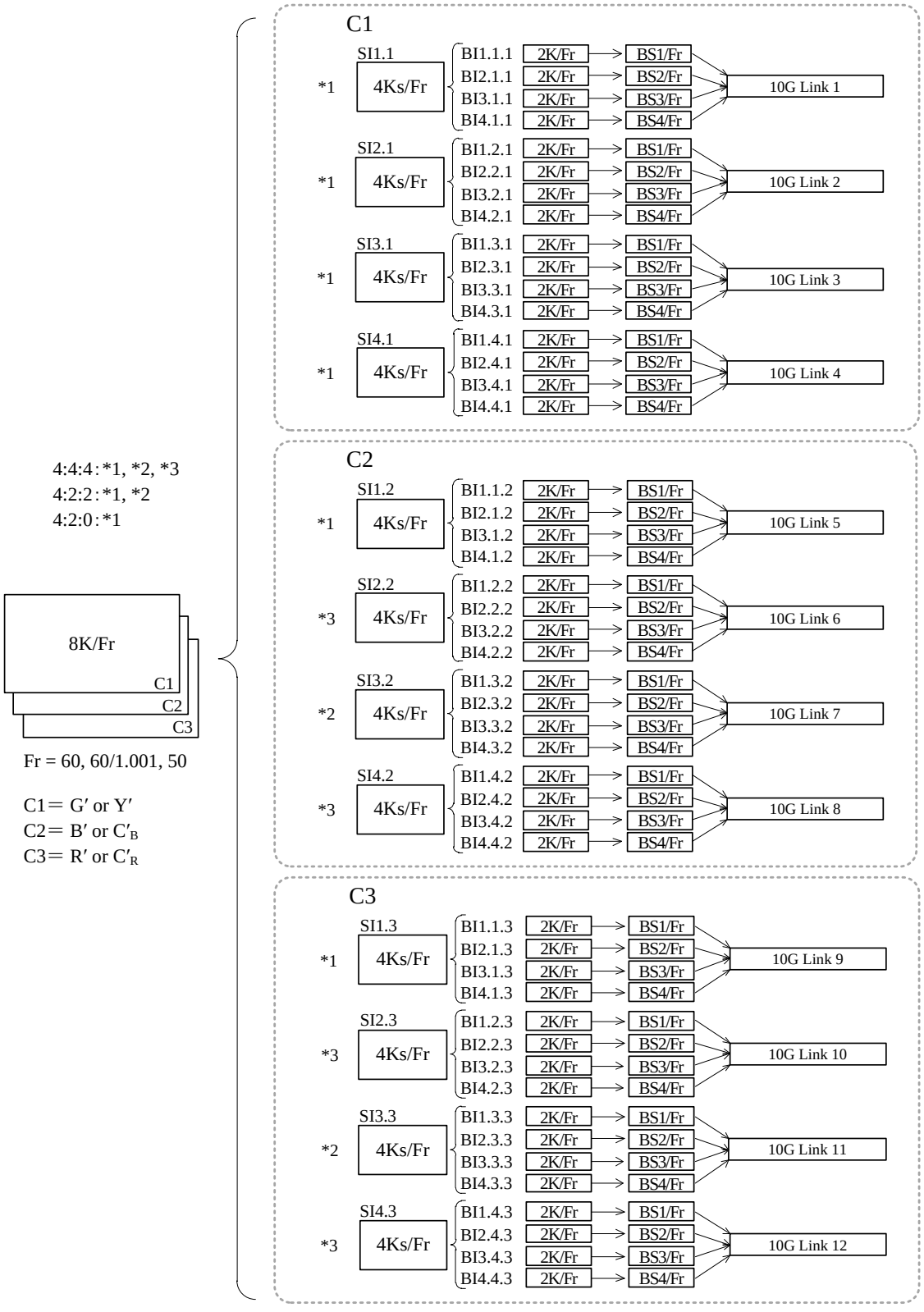

Figure 23 – Mapping to 10G links for 8K/Fr (Fr = 60, 60/1.001, 50)

7.2.3 8K/Fr (Fr = 30, 30/1.001, 25, 24, 24/1.001)

The mapping of the 8K/Fr (Fr = 30, 30/1.001, 25, 24, 24/1.001) images listed below to the 10G link signals shall be as illustrated in Figure 24. System numbers in this list are defined in Table 2.

System number U2.5, U2.6 and U2.7 (8K/Fr, G′B′R′, 4:4:4)

System number U2.12, U.2.13 and U2.14 (8K/Fr, $Y'C'_BC'_R$, 4:4:4)

System number U2.19, U2.20 and U2.21 (8K/Fr, $Y'C'_BC'_R$, 4:2:2)

System number U2.26, U2.27 and U2.28 (8K/Fr, $Y'C'_BC'_R$, 4:2:0)

SIp.q and BIu.p.q are as defined in Section 7.2.1. BS1/Fr to BS8/Fr represents the Fr Hz basic streams 1 to 8 illustrated in Figure 19. For the 8K/Fr mapping, one 10 G link signal shall be generated for each eight basic streams. In Figure 24, the 4K Sub-Images that are appended with *1 shall be generated with the entire UHDTV2 sampling structure, those appended with *2 shall be generated with only 4:4:4 and 4:2:2, and those appended with *3 shall be generated with only 4:4:4.

For the 4:2:0 case, the 4K Sub-Images appended with *2 shall not be generated, so the number of basic streams generated from the 4K Sub-Images of the C'_B and C'_R color components that are appended with *1 are less than eight. For that case, basic streams shall be generated from basic images for which the 12-bit data of the entire sample is 800h, and those streams shall be assigned to BS5/Fr, BS6/Fr, BS7/Fr, and BS8/Fr to generate the 10G link signal.

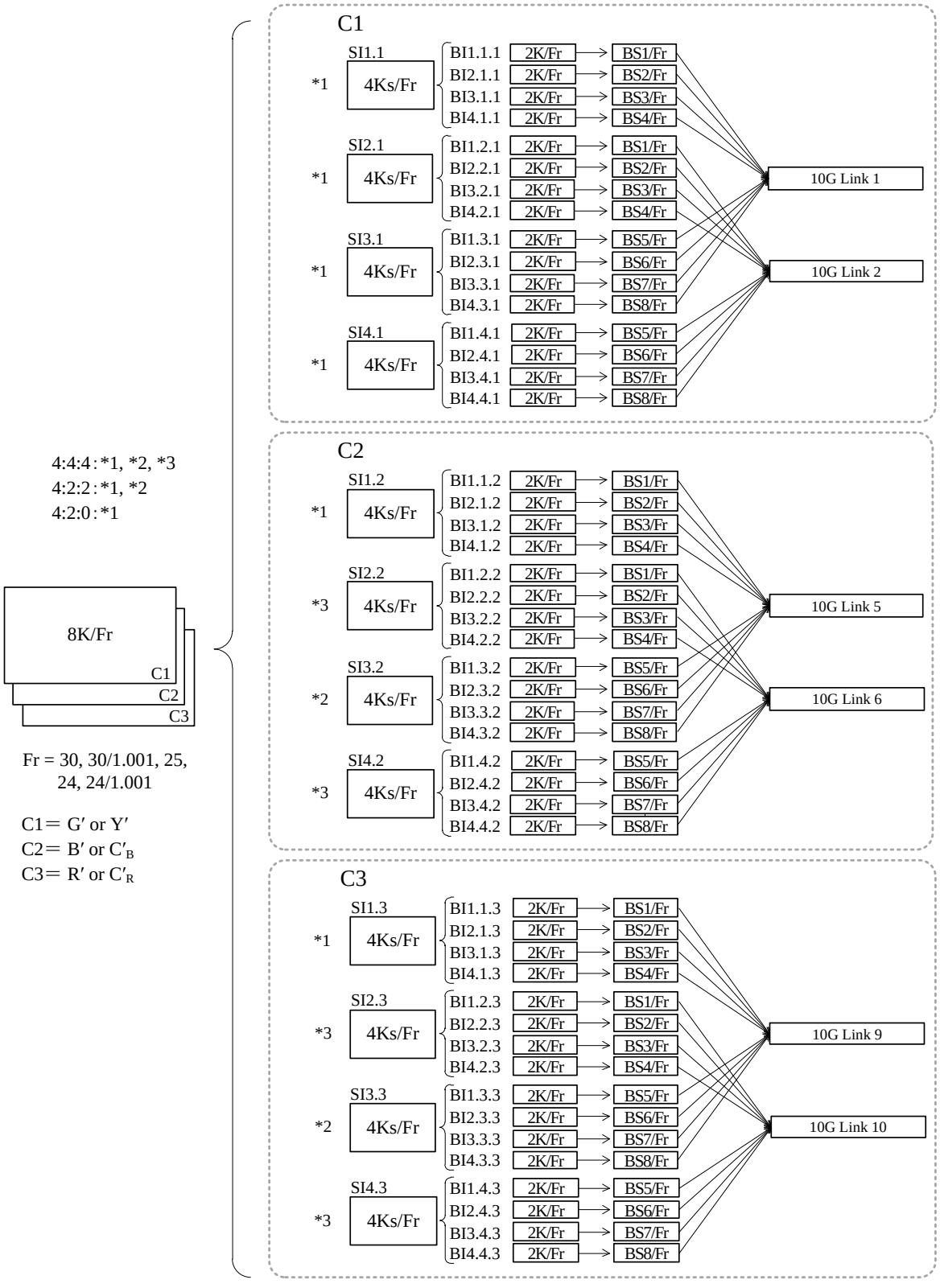

Figure 24 – Mapping to 10G links for 8K/Fr (Fr = 30, 30/1.001, 25, 24, 24/1.001)

7.2.4 4K/ Fr (Fr = 120, 120/1.001, 100)

The mapping of the 4K/Fr (Fr = 120, 120/1.001, 100) images listed below to the 10G link signals shall be as illustrated in Figure 25. System numbers in this list are defined in Table 1.

System number U1.1 and U1.2 (4K/Fr, G′B′R′, 4:4:4)

System number U1.8 and U1.9 (4K/Fr, Y′C′$_B$C′$_R$, 4:4:4)

System number U1.15 and U1.16 (4K/Fr, Y′C′$_B$C′$_R$, 4:2:2)

System number U1.22 and U1.23 (4K/Fr, Y′C′$_B$C′$_R$, 4:2:0)

The BIu.q (u is an integer greater than or equal to 1 and less than or equal to 4; q is an integer greater than or equal to 1 and less than or equal to 3) represents basic image u for color component Cq generated by dividing the UHDTV1 images and shall be mapped as shown in Figure 9. BS1/Fr and BS2/Fr represents the Fr Hz basic streams 1 and 2 that shall be as illustrated in Figure 13. For the 4K/Fr mapping, one 10G link signal shall be generated for each two Fr Hz basic streams.

For the case of 4:2:0, less than two Fr Hz basic streams shall be generated from each C′$_B$ and C′$_R$ color component of the UHDTV1 images. For that case, an Fr Hz basic stream shall be generated from basic images for which the 12-bit data of the entire sample is 800h, and the stream is assigned to BS2/Fr to generate the 10G link signal.

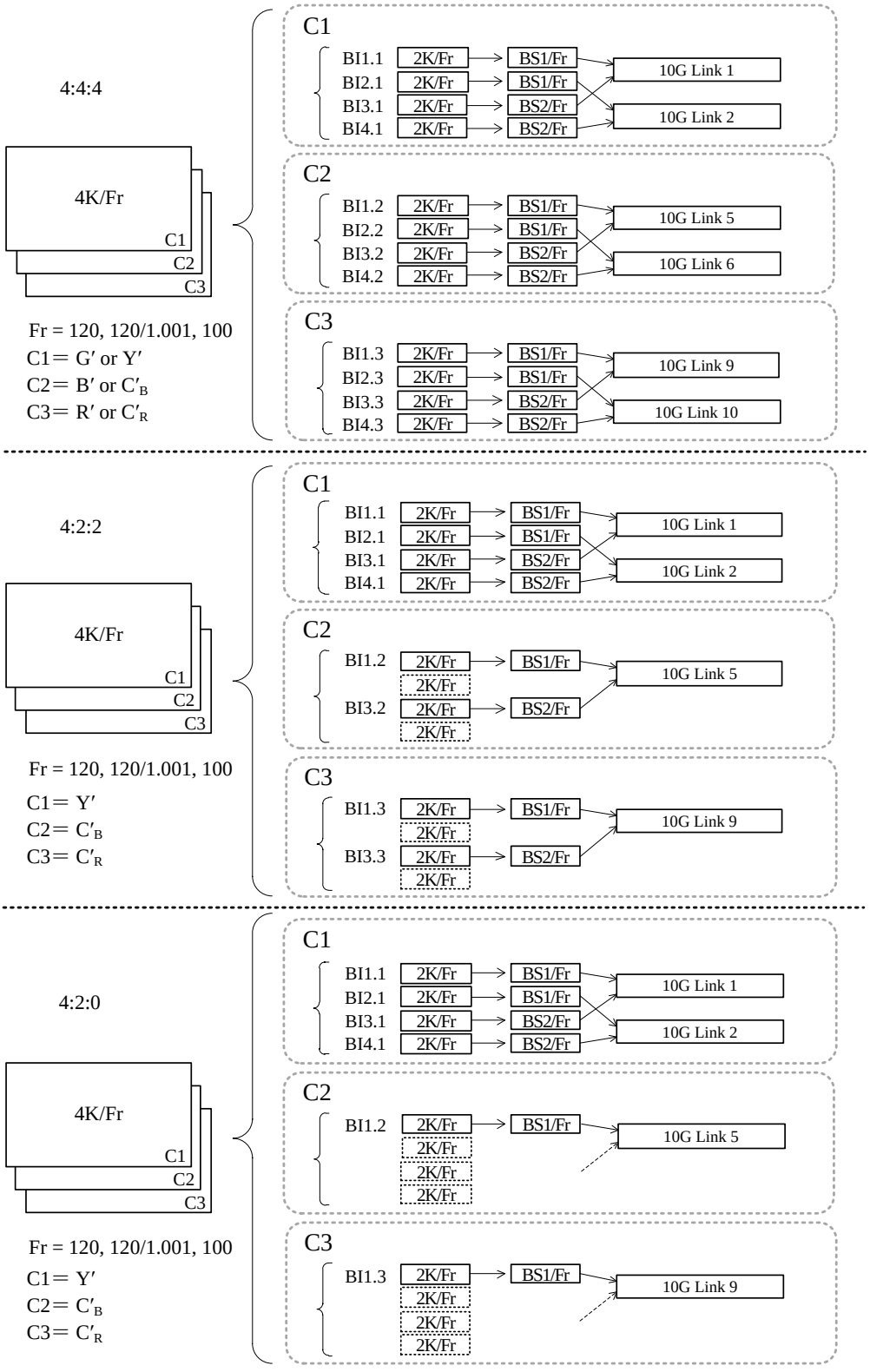

Figure 25 – Mapping to 10G links for 4K/Fr (Fr = 120, 120/1.001, 100)

7.2.5 4K/Fr (Fr = 60, 60/1.001, 50)

The mapping of the 4K/Fr (Fr = 60, 60/1.001, 50) images listed below to the 10G link signals shall be as illustrated in Figure 26. System numbers in this list are defined in Table 1.

System number U1.3 and U1.4 (4K/Fr, G′B′R′, 4:4:4)

System number U1.10 and U1.11 (4K/Fr, $Y'C'_BC'_R$, 4:4:4)

System number U1.17 and U1.18 (4K/Fr, $Y'C'_BC'_R$, 4:2:2)

System number U1.24 and U1.25 (4K/Fr, $Y'C'_BC'_R$, 4:2:0)

BIu.q shall be as defined in Section 7.2.4. BS1/Fr to BS4/Fr represents the Fr Hz basic stream 1 to 4 illustrated in Figure 17. For the UHDTV1 mapping, one 10G link signal shall be generated for each four basic streams.

For the case of 4:2:2 and 4:2:0, less than four basic streams shall be generated from the C'_B and C'_R color components of the UHDTV1 images, so basic streams shall be generated from basic images for which the 12-bit data of the entire sample is 800h, and those streams shall be assigned to BS2/Fr and BS4/Fr for 4:2:2 and to BS2/Fr, BS3/Fr, and BS4/Fr for 4:2:0 to generate the 10G link signal.

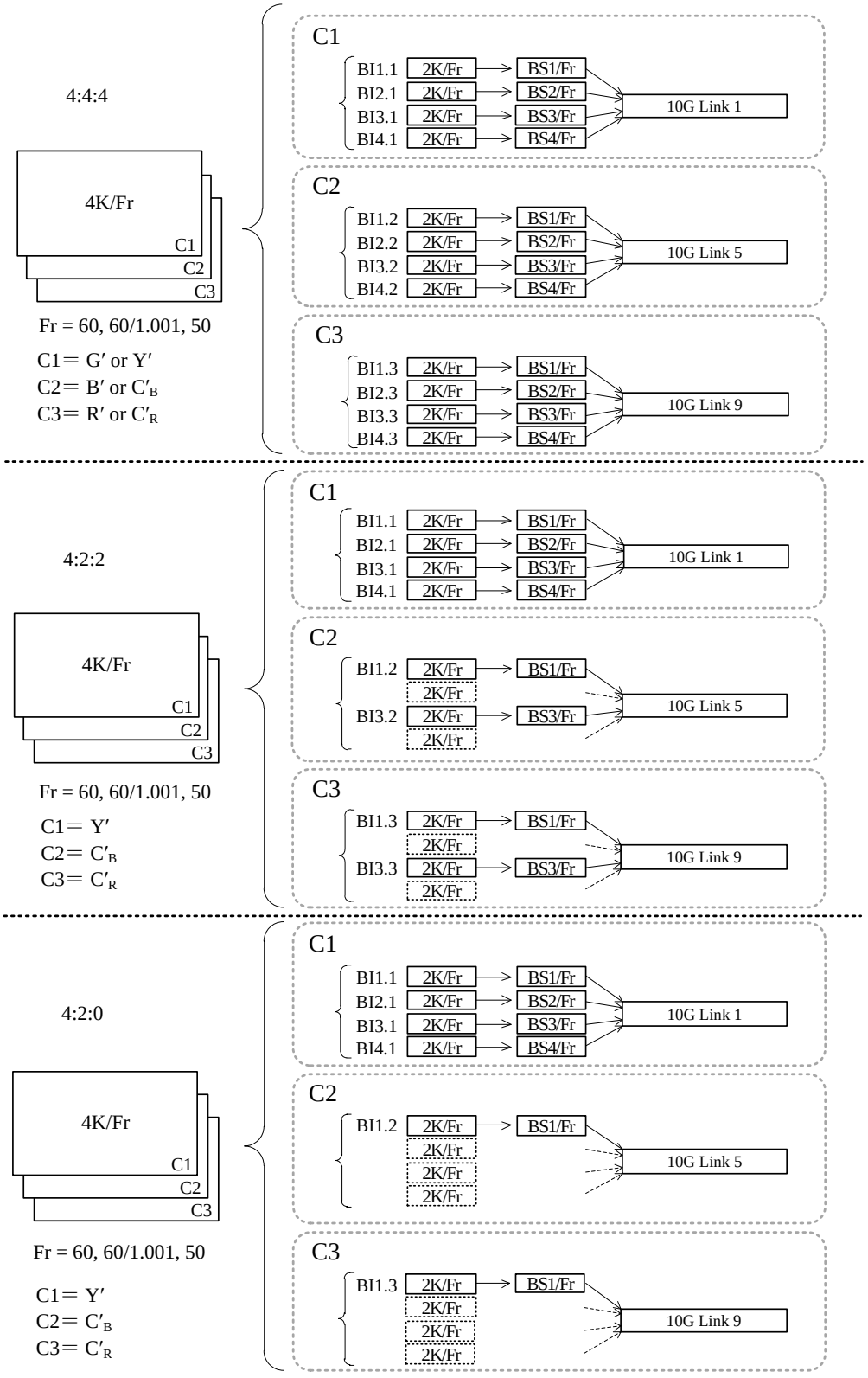

Figure 26 – Mapping to 10G links for 4K/Fr (Fr = 60, 60/1.001, 50)

7.2.6 4K/Fr (Fr = 30, 30/1.001, 25, 24, 24/1.001)

The mapping of the 4K/Fr (Fr = 30, 30/1.001, 25, 24, 24/1.001) images listed below to the 10G link signals shall be as illustrated in Figure. 27. System numbers in this list are defined in Table 1.

System number U1.5, U1.6 and U1.7 (4K/Fr, G′B′R′, 4:4:4)

System number U1.12, U1.13 and U1.14 (4K/Fr, $Y'C'_BC'_R$, 4:4:4)

System number U1.19, U1.20 and U1.21 (4K/Fr, $Y'C'_BC'_R$, 4:2:2)

System number U1.26, U1.27 and U1.28 (4K/Fr, $Y'C'_BC'_R$, 4:2:0)

BIu.q is as defined in Section 7.2.4. BS1/Fr to BS4/Fr represents the Fr Hz basic streams 1 to 4 illustrated in Figure 19. One 10 G link signal shall be generated for each eight basic streams, but less than eight basic streams shall be generated from the respective UHDTV1 color components, so basic streams shall be generated from basic images for which the 12-bit data of the entire sample is 100h for the color components Y′, G′, B′, and R′ or 800h for C'_B and C'_R and assigned to the unassigned basic stream shown in Figure 27 to generate the 10G link signal.

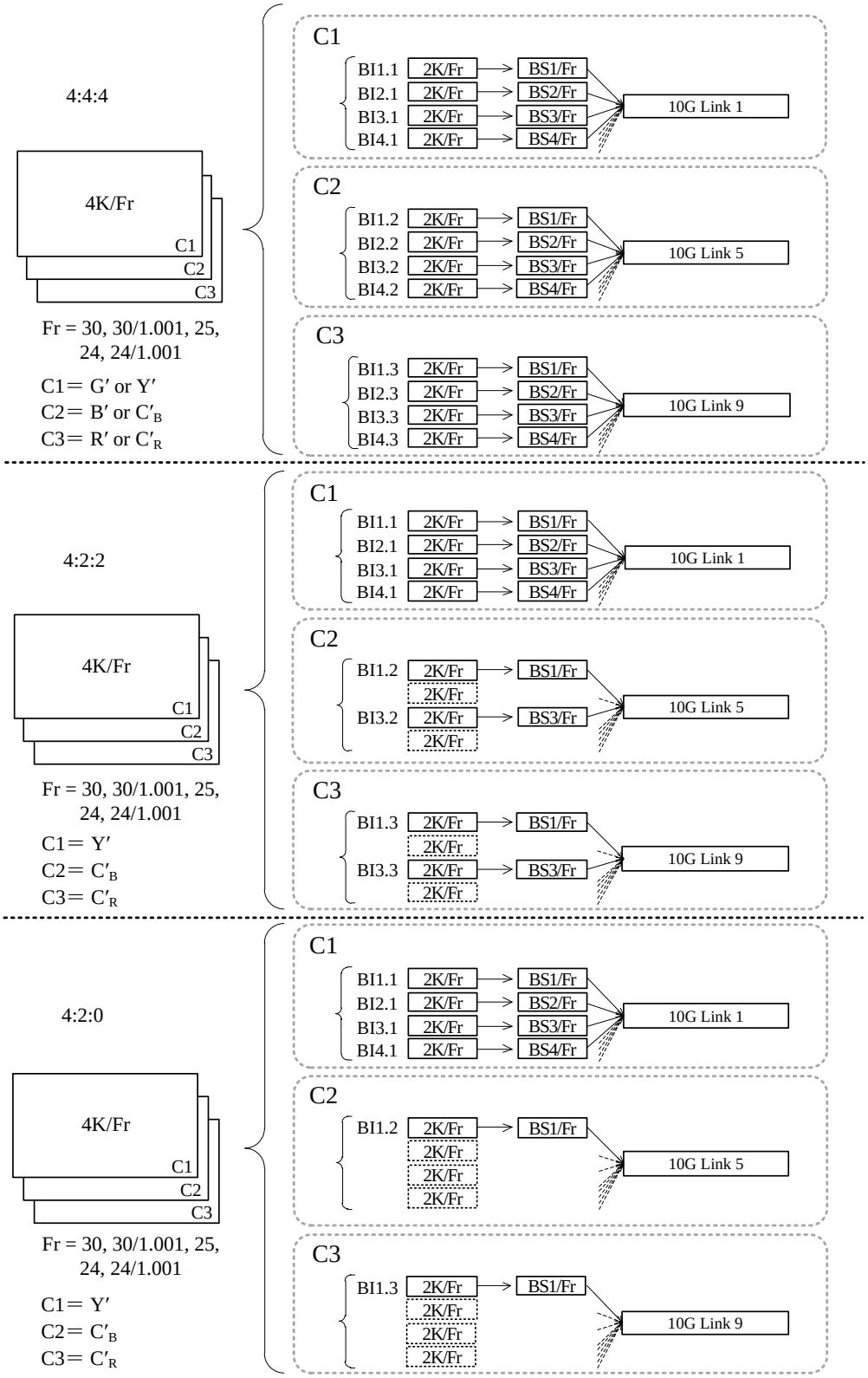

Figure 27 – Mapping to 10G links for 4K/Fr (Fr = 30, 30/1.001, 25, 24, 24/1.001)

8 Physical Layer

8.1 Optical Transmitter Characteristics

The optical transmitter characteristics of each 10G link shall be as shown in Table 15. In Figure 28, normalized amplitudes of 0 and 1 represent the amplitudes of logic ZERO and ONE respectively. These are defined by the means of the lower and upper halves of the central 0.2 UI of the eye. A UI is the period of one clock cycle of a 10G link signal. The eye pattern shall be measured with respect to the mask of the eye using a receiver with a fourth-order Bessel-Thomson response with a 3 dB frequency of 0.75 × 10.692 GHz = 8 GHz.

Table 15 – Optical transmitter characteristics

Optical Wavelength	840 nm to 860 nm
RMS spectral width (max) (Note 1)	0.65 nm
Signal rate	10.692 Gbit/s ± 0.001% (±10 ppm), or 10.692/1.001 Gbit/s ± 0.001% (±10 ppm)
Average launch power (max) (Note 2)	+2.4 dBm
Average launch power (min) (Note 2)	-7.6 dBm
Extinction Ratio (min)	3 dB
Maximum reflected power	-12 dB
Output optical eye mask (Note 3)	See Figure 28
Jitter	See Section 8.3
Electrical/optical transfer function	Logic ”1” = Higher optical power Logic “0” = Lower optical power
Note 1: RMS spectral width is the standard deviation of the spectrum. Note 2: Power is the average power measured with an average-reading power meter. Note 3: One thousand accumulated waveforms are recommended for transmitter optical output eye mask compliance test.	

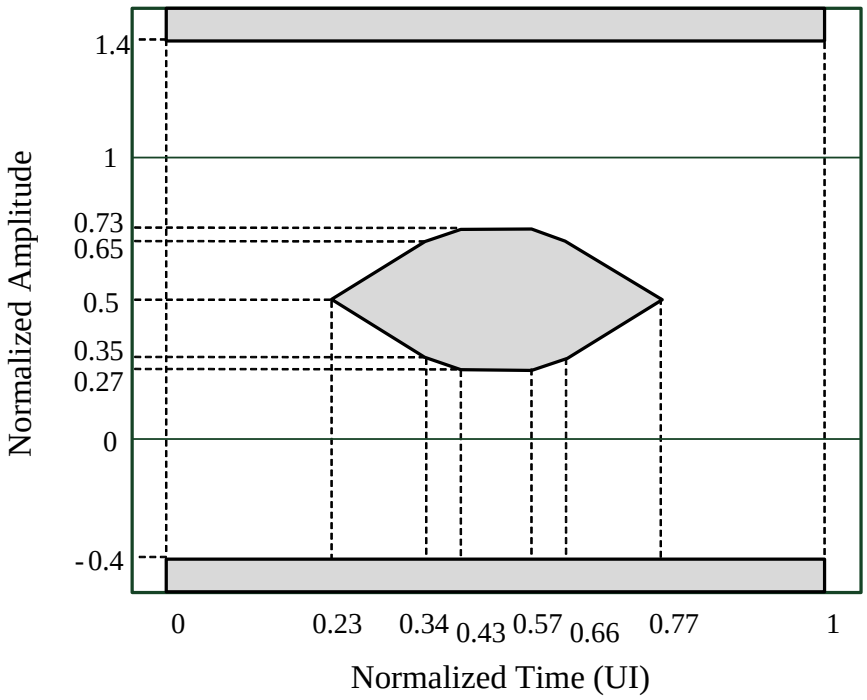

Figure 28 – Transmitter output optical eye mask

8.2 Optical Receiver Characteristics

Receiver characteristics of each 10G link shall be as shown in Table 16. Within the receiver input range a BER < 10^{-12} should be achieved with the test signals. A BER < 10^{-14} is recommended.

Note: The PRBS-31 pattern generator is defined in IEEE 802.3ae–2002 listed in Annex A.

Table 16 – Optical receiver characteristics

Average receive power (max) (Note 1)	+2.4 dBm
Average receive power (min) (BER = 10^{-12}) (Note 1, 2)	-9.5 dBm
Detector damage threshold (min)	+3.4 dBm
Jitter	See Section 8.3
Optical/electrical transfer function	Higher optical power = Logic “1” Lower optical power = Logic “0”
Test signal	PRBS-31 or Color bar
Note 1: Power is the average power measured with an average-reading power meter. Note 2: Measurement for 5 minutes is recommended for verifying BER = 10^{-12} when using BER-based test equipment.	

8.3 Jitter Specifications

Jitter measurement parameters in the timing of transitions of the data signal of each 10G link are defined in SMPTE RP 184 and shall have the values defined in Table 17.

Table 17 – Jitter specifications

Parameter	Value	Description
f1	10 Hz	Low-frequency specification limit
f2	20 kHz	Upper band edge for A1
f3	4 MHz	Lower band edge for A2
f4	> 1/10 the clock rate	High-frequency specification limit
A1	10 UI	Timing jitter: Sinusoidal jitter amplitude shall be less than $2 \times 10^5 / f + 0.1$ UI at 20 kHz < f ≤ 4 MHz.
A2	0.15 UI	Alignment jitter: Sinusoidal jitter amplitude shall be less than 0.15 UI at f > 4 MHz.
Error Criterion	BER = 10^{-12}	Criterion for onset of errors
Test signal	PRBS-31 or Color bar	Data rate of PRBS-31 shall be 10.692 Gbit/s or 10.692/1.001 Gbit/s
Note: See SMPTE RP 184 for definition of jitter terms.		

8.4 Timing Difference

The timing difference between 10G link signals should not exceed 400 ns.

8.5 Optical Connector

The optical connector characteristics shall be as shown in Table 18. A receptacle connector with equipment shall be as shown in Figure 29 and the dimensions of the receptacle shall be as shown in Table 19. A geometric array of the 24 fibers for the receptacle connector complies with IEC 61754-7.

Table 18 – Optical connector characteristics

Number of fibers	24
Fiber type	Multi mode fiber
Connection loss	Less than 0.75 dB
Insertion/withdrawals	More than 5000 times
Equilibrium tensile loading of connectors	250 N
Other requirements	Lock mechanism Dustproof structure

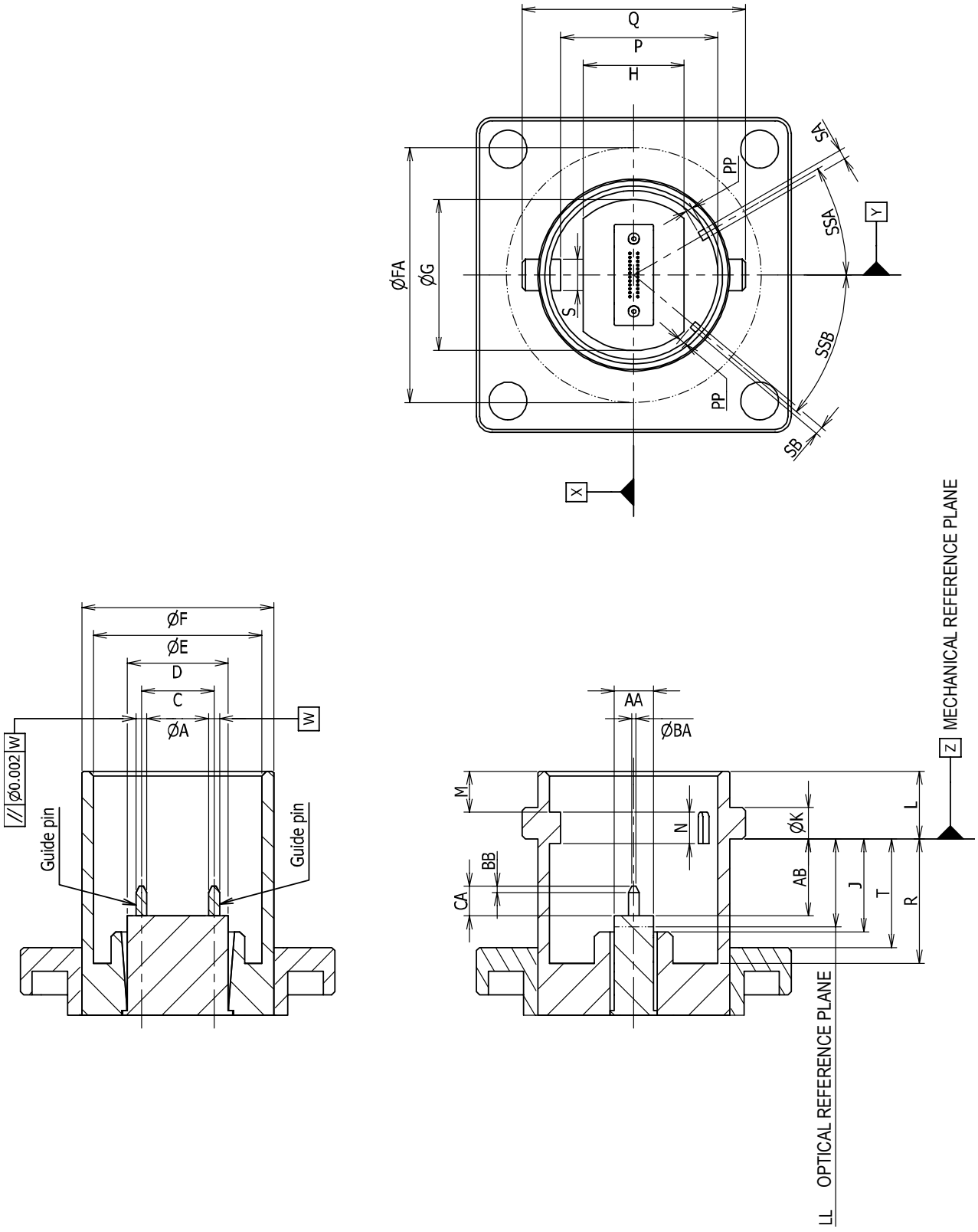

Figure 29 – Receptacle connector with equipment

Table 19 – Dimensions of the receptacle connector of equipment

Reference	Dimensions	
	minimum	maximum
A	0.697 mm	0.699 mm
C	4.597 mm	4.603 mm
D	6.3 mm	6.5 mm
E	10.7 mm	10.8 mm
F	12.2 mm	12.4 mm
G	–	9.6 mm
H	–	6.4 mm
J	5.7 mm	–
K	1.8 mm	2.2 mm
L	4.3 mm	4.5 mm
M	–	4.0 mm
N	1.0 mm	–
P	9.9 mm	10.1 mm
Q	14.2 mm	–
R	7.7 mm	–
S	1.95 mm	2.0 mm
T	6.7 mm	–
AA	2.4 mm	2.5 mm
AB	4.7 mm	5.1 mm
BA	0 mm	0.4 mm
BB	0.2 mm	0.5 mm
CA	1.6 mm	3.3 mm
FA	16.2 mm	–
SA	–	0.6 mm
SB	–	0.5 mm
PP	–	0.45 mm
SSA	29°	31°
SSB	39°	41°

8.6 Assignment of 10G Link Signals to a Receptacle Connector

The assignment of 10G link signals to an output receptacle connector shall be as shown in Figure 30, and the assignment of 10G link signals to an input receptacle connector shall be as shown in Figure 31. Each number in Figure 30 and Figure 31 represents the number of a 10G link signal. Symbol X and Y in Figure 30 and Figure 31 correspond to symbol X and Y respectively in Figure 29.

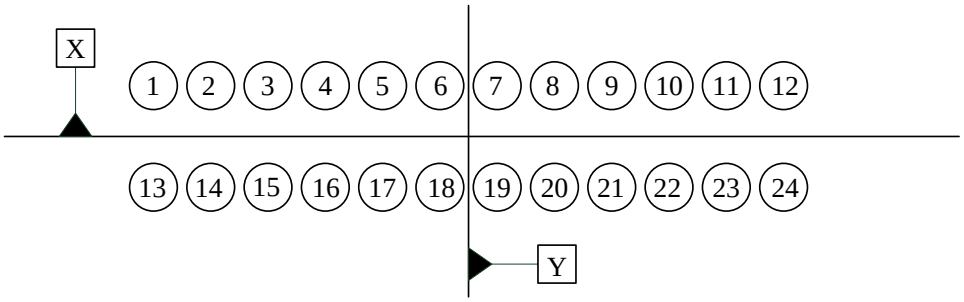

Figure 30 – Assignment of 10G link signals to an output receptacle connector with equipment

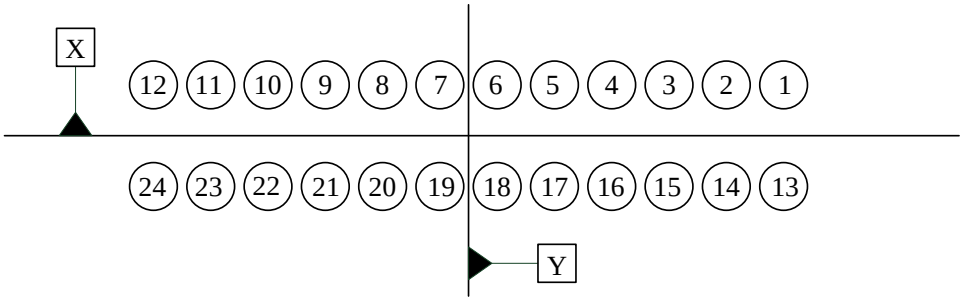

Figure 31 – Assignment of 10G link signals to an input receptacle connector with equipment

Annex A Bibliography (Informative)

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.

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

SMPTE ST 2036-2:2008, Ultra High Definition Television — Audio Characteristics and Audio Channel Mapping for Program Production

SMPTE ST 2036-3:2012, Ultra High Definition Television — Mapping into Single-link or Multi-link 10 Gb/s Serial Signal/Data Interface

Recommendation ITU-R BT.2020 (08/12), Parameter Values for Ultra-High Definition Television Systems for Production and International Programme Exchange