

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 UHD TV (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 UHD TV image sample structures for the interface are defined in SMPTE ST 2036-1. UHD TV has an image format (sample structure) of 3840×2160 (UHD TV1) or 7680×4320 (UHD TV2).

1 Scope

This document defines UHD TV 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 data¹ 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.

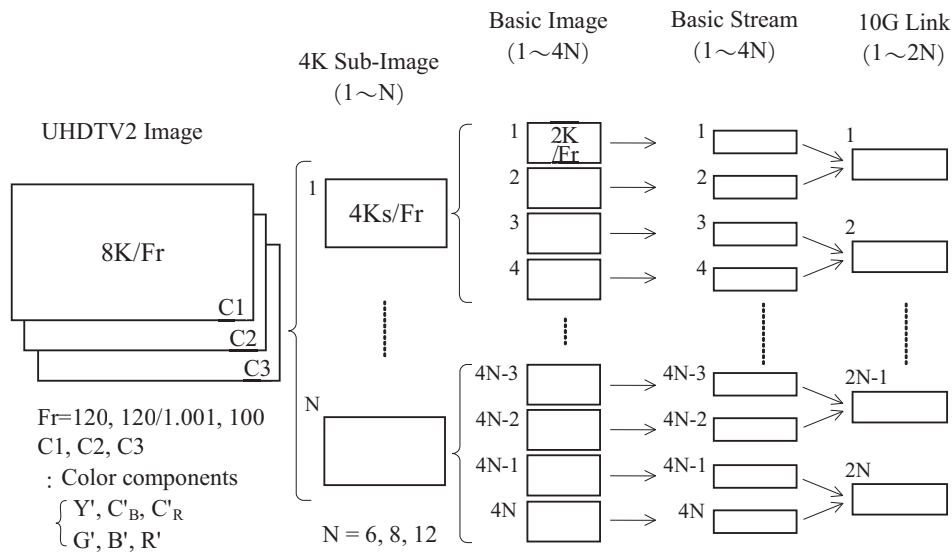


Figure 1 – Mapping overview of UHDTV2 images with 120-Hz, 120/1.001-Hz or 100-Hz frame frequency

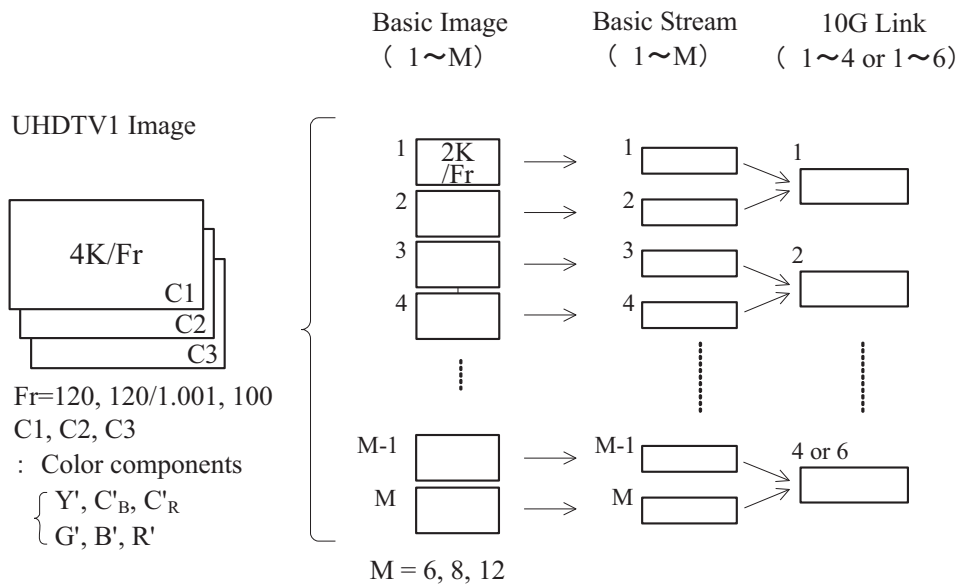


Figure 2 – Mapping overview of UHDTV1 images with 120-Hz, 120/1.001-Hz or 100-Hz frame frequency

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.

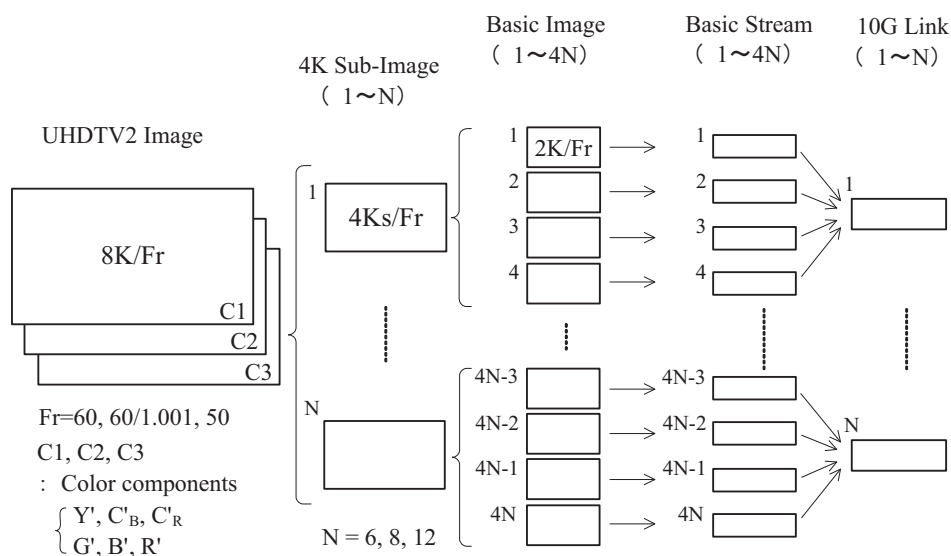


Figure 3 – Mapping overview of UHDTV2 images with 60-Hz, 60/1.001-Hz or 50-Hz frame frequency

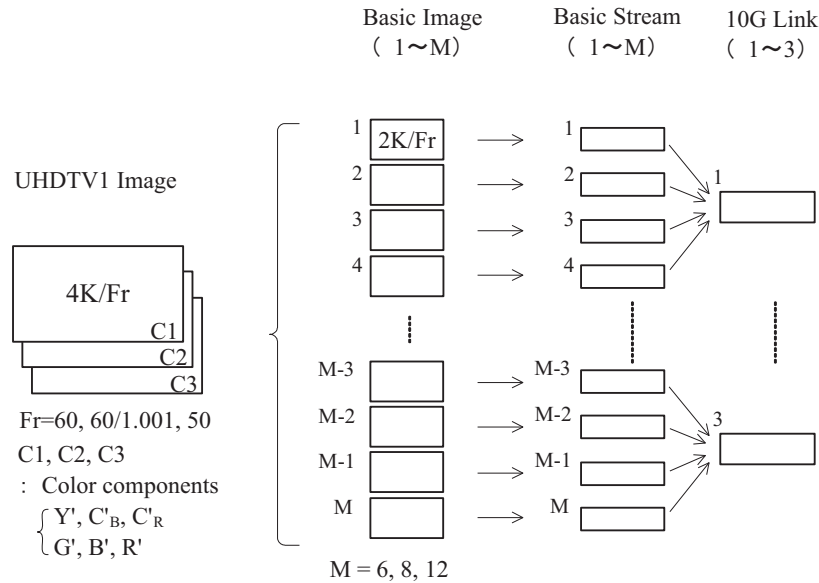


Figure 4 – Mapping overview of UHDTV1 images with 60-Hz, 60/1.001-Hz or 50-Hz frame frequency

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.

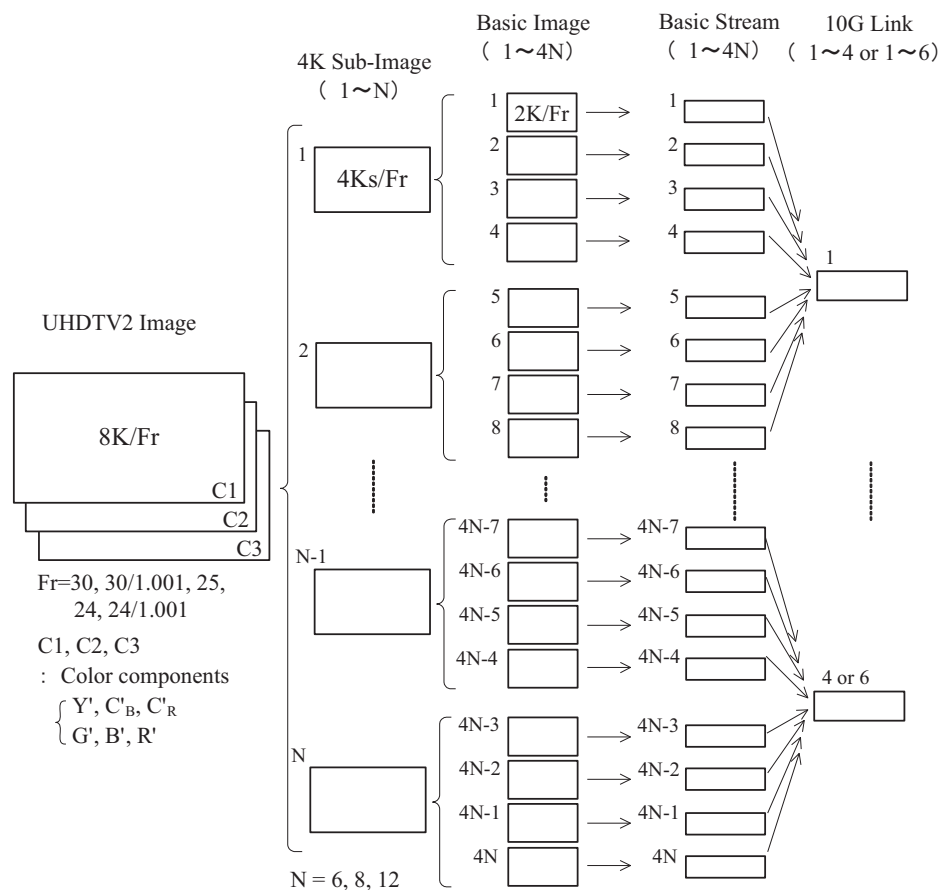


Figure 5 – Mapping overview of UHDTV2 images with 30-Hz, 30/1.001-Hz, 25-Hz, 24-Hz or 24/1.001-Hz frame frequency

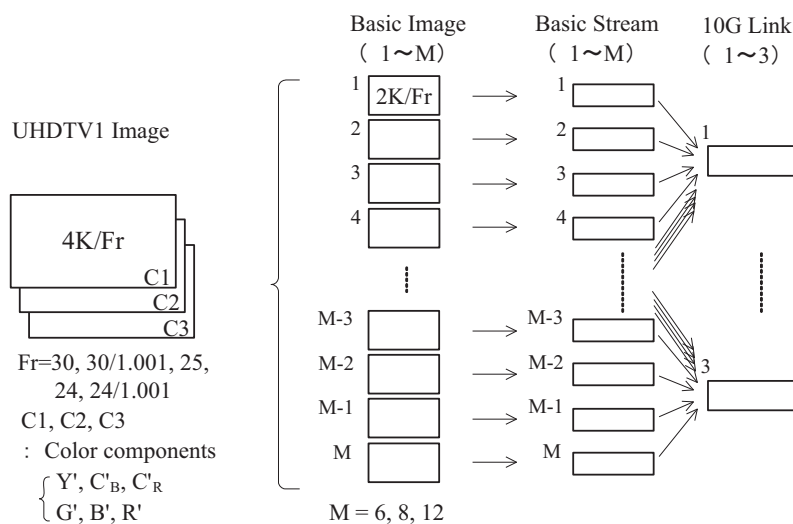


Figure 6 – Mapping overview of UHDTV1 images with 30-Hz, 30/1.001-Hz, 25-Hz, 24-Hz or 24/1.001-Hz frame frequency

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 ($Y'C'_B C'_R$) or 4:2:0 ($Y'C'_B C'_R$).

For the 4:2:2 ($Y'C'_B C'_R$) 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 ($Y'C'_B C'_R$), 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 $y1, y2, y3, y4, c_{B1}, c_{R1}$.

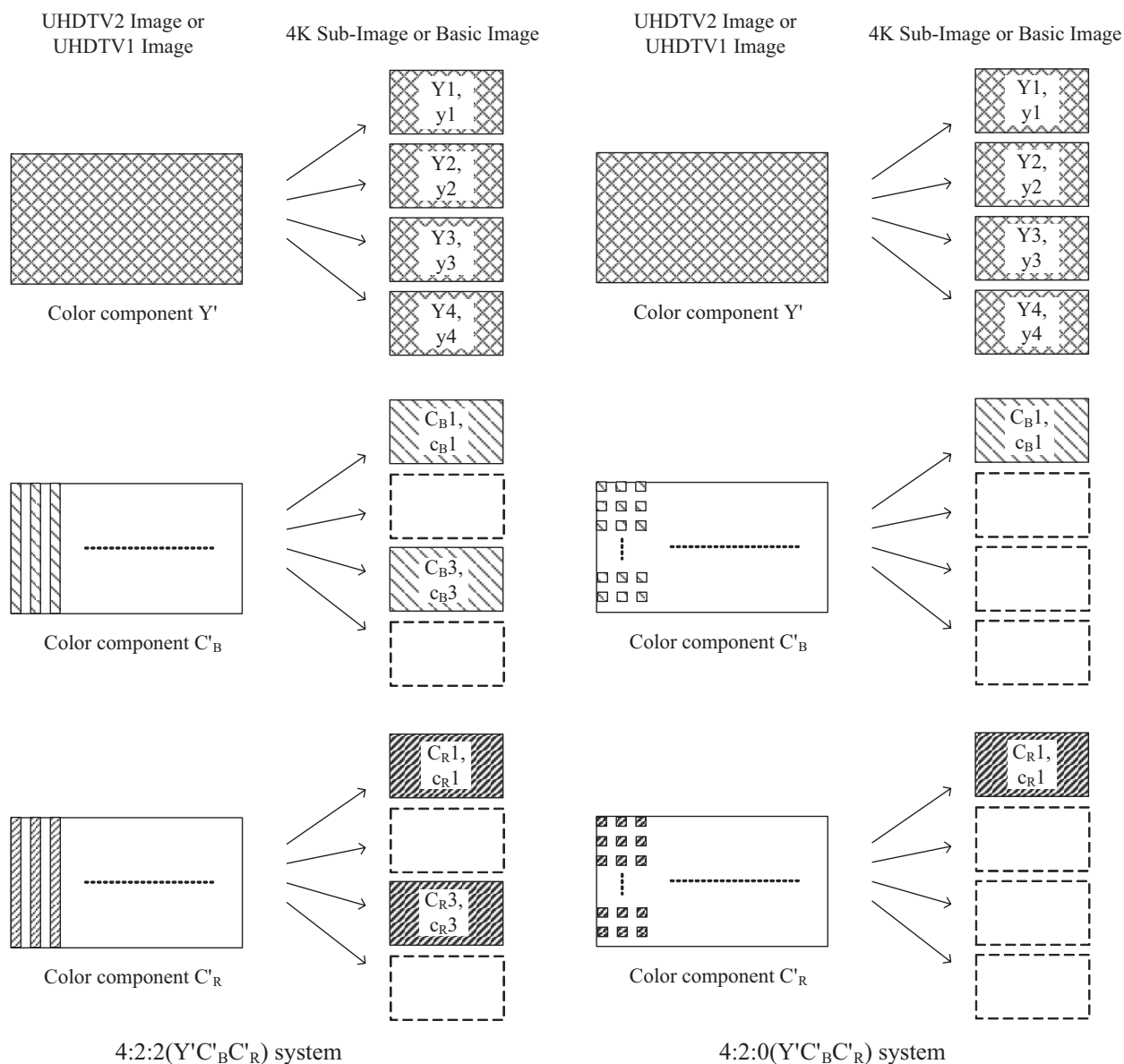


Figure 7 – Image division of 4:2:2 ($Y'C'_B C'_R$) and 4:2:0 ($Y'C'_B C'_R$) systems

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 _B 1, c _B 2, c _R 1, c _R 2, y3, y4, c _B 3, c _B 4, c _R 3, c _R 4	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 _B 1, c _R 1, y3, y4, c _B 3, c _R 3	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 _R 1, c _R 1, 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 – UHD TV2 Image formats

UHD TV2 Image Sampling Structure	4K Sub-Image		Frame Frequency (Hz)	Number of 10G Links	System Number
	Number of Sub-Images (N)	Elements of Color Components			
UHD TV2, 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
UHD TV2, 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	U2.9
			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
UHD TV2, 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
UHD TV2, 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.

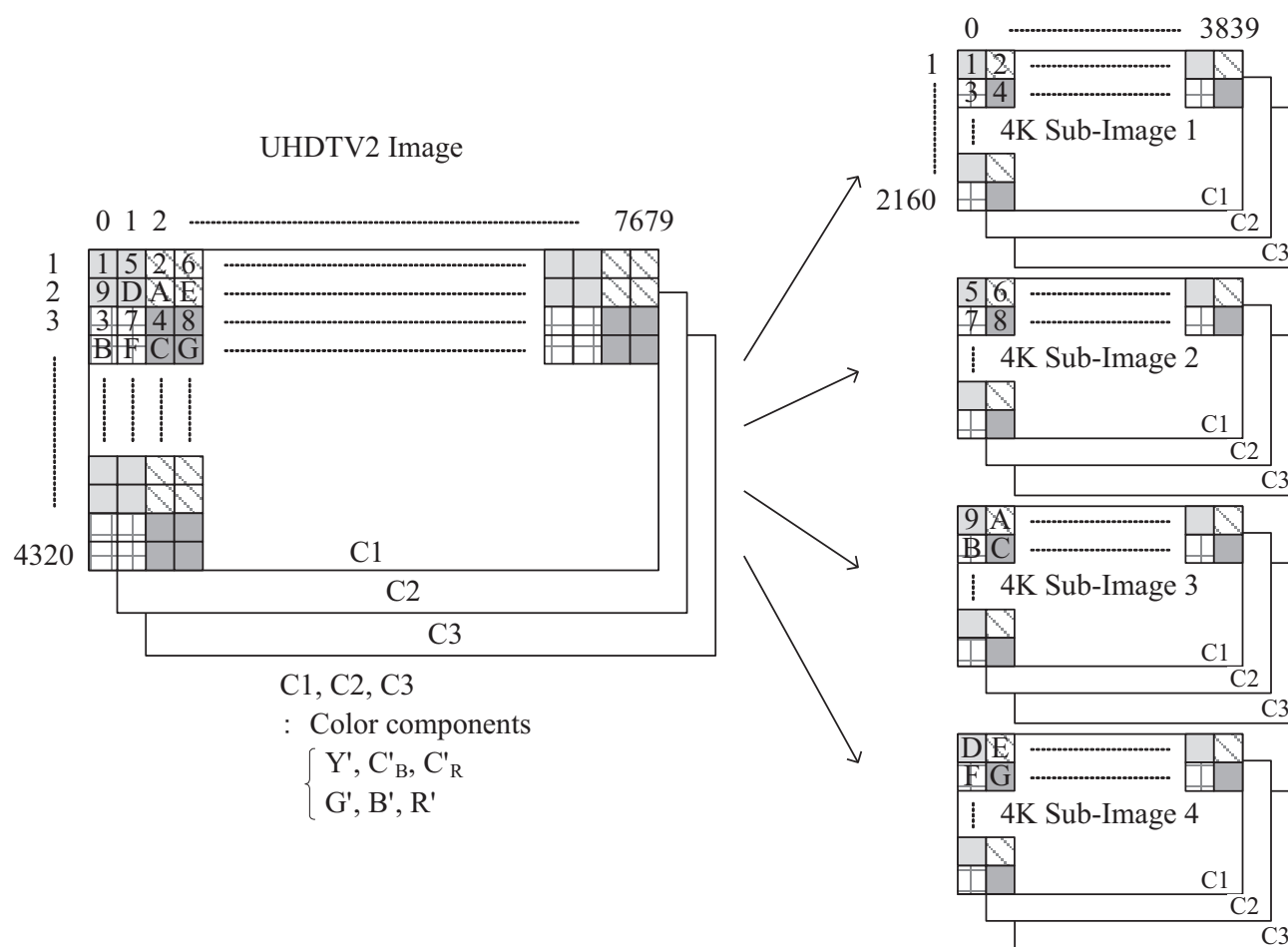


Figure 8 – Image division from UHDTV2 Images to 4K Sub-Images

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.

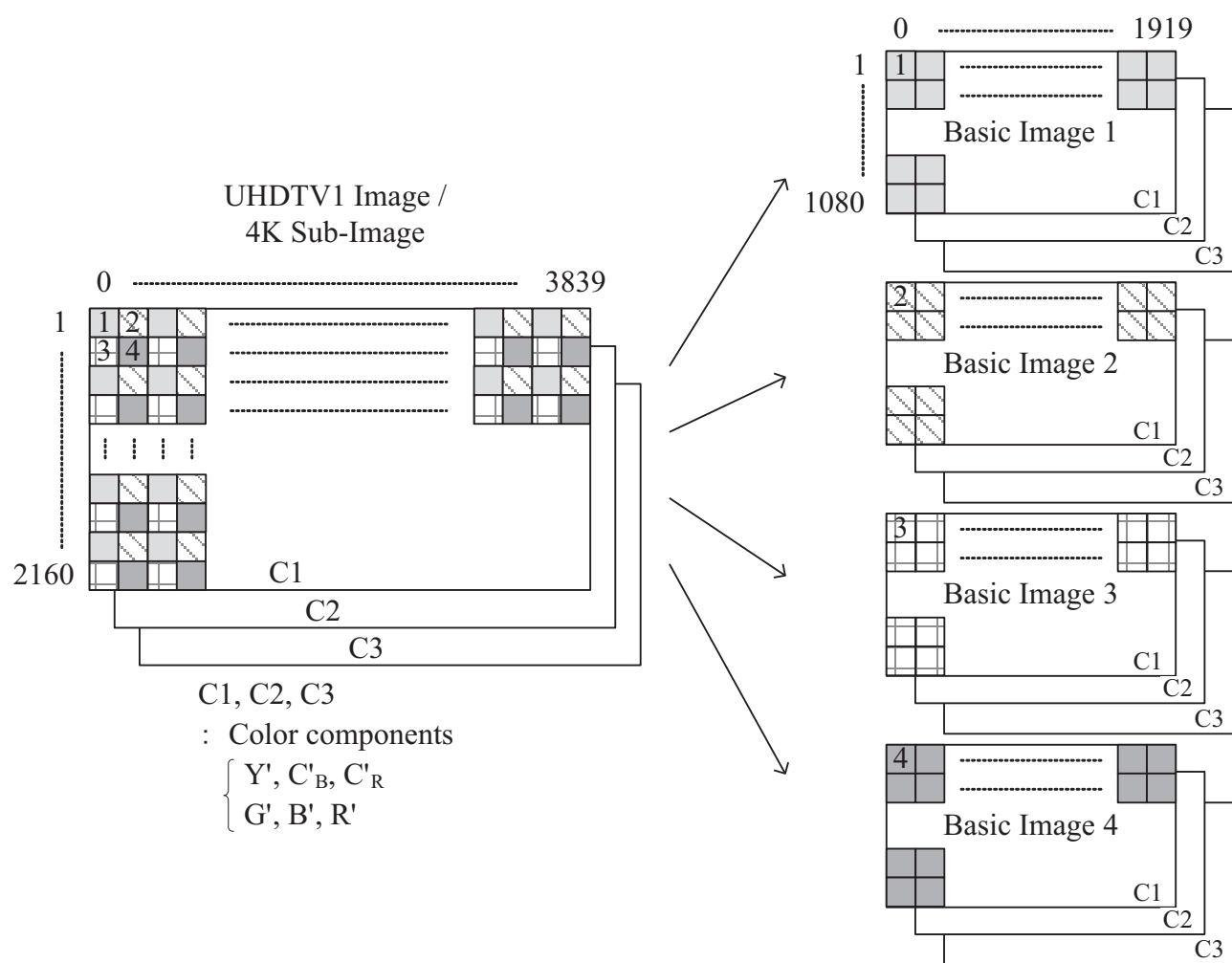


Figure 9 – Image division of UHDTV1 images or 4K Sub-Image into Basic Images

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.

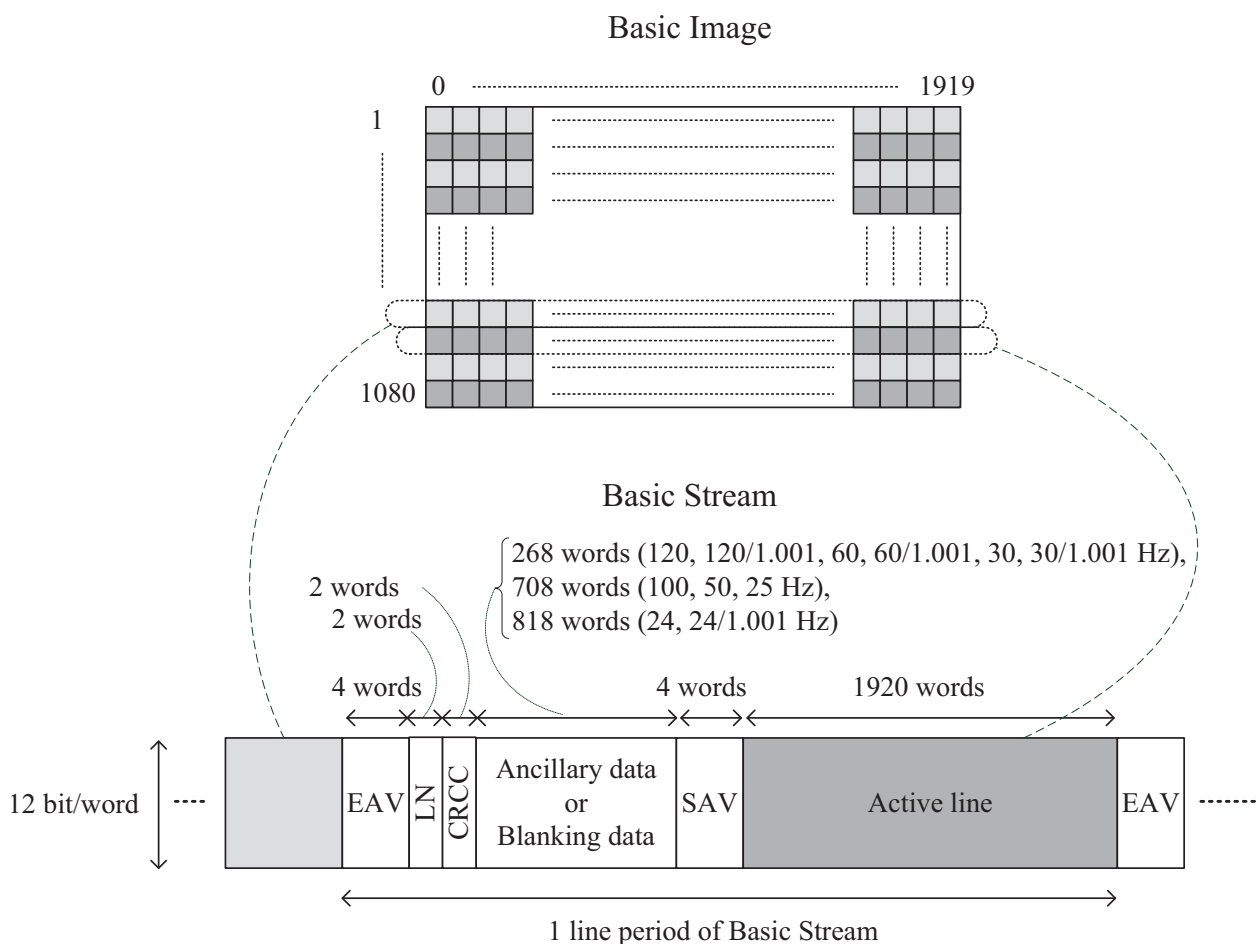
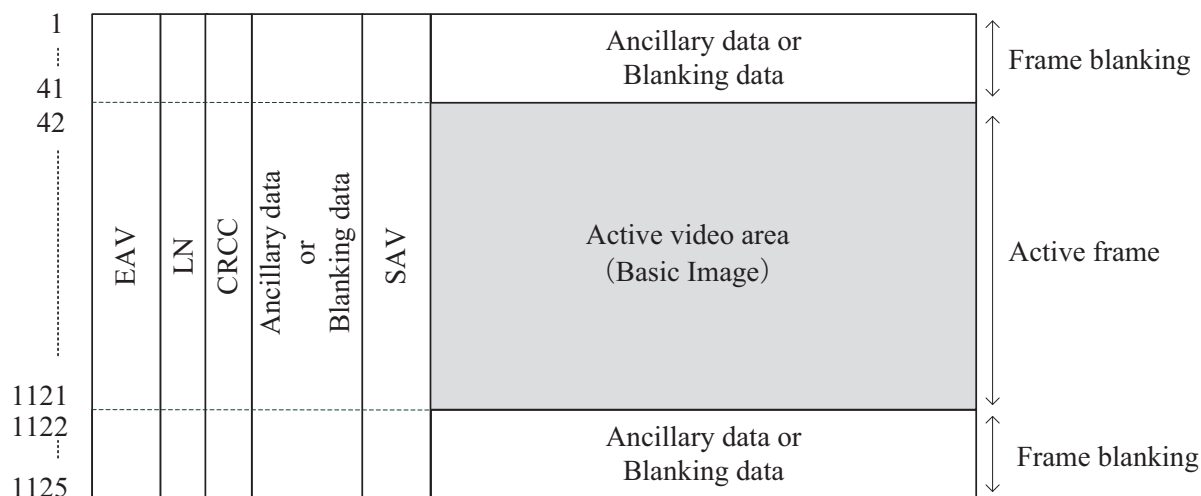


Figure 10 – Line structure of Basic Stream

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**