SMPTE ST 435-2:2012
Revision of
SMPTE 435-2-2009

SMPTE STANDARD

10 Gb/s Serial Signal/Data Interface — Part 2: 10.692[1] Gb/s Stream — Basic Stream Data Mapping

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[1]Nominal bit rate. The interface is also capable of transmitting streams with the data rate of 10.692/1.001 Gb/s.

Approved
August 1, 2012

Foreword

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SMPTE ST 435-2 was prepared by Technology Committee 32NF.

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Introduction

This 10 Gb/s interface is based upon multiplexing multiple 1.5 Gb/s Basic Streams that comply with the data structure of SMPTE ST 292-1. The ancillary data structure as defined by SMPTE ST 291 is utilized for the mapping of the data into HANC and VANC data areas of a Basic Stream. Audio data mapping is based upon the requirements defined in SMPTE ST 299-1.

1 Scope

This Standard specifies the multiplexing schemes to map up to 8 Basic Streams defined by SMPTE ST 435-1 into the 10 Gb/s Serial Interface. The source image formats supported are referenced in SMPTE ST 435-1. The mapping also supports transmission of the embedded audio, payload ID and other ancillary data defined in SMPTE ST 291 in the source stream.

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.

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

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

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

4 Definition of Terms

4.1 10.692 Gb/s

the term “10.692 Gb/s” is used as a generic term for 10.692 Gb/s and 10.692/1.001 Gb/s in this standard

4.2 Basic Stream
a 10-bit parallel stream which has the same structure as the source data defined in SMPTE ST 292-1

4.3 CRC
Cyclic Redundancy Check codes defined in SMPTE ST 292-1

4.4 EAV
the term EAV used in this standard designates all of timing information at the end of active video area; i.e., EAV bytes plus LN and CRC defined in SMPTE ST 292-1

4.5 Even Basic Stream
CH2, CH4, CH6 and CH8 (Link Bs) of Basic Streams defined in Section 6.3 (Mode C) and Section 6.4 (Mode D)

4.6 HANC Data
data included in a digital line blanking interval between EAV and SAV

4.7 K28.5
special code for the word boundary detection of 8B/10B coding defined in ANSI INCITS 230

4.8 LN
Line Number data defined in SMPTE ST 292-1

4.9 Odd Basic Stream
CH1, CH3, CH5 and CH7 (Link As) of Basic Streams defined in Section 6.3 (Mode C) and Section 6.4 (Mode D)

4.10 SAV
timing information defining the start of active video area defined in SMPTE ST 292-1

4.11 Stuffing Data
the term “Stuffing Data” designates one of the data byte D0.0 of 8B/10B coding defined in ANSI INCITS 230

5 Mapping Overview

The source data of the 10.692 Gb/s data stream shall be multiple Basic Streams as defined in SMPTE ST 435-1.

Figure 1 shows the overall block diagram of the 10.692 Gb/s interface which can carry 4096×2160/24P/4:4:4, 3840×2160/30P/4:4:4 or up to four pairs of 2048×1080/24P/4:4:4 or 1920×1080/60I/4:4:4 signals.

The outline of the data mapping process shall be as follows:

- The 10-bit Basic Streams shall be packed into arrays of 8 bit words.
- The generated byte array shall be channel coded as 8B/10B encoded data.
- The blocks of encoded data shall be interleaved and serialized into the 10.692 Gb/s serial stream.

HANC Data in some of the Basic Streams are not interleaved into 10.692 Gb/s stream in the case of mapping Mode B, C or D. Details are defined in Section 6.2, Section 6.3, and Section 6.4.

Figure 1 illustrates the signal processing involved at the TX and RX ends of the transport. Default data values (040h for Y’ data and 200h for C'_B/C'_R data) shall be inserted into unused HANC Data area of a Basic Stream if it has not been mapped onto the 10.692 Gb/s stream.

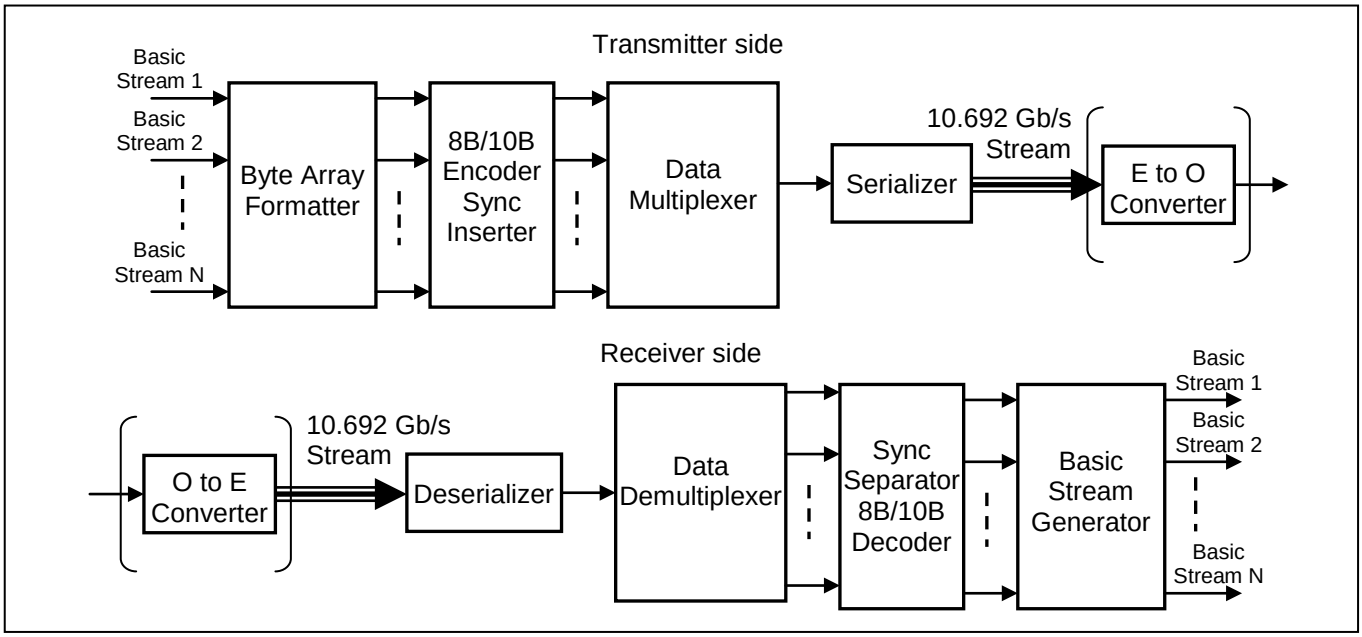

Figure 1 – Overall Block Diagram

6 Basic Stream Data Mapping

This section defines 4 data mapping structures. Mode A and Mode B shall be used for System 1.1 through System 4.3 images. Mode C shall be used for System 8.6 image exclusively. Mode D shall be used for System 8.2 through System 8.7 images, up to four pairs of System 2.2 through System 2.6 images or up to two pairs of System 4.1 through System 4.3 images.

Transmission of up to 5 Basic Streams as defined in SMPTE ST 435-1 is possible in Mode A, up to 6 Basic Streams is possible in Mode B and up to 8 Basic Streams is possible in Mode D. All Basic Streams that are mapped together onto a 10.692 Gb/s stream shall have the same frame rate and the same number of horizontal samples per line.

The placement of the ancillary data including the payload identifier as defined in SMPTE ST 352 shall be immediately following SAV of the line(s) specified in the Basic Stream interface document for Mode B, Mode C and Mode D.

The word clock frequency of each Basic Stream, as defined by SMPTE ST 435-1, shall be 148.5 MHz or 148.5/1.001 MHz. The word clock frequency shall be locked to the serial clock frequency (10.692 GHz or 10.692/1.001 GHz).

6.1 5-Channel Mode (Mode A)

Up to 5 Basic Streams may be embedded into the 10.692 Gb/s stream using mapping Mode A. The mapping shall maintain all the information included in each of the 5 Basic Streams.

The 8B/10B encoded 50-bit data block data from each Basic Stream shall be multiplexed into a single stream by the 50-bit block interleaving. The detail of the 50-bit block packing is defined in Section 6.1.1.

The Channel 1 Basic Stream data shall always be present for encoder and decoder synchronization. Other channels, when not used for image data, shall be filled with Stuffing Data.

Figure 2 defines the basic concept of Mode A mapping.

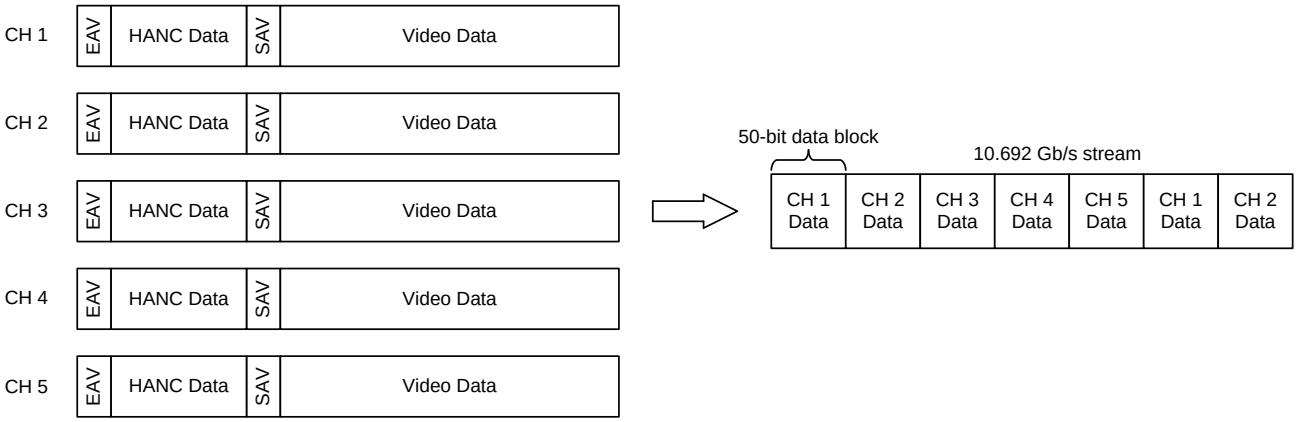

Figure 2 – Basic Stream interleaving for Mode A

6.1.1 Mode A 50-Bit Data Blocking and 8B/10B Encoding

4-word (40-bit) data blocks of the source Basic Stream data starting from the first SAV data shall be used for the blocking process.

Each 40-bit data block shall be packed into five 8-bit words and then shall be 8B/10B coded as defined in Section 11 of ANSI INCITS 230. Consequently a 50-bit encoded data block shall be generated from a 40-bit source data block. Figure 3 defines the blocking process.

Encoding disparity in a 10.692 Gb/s stream shall be alternated at every 10-bit word. Initial value of negative disparity shall be assigned to CH 1 first SAV word of each line.

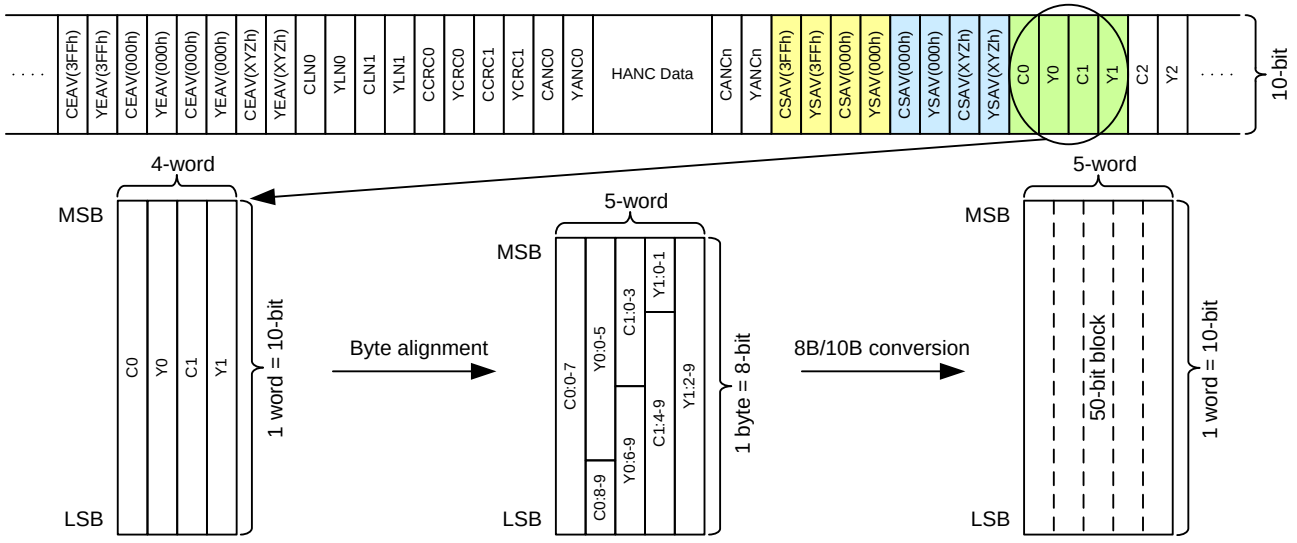

Figure 3 – Data alignment and 8B/10B encode process of 4-word data block

6.1.2 Data Replacement of SAV Part of Channel 1

In the Channel 1 stream, the first 40-bit byte aligned block at the beginning of each SAV shall be replaced by a synchronization block. This process shall be executed before 8B/10B encoding and shall be as defined in Figure 4.

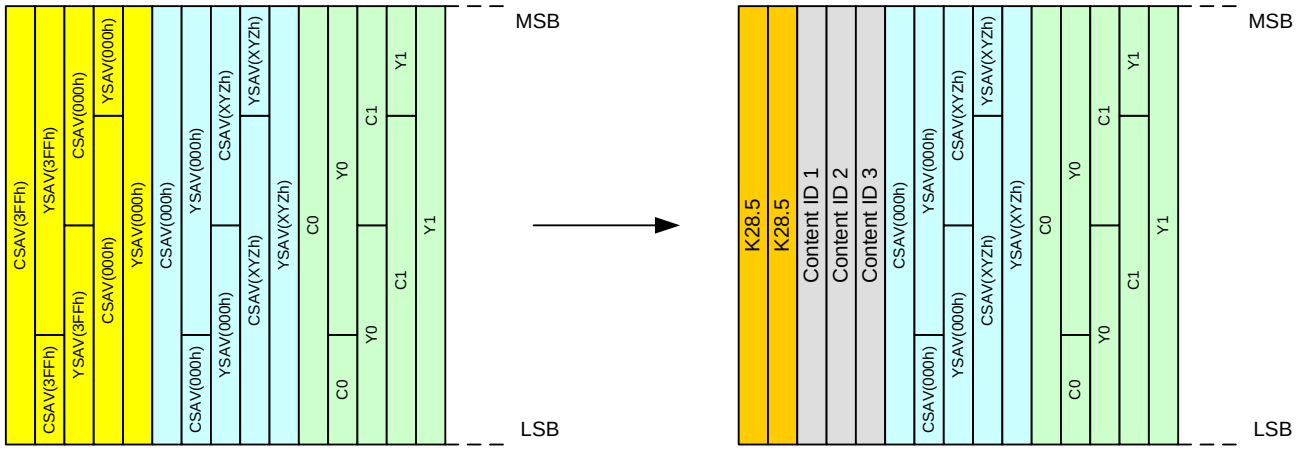

Figure 4 – SAV data replacement for Channel 1 data

The first 2 bytes of the byte aligned SAV data shall be replaced with two K28.5 special characters defined in 8B/10B Code, and successive 3 words of the byte aligned SAV data shall be replaced with the Content ID bytes as defined in Table 1.

Table 1 defines the layout of Content ID words.

Bit 7 of ID 1 shall be set to 0 in the case of the “1920×1080 Basic Stream”, "1280×720 Basic Stream” and shall be set to 1 in the case of the “2048×1080 Basic Stream”.

Bits 5 and 6 of ID 1 shall indicate the Mapping Structure and shall be assigned as defined in Table 3.

Bits 0 through 4 of ID1 shall indicate the System Number of CH 1 basic stream and shall be set as defined in Table 2.

Table 1 – Content ID data arrangement for Mode A

Bit	7 (MSB)	6	5	4	3	2	1	0 (LSB)
ID 1	Basic Stream	Mapping Structure=00		System ID				
ID 2	Reserved (00h)							
ID 3	Reserved (00h)							

Table 2 – System ID assignment

System ID	System Number
00000	1.1
00001	1.2
00010 ~ 00011	Reserved
00100	2.1
00101	2.2
00110	2.3
00111	2.4
01000	2.5
01010	2.6
01011~ 01111	Reserved
10000	4.1
10001	4.2
10010	4.3
10011 ~ 10101	Reserved
10110	8.2
10111	8.3
11000	8.4
11001	8.5
11010	8.6
11011	8.7
11100 ~ 11111	Reserved

Table 3 – Mapping Structure value

00: Mode A	01: Mode B	10: Mode C	11: Mode D

6.1.3 10.692 Gb/s Stream for Mode A Transmission

The 50-bit encoded data block units from 5 source streams shall be interleaved from CH 1 through CH 5 as shown in Figure 5. The Stuffing Data shall be appended to the end of the HANC code blocks to adjust a line data period of Mode A to be consistent with a line period of a source stream. The data length in a line, and the number of Stuffing Data bytes in Mode A shall be as shown in Table A.1 of Annex A

The interleaved stream shall be serialized to 10.692 Gb/s stream with LSB first order.

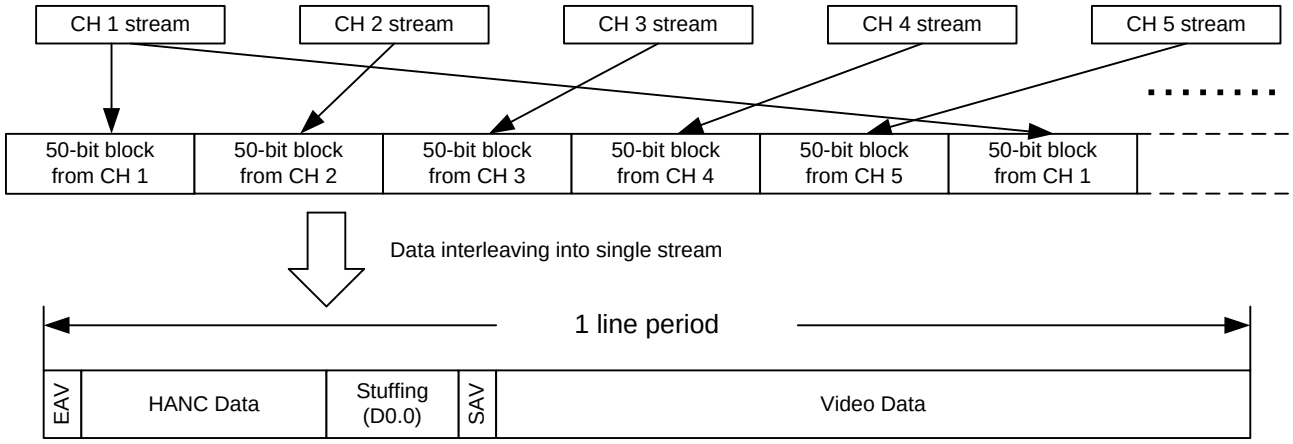

Figure 5 – Data alignment process for a total line

6.2 6-Channel Mode (Mode B)

Up to 6 Basic Streams may be embedded into the 10.692 Gb/s stream using mapping Mode B.

The Mode B mapping shall maintain all of the information included in channel 1 through 6 Basic Streams with the exception of HANC Data in Basic Streams assigned to channel 5 and 6.

The CH 1 Basic Stream shall always be present for encoder and decoder synchronization. Other channels, where not used for image data, shall be wholly filled with Stuffing Data.

Figure 6 illustrates the basic concept of Mode B mapping.

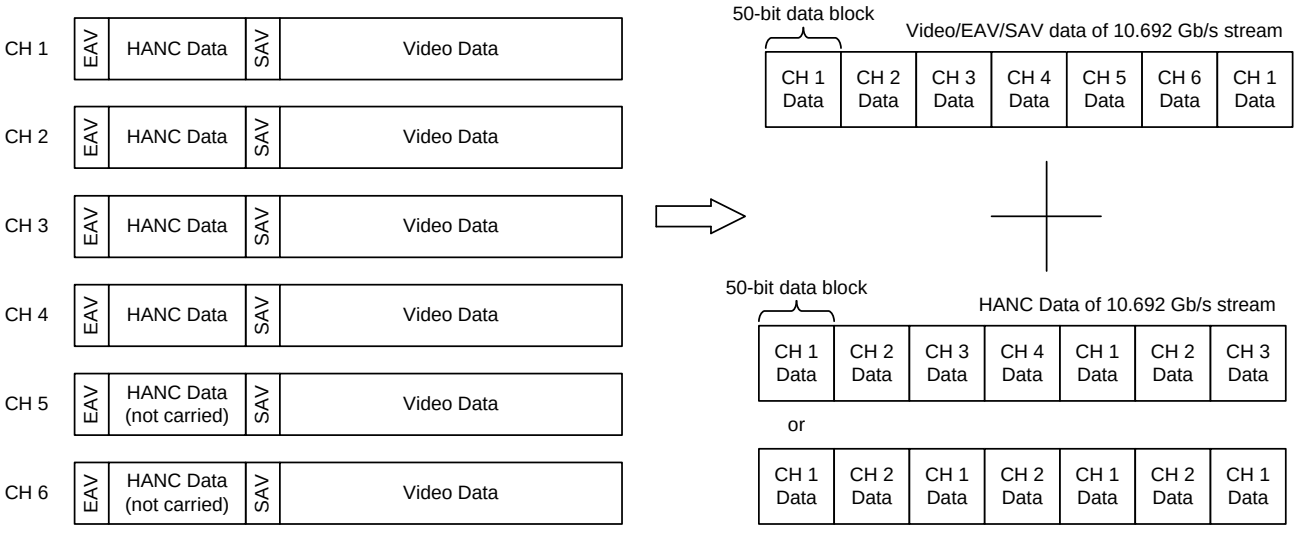

Figure 6 – Basic Stream interleaving for Mode B

6.2.1 Mode B 50-Bit Data Blocking and 8B/10B Encoding

4-word (40-bit) data block of the source stream starting from the first SAV data shall be used for the blocking process.

Each 4-word block shall be packed into five 8-bit words and then shall be encoded with 8B/10B coding as defined in Section 6.1.1.

6.2.2 Data Replacement of SAV Part of Channel 1

Data replacement of each SAV of the CH 1 Basic Stream shall be defined in Section 6.1.2.

Table 4 specifies the layout of the Content ID words for Mode B.

Table 4 – Content ID data arrangement for Mode B

Bit	7 (MSB)	6	5	4	3	2	1	0 (LSB)
ID 1	Basic Stream	Mapping Structure = 01		System ID				
ID 2	Division	Reserved (0)						
ID 3	Reserved (00h)							

Bit 7 of ID1 shall be set using the same definitions as Section 6.1.2 and ID 2 and ID 3 shall be specific to Mode B

Bit 7 of ID 2 shall be set to 0 in the case of the “Square division” and shall be set to 1 in the case of the “2-sample interleave division”. The Square division and the 2-sample interleave division is defined in Section 6.4.1 of SMPTE ST 435-1.

Bit 0 through bit 6 of ID 2 shall be reserved and shall be set to 0.

ID 3 shall be reserved and shall be set to 00h.

6.2.3 10.692 Gb/s Stream for Mode B Transmission

Figure 7 defines the stream structure of Mode B transmission. The mapping of this mode shall carry all the Video Data included in CH 1 through CH 6 Basic Stream.

In the case of “2048×1080 Basic Stream”, HANC Data included in CH 1 through CH 4 at frame rates of 23.98 Hz, 24 Hz and 25 Hz or HANC Data included in CH 1 and CH 2 at frame rates of 29.97 Hz and 30 Hz shall be 8B/10B encoded and embedded in the 10.692 Gb/s stream with 50-bit blocking. Each 4-word HANC Data block shall be packed to five 8-bit words and then shall be encoded with 8B/10B coding as the same way as defined in Section 6.1.1**.** HANC Data included in CH 5 and CH 6 at frame rates of 23.98 Hz, 24 Hz and 25 Hz or HANC Data included in CH 3 through CH 6 at frame rates of 29.97 Hz and 30 Hz shall be discarded. All other data included in CH 1 to CH 6 shall be embedded in the same way as Mode A transmission.

In the case of “1920×1080 Basic Stream”, HANC Data included in CH 1 through CH 4 at the frame rates of 23.98 Hz through 30 Hz shall be 8B/10B encoded and embedded in the 10.692 Gb/s stream with 50-bit blocking. Each 4-word HANC Data block shall be packed to five 8-bit words and then shall be encoded with 8B/10B coding as the same way as defined in Section 6.1.1. HANC Data included in other channels shall be discarded. All other data included in CH 1 through CH 6 shall be embedded in the same way as Mode A transmission.

Stuffing Data shall be appended to the end of the HANC code blocks to adjust the line data period of Mode B to be consistent with the line period of source stream. The data length in a line and the number of Stuffing bytes in Mode B shall be as shown in Table A.2 of Annex A.

The interleaved stream shall be serialized into 10.692 Gb/s stream with LSB first.

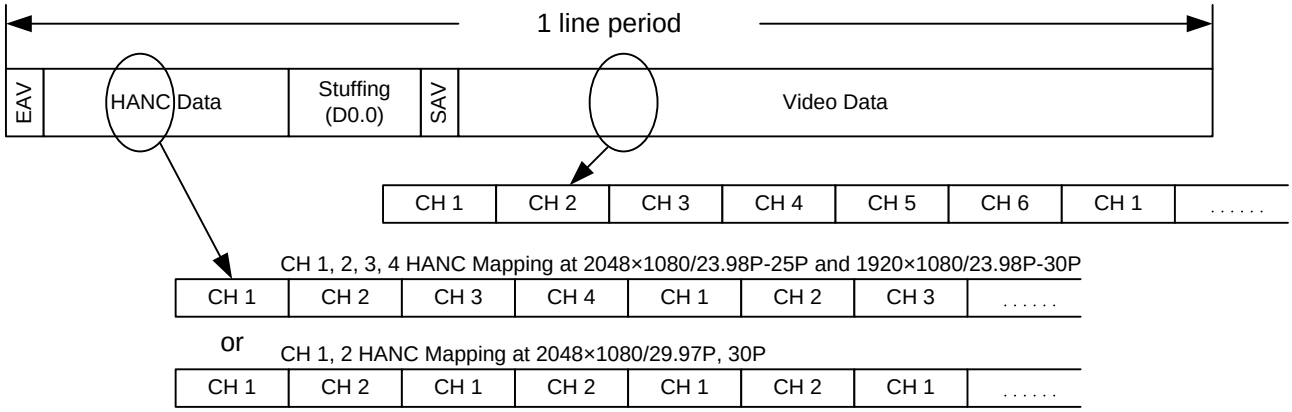

Figure 7 – Data alignment structure of Mode B stream

6.3 8-Channel Mode (Mode C)

Mode C shall be used for 4096x2160/23.98P,24P/4:4:4/12-bit, 8.6 image formats. The mapping for this mode shall carry all the data included in channel 1 Basic Stream. Mode C also carries all the data with the exception of the HANC Data area in CH 2 through CH 8.

A pair of four word blocks from each of the Odd and Even Basic Stream derived from each sub image shall be combined to make a 90-bit block. The detail of the 90-bit blocking is described in Section 6.3.1. Blocks for the CH 1 HANC Data area shall be as defined in Section 6.1.1.

The CH 1 Basic Stream shall always be present for encoder and decoder synchronization. Other channels, where not used for image data, shall be wholly filled with Stuffing Data.

Figure 8 illustrates the basic concept of Mode C mapping.

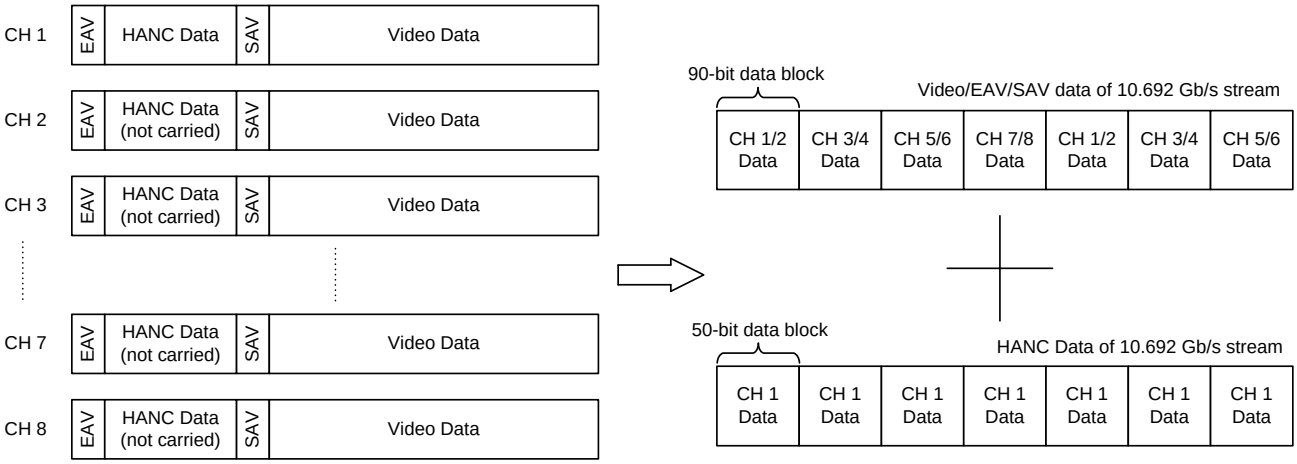

Figure 8 – Basic Stream interleaving for Mode C

6.3.1 Video Data Blocking and 8B/10B Encoding

4-word (40-bit) data blocks of the source stream starting from the first SAV data shall be used for the mapping operation.

Each 40-bit data block in an Odd Basic Stream shall be packed into five 8 bit words as defined in Section 6.1.1.

For an Even Basic Stream, the parity bits and the reserved bits included in an alpha channel data block shall be discarded before the blocking. The remaining 32-bits of data from a 4-word block shall be aligned to a 4-byte length. In the case of LN or CRC values in an alpha channel, the data blocking process defined in Section 6.3.2 shall be used.

The 5-byte block from an Odd Basic Stream and the 4-byte block from an Even Basic Stream shall be combined to a 9-byte block, the block shall be 8B/10B encoded to make a 90-bit data block. Figure 9 illustrates the detail of the process.

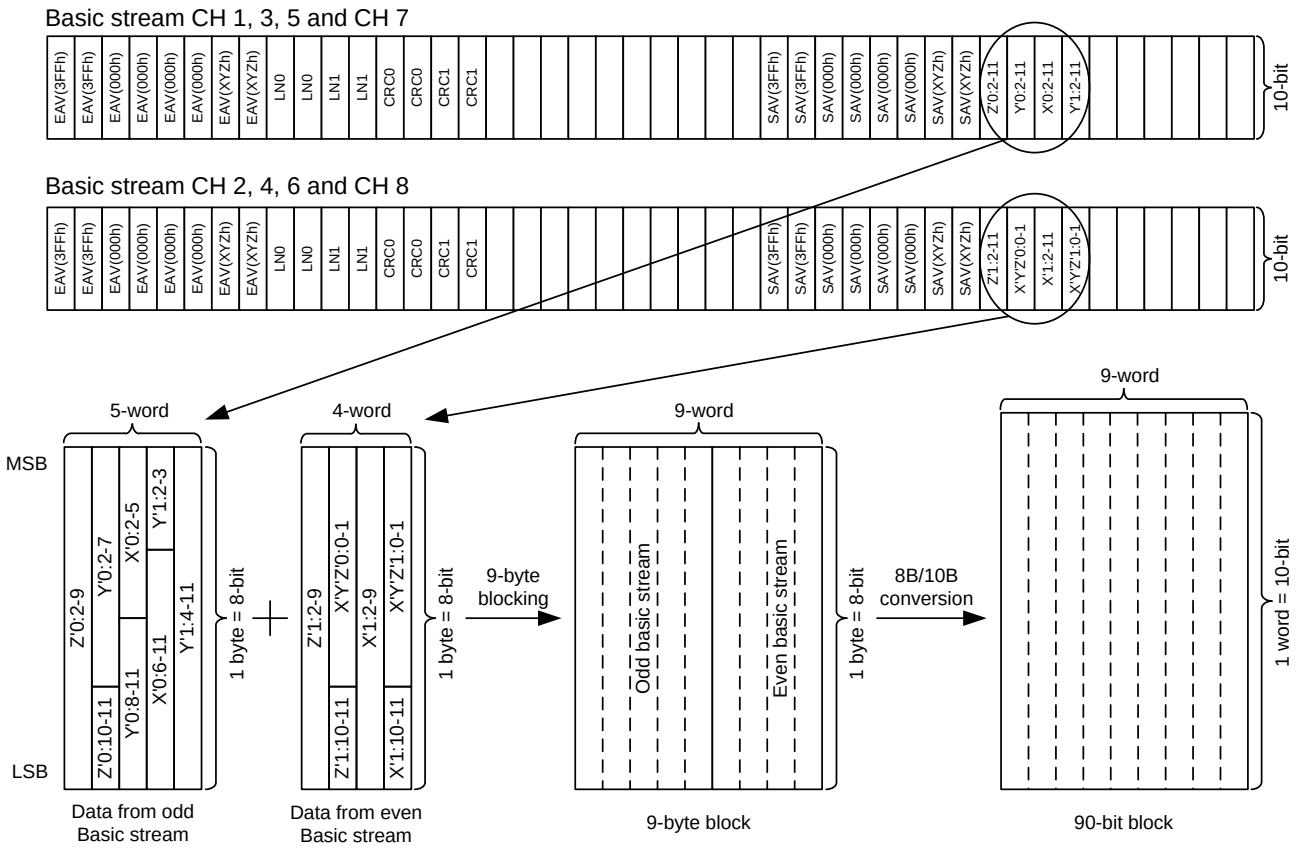

Figure 9 – 90-bit blocking in Mode C

6.3.2 Data Blocking for CRC and LN Area in an Even Basic Stream

18-bits of CRC data in the alpha channel of an Even Basic Stream shall be aligned to three 6-bit areas within two 4-byte data blocks as illustrated in Figure 10. The parity bit (b9) in CRC words shall be discarded before blocking.

The lower 6 bits of word YCR0 shall be aligned to follow after the CLN1 word.

The higher 3 bits of word YCR0 and the lower 3 bits of YCR1 word shall be aligned to just after word CCR0.

The higher 6 bits of word YCR1 shall be aligned to just after the CCR1 word.

These blocking processes shall be used for 4-word blocking of the CRC and LN values in an Even Basic Stream.

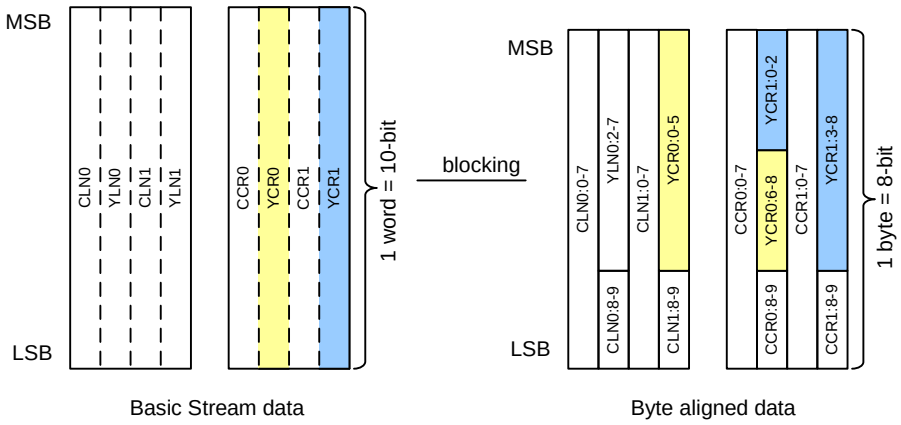

Figure 10 – Blocking of CRC and LN words

6.3.3 Data Replacement of SAV Part of Channel 1

Data replacement of CH 1 Basic Stream SAV shall be as defined in Section 6.1.2.

Table 5 specifies the layout of the Content ID words for Mode C. ID 1 shall have the same value as defined in Section 6.1.2 and ID 2 and ID 3 shall be specific to Mode C. The System ID information shall be the system ID value 11010 for the system number 8.6 as defined in Table 2.

Table 5 – Content ID data arrangement for Mode C

Bit	7 (MSB)	6	5	4	3	2	1	0 (LSB)
ID 1	Basic Stream = 1	Mapping Structure = 10		System ID = 11010				
ID 2	Division	Reserved (0)						
ID 3	Reserved (00h)							

Bit 7 of ID 1 shall be set to 1 for the “2048×1080 Basic Stream”.

Bit 7 of ID 2 shall be set to 0 in the case of the “Square division” and shall be set to 1 in the case of the “2-sample interleave division”. The Square division and the 2-sample interleave division is defined in Section 6.4.1 of SMPTE ST 435-1.

Bit 0 through bit 6 of ID 2 shall be reserved and shall be set to 0.

ID 3 shall be reserved and shall be set to 00h.

6.3.4 10.692 Gb/s Stream for Mode C Transmission

Figure 11 illustrates the stream structure of video data in Mode C transmission. Data from each sub image shall be interleaved with a unit of 90-bit Blocks

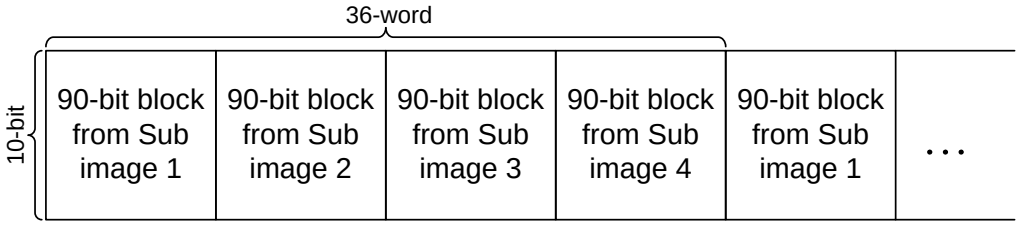

Figure 11 – 90-bit block interleaving derived from Basic Stream pair

Figure 12 illustrates the stream structure of Mode C transmission. HANC Data included in CH 1 shall be embedded in the 10.692 Gb/s stream with 50-bit blocking. HANC Data included in CH 2 through CH 8 shall be discarded. All other data included in CH 1 to CH 8 shall be embedded with 90-bit block interleaving.

Stuffing Data shall be appended to the end of the HANC code blocks to adjust the line data period of Mode C to be consistent with the line period of the source stream. The data length in a line and the number of Stuffing bytes in Mode C shall be as shown in Table A.3 of Annex A.

The interleaved stream shall be serialized to 10.692 Gb/s stream with LSB first order.

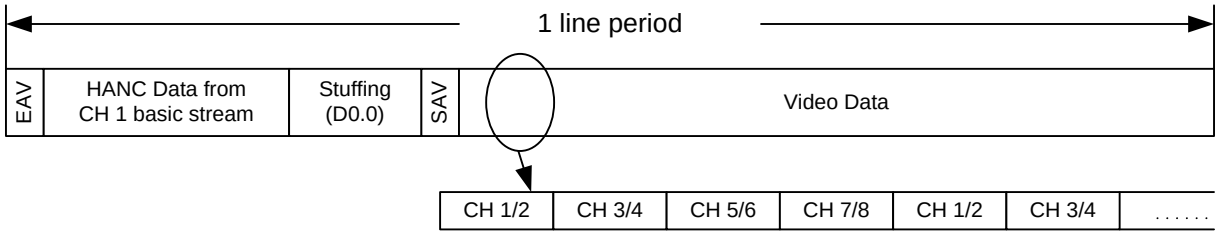

Figure 12 – Data alignment structure of Mode C

6.4 8-Channel Mode (Mode D)

Up to 8 basic streams may be embedded into the 10.692 Gb/s stream using mapping Mode D. Mode D shall be used for System 8.2 through System 8.7 images, up to four pairs of System 2.2 through System 2.6 images or up to two pairs of System 4.1 through System 4.3 images may be carried. The mapping for this mode shall carry all the Video Data included in the CH 1 through CH8 Basic Stream. Mode D also carries the HANC Data included in CH 1, 3, 5 of the “2048×1080 Basic Stream” at frame rates of 23.98 Hz, 24 Hz and 25 Hz, CH 1, 3, 5, 7 of “1920×1080 Basic Stream” at frame rates of 23.98 Hz, 24 Hz and 25 Hz and CH 1 of “1920×1080 Basic Stream” at frame rates of 29.97 Hz and 30 Hz.

A pair of four word blocks from each of the Odd and Even Basic Stream derived from each sub image shall be combined to make an 80-bit block. The details of the 80-bit blocking is described in Section 6.4.1. Blocking for CH 1 or CH 1, 3, 5, 7 (Link As) HANC Data area shall be as defined in Section 6.1.1.

The CH 1 Basic Stream data shall always be present for encoder and decoder synchronizing. Other channels, when not used for Video Data and HANC Data, shall be filled with Stuffing Data.

Figure 13 illustrates the basic concept of Mode D mapping.

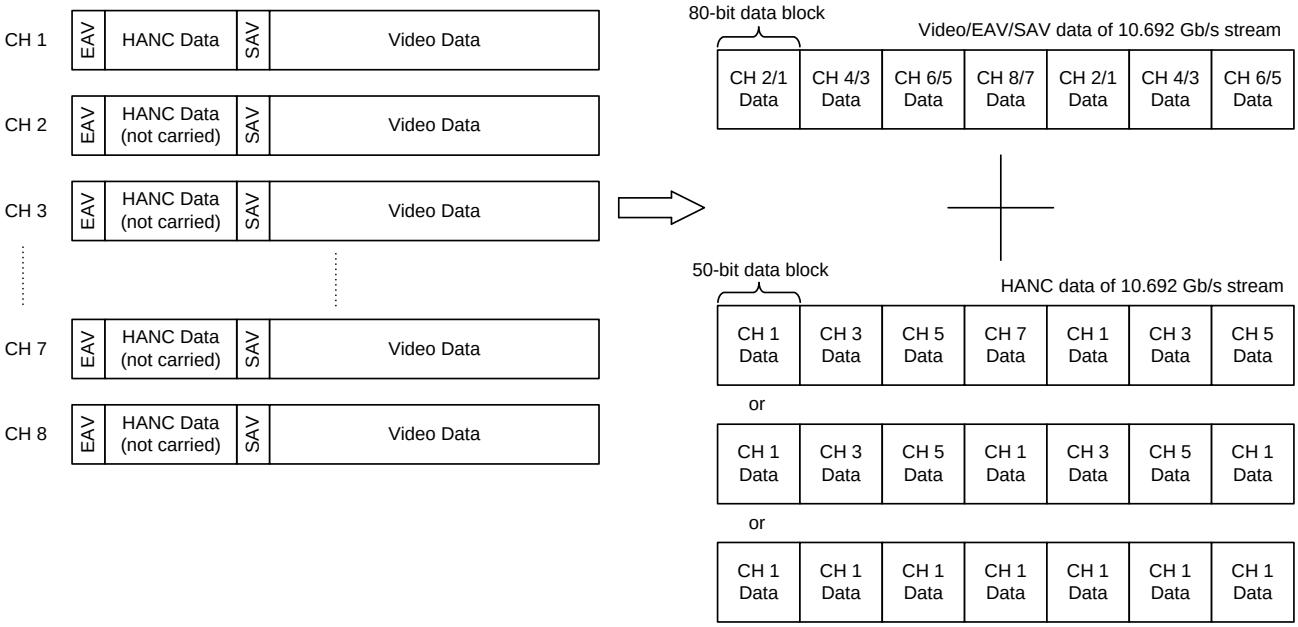

Figure 13 – Basic Stream interleaving for Mode D

6.4.1 Mode D Video Data Blocking, Scrambling and 8B/10B Encoding

4-word (40-bit) data blocks of the source stream starting from the first SAV data shall be used for the mapping operation. Figure 14 illustrates the detail of the blocking process.

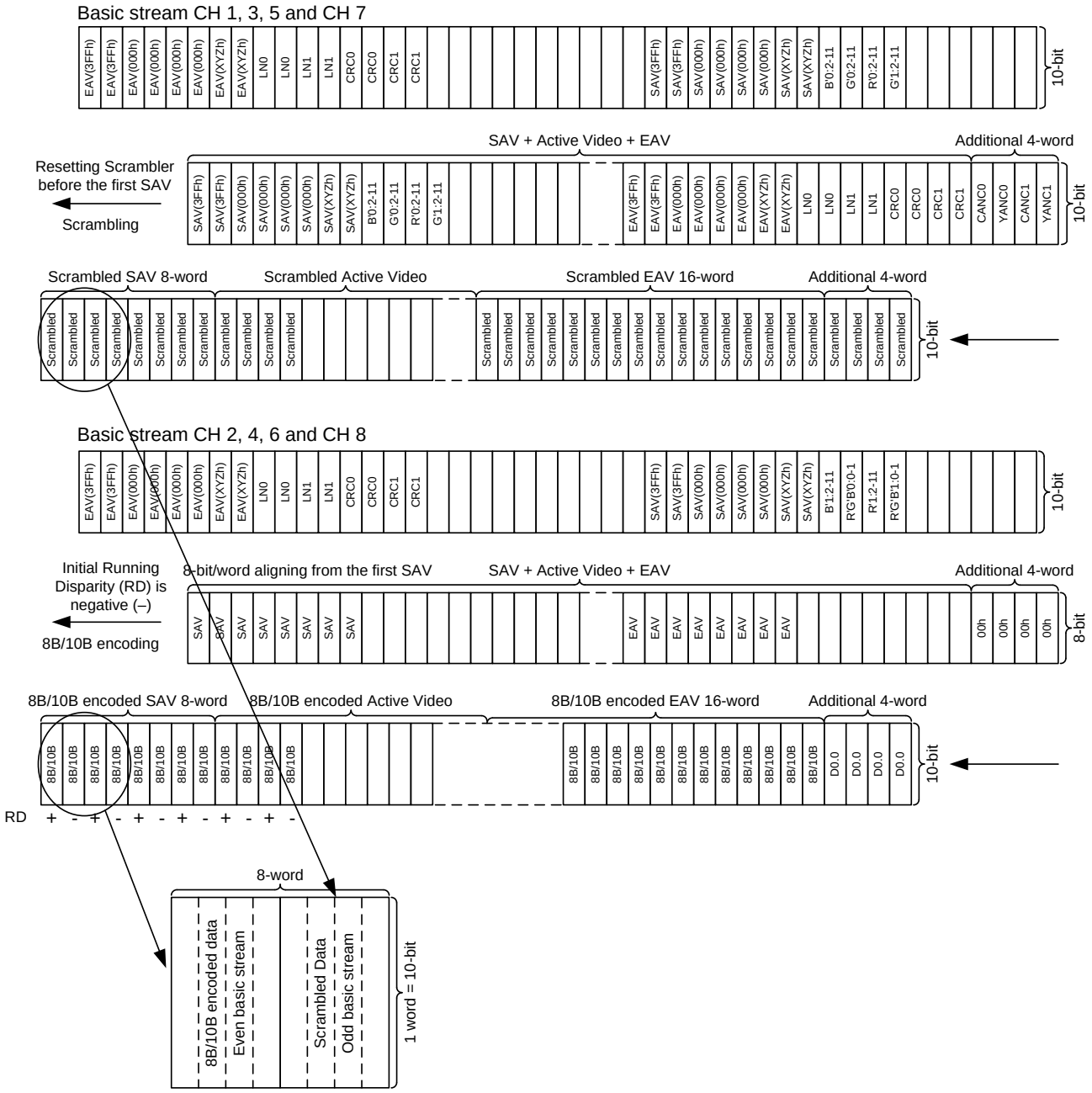

Figure 14 – 80-bit blocking in Mode D

Each 4-word block of each Odd Basic Stream shall be scrambled using the same scrambling polynomial as defined in SMPTE ST 292-1 with the initial value of the scrambler set to zero before the first SAV of each line. Bits b0 and b1 of XYZh(C) in the SAV of CH 1, CH 3, CH 5 and CH 7 shall be set to (0,0), (0,1), (1,0) and (1,1) respectively to randomize each scrambled data. The scrambled data starts from 1F5h, which is the scrambled 3FFh(C) and does not include initial register value of 0.

At the receiver side, de-scrambling shall be performed with the initial value of the de-scrambler set to zero before the first SAV of each line. After descrambling, bits b0 and b1 of XYZh(C) of the SAV shall be set to (0,0).

For an Even Basic Stream, bits b8 and b9 of the parity bits, and bits b0 and b1 of the reserved bits included in an alpha channel data block shall be discarded before the blocking. The remaining 32-bit data from a 4-word block shall be aligned to 4-byte length. Except in the case of LN and CRC values in an alpha channel, where the data blocking process defined in Section 6.4.2 shall be used.

The 4-byte block from an Even Basic Stream shall be 8B/10B encoded to make a 40-bit data block. Running Disparity (RD) of the 8B/10B encoded data shall alternate positive and negative from the first SAV.

A 40-bit 8B/10B encoded data block from an Even Basic Stream and a 40-bit scrambled data block from an Odd Basic Stream shall be interleaved in the order of an Even Basic Stream followed by an Odd Basic Stream and shall be combined to make an 80-bit block.

In the case of system 8.2 images, unused input channels for Even Basic Streams (Link B) shall not be used.

6.4.2 Data Blocking for CRC and LN Area in an Even Basic Stream

18-bits of CRC data in the alpha channel of an Even Basic Stream shall be aligned to three 6-bit areas within two 4-byte data blocks as illustrated in Figure 15 and as defined in § 6.3.2. The parity bit (b9) in CRC words shall be discarded before blocking.

The lower 6 bits of word YCR0 shall be aligned to follow after the CLN1 word. The higher 3 bits of word YCR0 and the lower 3 bits of word YCR1 shall be aligned to follow after the CCR0 word. The higher 6 bits of word YCR1 shall be aligned to follow after the CCR1 word.

These blocking processes shall be used for 4-word blocking of CRC and LN values in an Even Basic Stream.

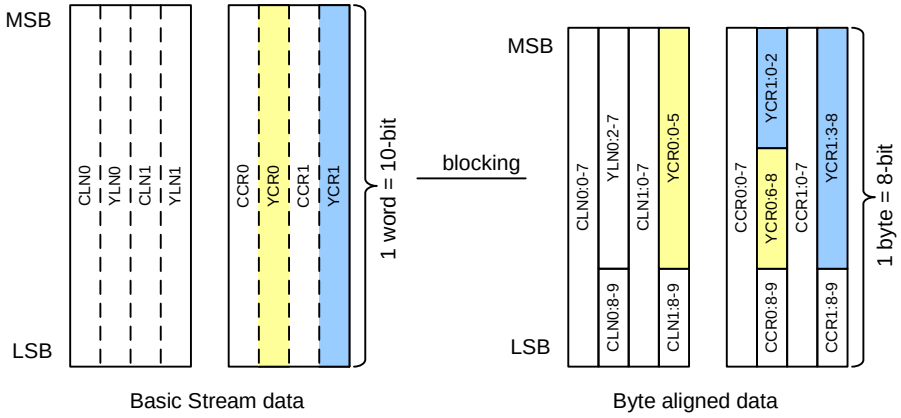

Figure 15 – Blocking of CRC and LN word

6.4.3 Data Replacement of SAV Part of Channel 2

Data replacement of the synchronization word shall be done on the byte aligned data at the beginning of the SAV of the CH 2 Basic Stream in Mode D. This process shall be executed before 8B/10B encoding.

The first 2 words of the SAV shall be replaced with two K28.5 special characters defined in 8B/10B coding and successive 2 words of the byte aligned data shall be replaced with Content IDs. These processes are illustrated in Figure 16.

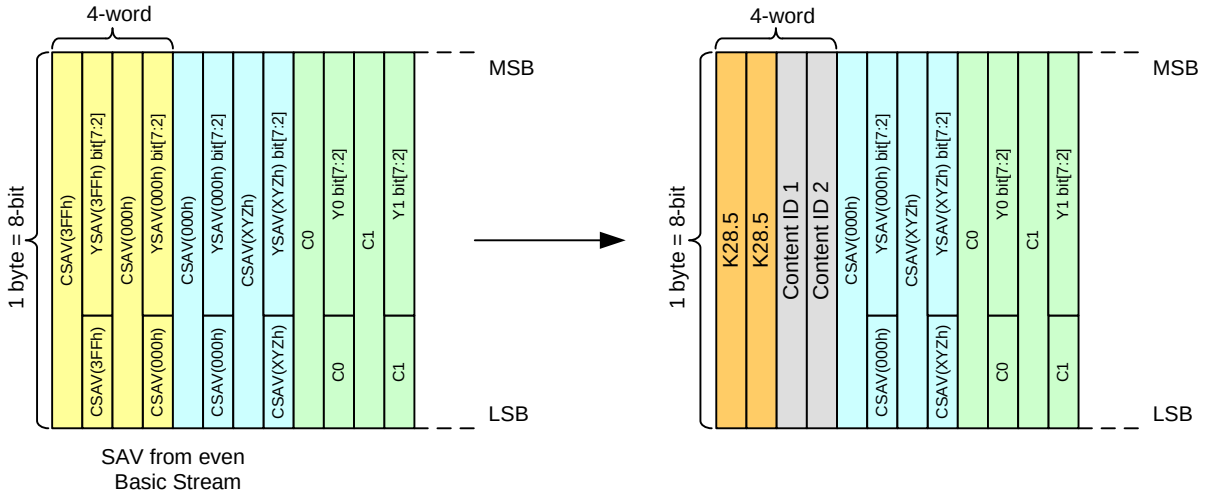

Figure 16 – SAV data replacement for Channel 2 data

Table 6 specifies the layout of the Content ID words for Mode D. ID 1 shall be set using the same definitions as Section 6.1.2 and ID 2 shall be specific to Mode D. The System ID information shall be a representation of the System Number of the CH 1 Basic Stream as defined in Table 2.

Table 6 – Content ID data arrangement for Mode D

Bit	7 (MSB)	6	5	4	3	2	1	0 (LSB)
ID 1	Basic Stream	Mapping Structure = 11		System ID				
ID 2	Division	Reserved (0)						

Bit 7 of ID 1 shall be set to 0 in the case case of the “1920×1080 Basic Stream” and shall be set to 1 in the case of the “2048×1080 Basic Stream”.

Bit 7 of ID 2 shall be set to 0 in the case of the “Square division” and shall be set to 1 in the case of the “2-sample interleave division”. The Square division and the 2-sample interleave division is defined in Section 6.4.1 of SMPTE ST 435-1.

Bit 0 through bit 6 of ID2 shall be reserved and shall be set to 0.

6.4.4 10.692 Gb/s Stream for Mode D Transmission

Figure 17 illustrates the stream structure of video data in Mode D transmission. Data from each sub image shall be interleaved with a unit of 80-bit Block.

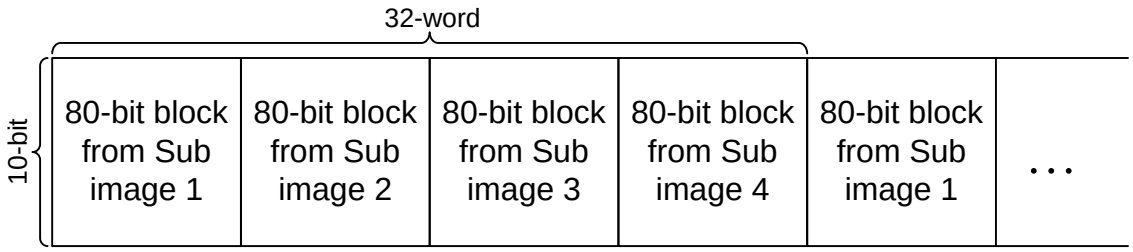

Figure 17 – 80-bit array interleaving derived from Basic Stream pair

Figure 18 illustrates the stream structure of Mode D transmission.

In the case of “2048×1080 Basic Stream”, HANC Data included in CH 1, 3, 5 at frame rates of 23.98 Hz, 24 Hz and 25 Hz shall be 8B/10B encoded and embedded in the 10.692 Gb/s stream with 50-bit blocking. HANC Data included in CH 2, 4, 6, 7, 8 shall be discarded. All other data included in CH 1 through CH 8 shall be embedded with 80-bit block interleaving.

In the case of “1920×1080 Basic Stream” HANC Data included in CH 1, 3, 5, 7 at frame rates of 23.98 Hz, 24 Hz, 25 Hz, and HANC Data in CH 1 at frame rates of 29.97 Hz, 30 Hz shall be 8B/10B encoded and embedded in the 10.692 Gb/s stream with 50-bit blocking. HANC Data included in other channels shall be discarded. All other data included in CH 1 through CH 8 shall be embedded with 80-bit block interleaving.

The interleaved stream shall be serialized to 10.692 Gb/s stream with LSB first. The data length in a line in Mode D shall be as shown in Table A.4 of Annex A.

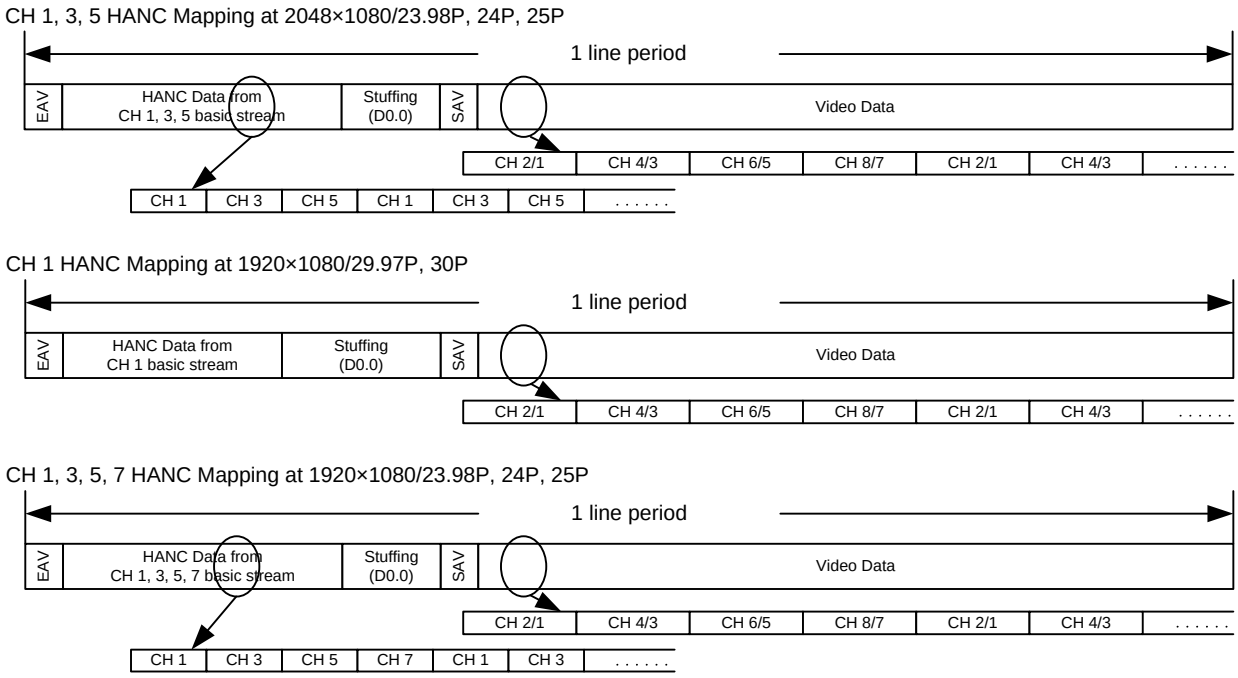

Figure 18 – Data alignment structure of Mode D

Annex A Data Length in a Line in Mode A, B, C and D (Normative)

Data length in a line in Mode A, B, C and D shall be as shown in Tables A.1, A.2, A.3 and A.4 respectively.

Table A.1 – Data length in a line (Mode A)

Basic Stream	System No.	Frame rate	Total word for a line	Video Data	HANC and EAV/SAV data		Stuffing Data
2048×1080	1.1, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 4.1, 4.2, 4.3,	23.98Hz, 24Hz or 48Hz	39600	25600	CH 1,2,3,4,5	8775	5225
		25Hz or 50Hz	38016	25600	CH 1,2,3,4,5	7400	5016
		29.97Hz, 30Hz 59.94Hz or 60Hz	31680	25600	CH 1,2,3,4,5	1900	4180
1920×1080	1.1, 2.1, 2.2, 2.3, 2.4, 2.5, 4.1, 4.2, 4.3	23.98Hz or 24Hz	39600	24000	CH 1,2,3,4,5	10375	5225
		25Hz or 50Hz	38016	24000	CH 1,2,3,4,5	9000	5016
		29.97Hz, 30Hz 59.94Hz or 60Hz	31680	24000	CH 1,2,3,4,5	3500	4180
1280×720	1.2	50Hz	28512	16000	CH 1,2,3,4,5	8750	3762
		59.94Hz or 60Hz	23760	16000	CH 1,2,3,4,5	4625	3135

Table A.2 – Data length in a line (Mode B)

Basic Stream	System No.	Frame rate	Total word for a line	Video Data	HANC and EAV/SAV data		Stuffing Data
2048×1080	1.1, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 4.1, 4.2, 4.3,	23.98Hz, 24Hz or 48Hz	39600	30720	CH 1,2,3,4	7080	1800
		25Hz or 50Hz	38016	30720	CH 1,2,3,4	5980	1316
		29.97Hz, 30Hz 59.94Hz or 60Hz	31680	30720	CH 1,2	880	80
1920×1080	1.1, 2.1, 2.2, 2.3, 2.4, 2.5, 4.1, 4.2, 4.3	23.98Hz or 24Hz	39600	28800	CH 1,2,3,4	8360	2440
		25Hz or 50Hz	38016	28800	CH 1,2,3,4	7260	1956
		29.97Hz, 30Hz 59.94Hz or 60Hz	31680	28800	CH 1,2,3,4	2860	20
1280×720	1.2	50Hz	28512	19200	CH 1,2,3,4	7060	2252
		59.94Hz or 60Hz	23760	19200	CH 1,2,3,4	3760	800

Table A.3 – Data length in a line (Mode C)

Basic Stream	System No.	Frame rate	Total word for a line	Video Data	HANC and EAV/SAV data		Stuffing Data
2048×1080	8.6	23.98Hz, or 24Hz	39600	36864	CH 1	1941	795

Table A.4 – Data length in a line (Mode D)

Basic Stream	System Number	Frame rate	Total word for a line	Video Data	HANC and EAV/SAV data		Stuffing Data
2048×1080	8.2, 8.3, 8.4, 8.5, 8.6, 8.7	23.98 Hz or 24 Hz	39600	32768	CH 1,3,5	5367	1465
		25 Hz	38016	32768	CH 1,3 5	4542	706
1920×1080	8.2, 8.3, 8.4, 8.5, 8.6, 8.7	23.98 Hz or 24 Hz	39600	30720	CH 1,3,5,7	8372	508
		25 Hz	38016	30720	CH 1,3,5,7	7272	24
		29.97 Hz or 30Hz	31680	30720	CH 1	862	98

Note: To carry 8.2 through 8.7 system images of "2048×1080 Basic Stream" at 29.97P and 30P, 10G dual link is required and is specified in the 4096 mapping document, SMPTE ST 2048-3.

Annex B Channel Assignment of the Basic Streams (Informative)

Tables B.1, B.2, B.3 and B.4 show examples of the channel assignment of the 10.692 Gb/s interface. However, this annex does not exclude other possible channel assignment schemes.

Channel 1 is used as the reference channel in all channel assignment schemes.

B.1 Mode A Channel Assignment Examples

Mode A is used to transmit up to 5 channels of 1.5 Gb/s class data streams, up to two pairs of the dual link 1.5 Gb/s class data streams, the quad link 1.5 Gb/s class data stream or the combination of these classes as long as the total number of input channels are not greater than 5. Table B.1 shows assignment examples.

Table B.1 – Channel assignment examples for Mode A

<table>
<tr><th colspan="5">2048×1080 Basic Stream</th></tr>
<tr><td>CH 1</td><td>CH 2</td><td>CH 3</td><td>CH 4</td><td>CH 5</td></tr>
<tr><td>System 1.1
2048/24P</td><td>System 1.1
2048/24P</td><td>System 1.1
2048/24P</td><td>System 1.1
2048/24P</td><td>System 1.1
2048/24P</td></tr>
<tr><td colspan="2">System 2.1
2048/48P, Link(Basic Stream) A, B</td><td colspan="2">System 2.1
2048/48P, Link(Basic Stream) A, B</td><td>System 1.1
2048/24P</td></tr>
<tr><td colspan="2">System 2.1
2048/48P Link(Basic Stream) A, B</td><td>System 1.1
2048/24PsF</td><td>System 1.1
2048/24P</td><td>System 1.1
2048/24P</td></tr>
<tr><td colspan="2">System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 3
2048/24P Link(Basic Stream) A, B</td><td colspan="2">System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 3
2048/24P, Link(Basic Stream) A, B</td><td>System 1.1
2048/24P or None</td></tr>
<tr><td>System 1.1
2048/24P</td><td>System 1.1
2048/24P</td><td>System 1.1
2048/24P</td><td colspan="2">System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 3
2048/24P, Link(Basic Stream) A,B</td></tr>
<tr><td colspan="4">System 4.1, 4.2 or 4.3 *Note 3
2048/48P, Basic Stream A, B, C, D</td><td>System 1.1
2048/24P</td></tr>
<tr><td colspan="5">Note 1: Frame rates shown in this table are the lowest case of each image system. Other frame rates can also be applicable so far as the image format allows.

Note 2: Use of shaded area is optional.

Note 3: Mixed transmission of different image systems is possible if the frame rates and the horizontal samples per line of the Basic Streams are consistent with each other.</td></tr>
</table>

<table>
<tr><th colspan="5">1920×1080 Basic Stream</th></tr>
<tr><td>CH 1</td><td>CH 2</td><td>CH 3</td><td>CH 4</td><td>CH 5</td></tr>
<tr><td>System 1.1
1920/24P</td><td>System 1.1
1920/24P</td><td>System 1.1
1920/24P</td><td>System 1.1
1920/24P</td><td>System 1.1
1920/24P</td></tr>
<tr><td colspan="2">System 2.1
1920/50P, Link(Basic Stream) A, B</td><td colspan="2">System 2.1
1920/50P, Link(Basic Stream) A, B</td><td>System 1.1
1920/25P</td></tr>
<tr><td colspan="2">System 2.1
1920/50P Link(Basic Stream) A, B</td><td>System 1.1
1920/50I</td><td>System 1.1
1920/25P</td><td>System 1.1
1920/25P</td></tr>
<tr><td colspan="2">System 2.2, 2.3, 2.4 or 2.5
*Note 3
1920/24P Link(Basic Stream) A, B</td><td colspan="2">System 2.2, 2.3, 2.4 or 2.5
*Note 3
1920/24P, Link(Basic Stream) A, B</td><td>System 1.1
1920/24P or None</td></tr>
<tr><td>System 1.1
1920/24P</td><td>System 1.1
1920/24P</td><td>System 1.1
1920/24P</td><td colspan="2">System 2.2, 2.3, 2.4 or 2.5
*Note 3
1920/24P, Link(Basic Stream) A,B</td></tr>
</table>

System 4.1, 4.2 or 4.3 1920/50P, Basic Stream A, B, C, D			*Note 3	System 1.1 1920/25P
System 1.2 1280/50P	System 1.2 1280/50P	System 1.2 1280/50P	System 1.2 1280/50P	System 1.2 1280/50P

Note 1: Frame rates shown in this table are the lowest case of each image system. Other frame rates can also be applicable so far as the image format allows.

Note 2: Use of shaded area is optional.

Note 3: Mixed transmission of different image systems is possible if the frame rates and the horizontal samples per line of the Basic Streams are consistent with each other.

B.2 Mode B Channel Assignment Examples

Mode B is used to transmit up to 6 channels of the 1.5 Gb/s class data streams, up to three pairs of the dual link 1.5 Gb/s class data streams, the quad link 1.5 Gb/s class or the combination of these classes as long as the total number of input channels are not greater than 6. Table B.2 shows the assignment examples.

Table B.2 – Channel assignment examples for Mode B

2048×1080 Basic Stream					
CH 1	CH 2	CH 3	CH 4	CH 5	CH 6
System 1.1 2048/24P	System 1.1 2048/24P	System 1.1 2048/24P	System 1.1 2048/24P	System 1.1 2048/24P	System 1.1 2048/24P
System 2.1 2048/48P, Link(Basic Stream) A, B		System 2.1 2048/48P, Link(Basic Stream) A, B		System 2.1 2048/48P, Link(Basic Stream) A, B	
System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 4 2048/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 4 2048/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 4 2048/24P, Link(Basic Stream) A, B	
System 4.1, 4.2 or 4.3 2048/48P, Basic Stream A, B, C, D			*Note 4	System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 4 2048/24P Link(Basic Stream) A, B	

Note 1: HANC Data included in CH 5 and CH 6 are discarded at frame rates from 23.98P to 25P and HANC Data in CH 3 through CH 6 are discarded at frame rates 29.97P and 30P.

Note 2: Frame rates shown in this table are the lowest case of each image system. Other frame rates can also be applicable so far as the image format allows.

Note 3: Use of shaded area is optional.

Note 4: Mixed transmission of different image systems is possible if the frame rates and the horizontal samples per line of the Basic Streams are consistent with each other.

1920×1080 Basic Stream					
CH 1	CH 2	CH 3	CH 4	CH 5	CH 6
System 1.1 1920/24P	System 1.1 1920/24P	System 1.1 1920/24P	System 1.1 1920/24P	System 1.1 1920/24P	System 1.1 1920/24P
System 2.2, 2.3, 2.4 or 2.5 *Note 4 1920/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4 or 2.5 *Note 4 1920/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4 or 2.5 *Note 4 1920/24P, Link(Basic Stream) A, B	
System 4.1, 4.2 or 4.3 1920/50P, Basic Stream A, B, C, D			*Note 4	System 2.2, 2.3, 2.4 or 2.5 *Note 4 1920/25P Link(Basic Stream) A, B	

System 1.2 1280/50P	System 1.2 1280/50P	System 1.2 1280/50P	System 1.2 1280/50P	System 1.2 1280/50P	System 1.2 1280/50P

Note 1: HANC Data included in CH 5 and CH 6 are discarded.

Note 2: Frame rates shown in this table are the lowest case of each image system. Other frame rates can also be applicable so far as the image format allows.

Note 3: Use of shaded area is optional.

Note 4: Mixed transmission of different image systems is possible if the frame rates and the horizontal samples per line of the Basic Streams are consistent with each other.

B.3 Mode C Channel Assignments

This mode is used for the System 8.6 octal link 1.5 Gb/s class exclusively. Table B.3 shows the assignment.

Table B.3 – Channel assignment for Mode C

CH 1	CH 2	CH 3	CH 4	CH 5	CH 6	CH 7	CH 8
System 8.6, 4096×2160/24P, Basic Stream CH 1, 2, 3, 4, 5, 6, 7 and 8							
Note: HANC Data included in CH 2 through CH 8 are discarded.							

B.4 Mode D Channel Assignment Examples

Mode D is used for the System 8.2 through 8.7 octa link “2048×1080” Basic Streams at frame rates from 23.98P to 25P or for the System 8.2 through 8.7 octa link “1920×1080” Basic Streams at frame rates from 23.98P to 30P.

Mode D is also used to transmit up to four pairs of the dual link “2048×1080” Basic Streams at frame rates from 23.98P to 25P or the dual link “1920×1080” Basic Streams at frame rates from 23.98P to 30P, up to two pairs of the quad link “2048×1080” Basic Streams at frame rates from 47.95P to 50P or the quad link “1920×1080” Basic Streams at frame rates from 50P to 60P or the combination of these classes as long as the total number of input channels are not greater than 8.

Table B.4 shows the assignment examples.

Table B.4 – Channel assignment for Mode D

2048×1080 Basic Stream							
CH 1	CH 2	CH 3	CH 4	CH 5	CH 6	CH 7	CH 8
System 8.2, 8.3, 8.4, 8.5, 8.6 or 8.7 4096/24P, Basic Stream CH1, 2, 3, 4, 5, 6, 7 and 8							
System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 4 2048/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 4 2048/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 4 2048/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 4 2048/24P, Link(Basic Stream) A, B	
System 4.1, 4.2 or 4.3 *Note 4 2048/48P, Basic Stream A, B, C, D				System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 4 2048/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4, 2.5 or 2.6 *Note 4 2048/24P, Link(Basic Stream) A, B	

System 4.1, 4.2 or 4.3 *Note 4 2048/48P, Basic Stream A, B, C, D	System 4.1, 4.2 or 4.3 *Note 4 2048/48P, Basic Stream A, B, C, D

Note 1: HANC Data included in CH 2, CH 4, CH6, CH7 and CH 8 are discarded.

Note 2: Frame rates shown in this table are the lowest case of each image system. Other frame rates also can be applicable so far as the image format allows.

Note 3: Use of shaped area is optional.

Mixed transmission of different image systems is possible if the frame rates and the horizontal samples per line of the Basic Streams are consistent with each other.

1920×1080 Basic Stream

CH 1	CH 2	CH 3	CH 4	CH 5	CH 6	CH 7	CH 8
System 8.2, 8.3, 8.4, 8.5, 8.6 or 8.7 3840/24P, Basic Stream CH1, 2, 3, 4, 5, 6, 7 and 8							
System 2.2, 2.3, 2.4 or 2.5 *Note 4 1920/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4 or 2.5 *Note 4 1920/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4 or 2.5 *Note 4 1920/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4 or 2.5 *Note 4 1920/24P, Link(Basic Stream) A, B	
System 4.1, 4.2 or 4.3 *Note 4 1920/50P, Basic Stream A, B, C, D				System 2.2, 2.3, 2.4 or 2.5 *Note 4 1920/24P, Link(Basic Stream) A, B		System 2.2, 2.3, 2.4 or 2.5 *Note 4 1920/24P, Link(Basic Stream) A, B	
System 4.1, 4.2 or 4.3 *Note 4 1920/50P, Basic Stream A, B, C, D				System 4.1, 4.2 or 4.3 *Note 4 1920/50P, Basic Stream A, B, C, D			

Note 1: HANC Data included in CH 2 through CH 8 at frame rates of 29.97P and 30P and HANC Data included in CH 2, CH 4, CH 6 and CH 8 at frame rates of 23.98P, 24P and 25P are discarded.

Note 2: Frame rates shown in this table are the lowest case of each image system. Other frame rates also can be applicable so far as the image format allows.

Note 3: Use of shaped area is optional.

Note 4: Mixed transmission of different image systems is possible if the frame rates and the horizontal samples per line of the Basic Streams are consistent with each other.

Annex C Bibliography (Informative)

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

SMPTE ST 2048-3:2012 4096×2160 Digital Cinematography Production Images Formats FS/709 — Mapping into Multi-link 10 Gb/s Serial Signal/Data Interface