

SMPTE STANDARD

4320-line and 2160-line Source Image and Ancillary Data Mapping for Quad-link 12G-SDI



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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 2082-12 was prepared by Technology Committee 32NF.

Intellectual Property

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

Introduction

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

SMPTE ST 2082-12 defines the mapping of various source images and associated ancillary data into a Quad-link 12 Gb/s [nominal] SDI bit-serial interface.

The general process for creating a quad-link 12G-SDI is illustrated below in Figures 1 and 2. Detailed definitions of how this process applies to each of the modes defined in the scope follow in other sections of this document.

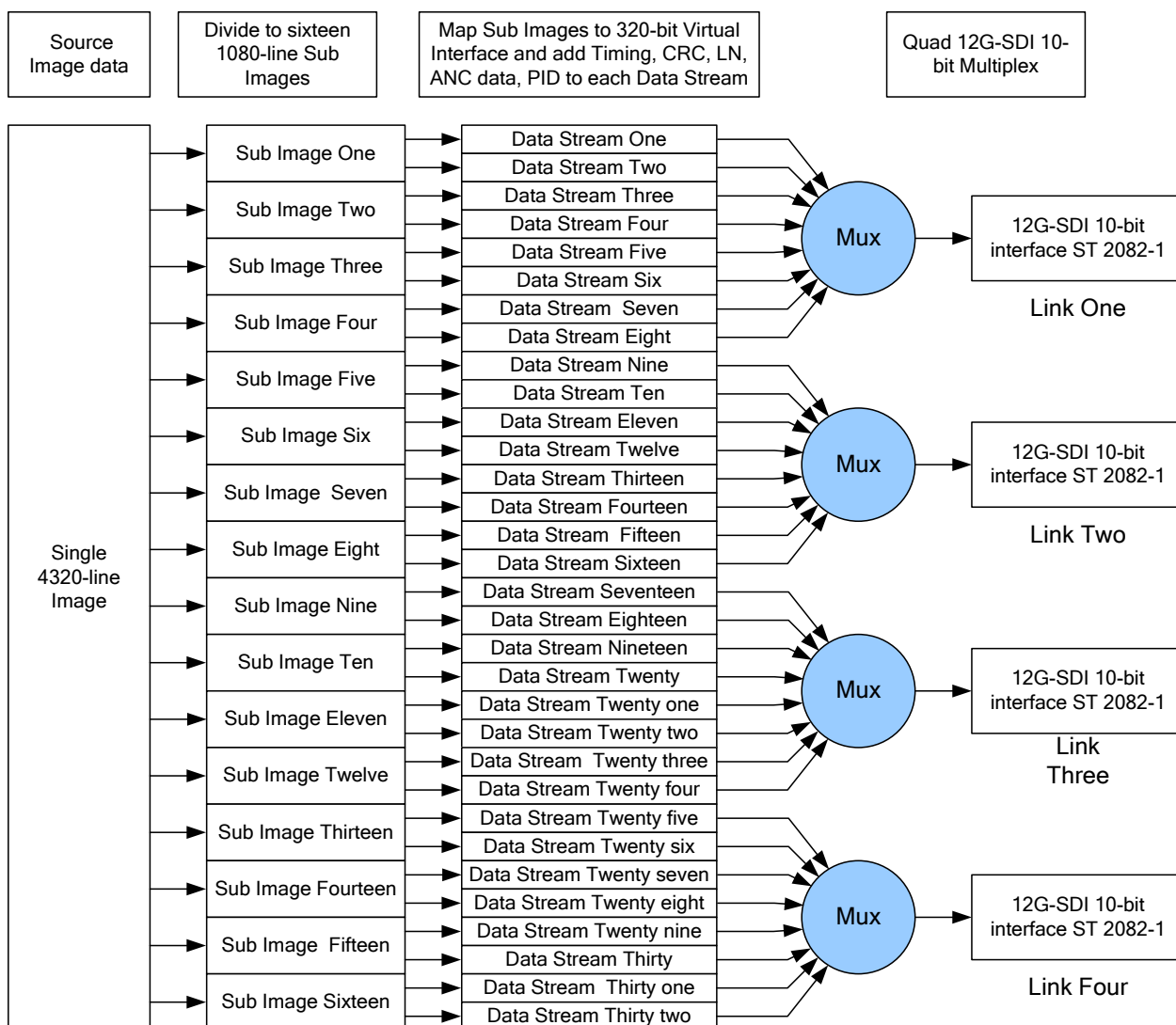


Figure 1 – Carriage of 4320-line Images on a Quad-link 12G interface – generalized process as used by Mode 1

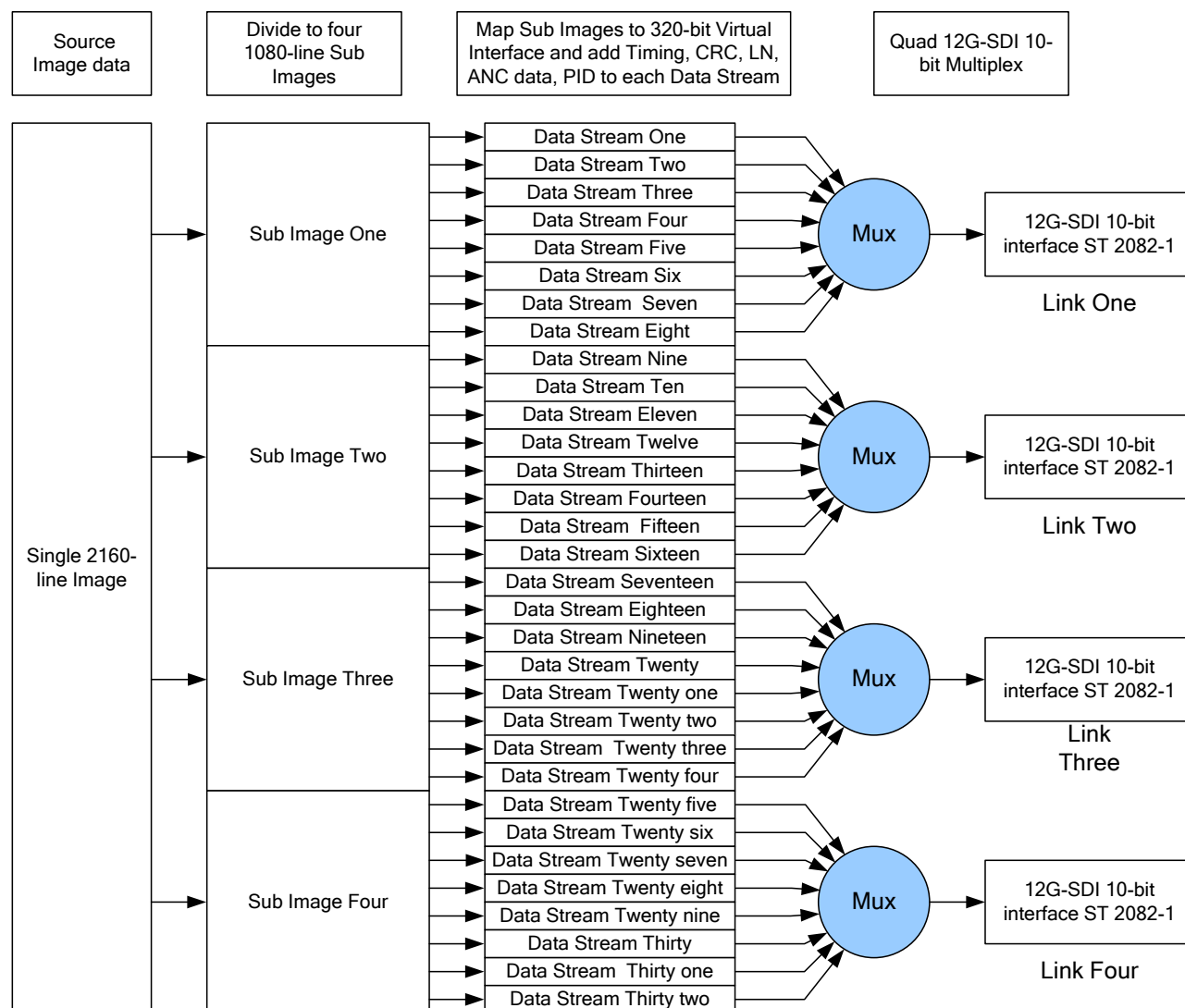


Figure 2 – Carriage of 2160-line Images on a Quad-link 12G interface – generalized process as used by Mode 2

Formatting

The source images are divided into four or sixteen 1080-line sub images as appropriate to the source image format.

The sub images are then mapped on to a 320-bit virtual interface consisting of thirty two 10-bit data streams.

Each 10-bit data stream includes timing and sync words, line numbers, cyclic redundancy codes, ancillary data, including audio, and payload identification packets

Multiplex

The 320-bit virtual interface is then multiplexed onto four 12G-SDI 10-bit interfaces.

The first eight data streams are multiplexed in the order data stream eight, data stream four, data stream six, data stream two, data stream seven, data stream three, data stream five, data stream one...onto 12G-SDI Link 1.

The second eight data streams are multiplexed in the order data stream sixteen, data stream twelve, data stream fourteen, data stream ten, data stream fifteen, data stream eleven, data stream thirteen, data stream nine...onto 12G-SDI Link 2.

The third eight data streams are multiplexed in the order data stream twenty four, data stream twenty, data stream twenty two, data stream eighteen, data stream twenty three, data stream nineteen, data stream twenty one, data stream seventeen...onto 12G-SDI Link 3.

The fourth eight data streams are multiplexed in the order data stream thirty two, data stream twenty eight, data stream thirty, data stream twenty six, data stream thirty one, data stream twenty seven, data stream twenty nine, data stream twenty five ...onto 12G-SDI Link 4.

1 Scope

This Standard defines the mapping of:

- **MODE 1:** 4320-line Standard Dynamic Range (SDR) and High Dynamic Range (HDR) Source image formats and ancillary data into a Quad-link 12 Gb/s [nominal] SDI bit-serial interface
- **MODE 2:** 2160-line Standard Dynamic Range (SDR) and High Dynamic Range (HDR) Y'C_BC_R or R'G'B' 4:4:4:4 10-bit or 4:4:4 10-bit or 12-bit High Frame Rate (HFR) Source image formats and ancillary data into a Quad-link 12 Gb/s [nominal] SDI bit-serial interface

This Standard also defines the carriage of the SMPTE ST 352 payload ID's for the Quad-link 12Gb/s SDI interface.

It is not necessary for implementations to include support for all formats that are included in this Standard. Implementers are encouraged to indicate supported formats in commercial publications.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions that, 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 12-2:2014, Transmission of Time Code in the Ancillary Data Space

SMPTE ST 12-3:2016, Time Code for High Frame Rate Signals and Formatting in the Ancillary Data Space

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

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

SMPTE ST 299-2:2010, Extension of the 24-Bit Digital Audio Format to 32 Channels for 3 Gb/s Bit-Serial Interfaces

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

SMPTE ST 425-5:2019, Image Format and Ancillary Data Mapping for the Quad Link 3 Gb/s Serial Interface

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

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

Amendment 1:2016 to SMPTE ST 2048-1:2011

SMPTE ST 2082-10:2018, 2160-line Source Image and Ancillary Data Mapping for 12G-SDI

SMPTE RP 2077:2013, Full Range Image Mapping

Recommendation ITU-R BT.2100-2 (07/2018), Image parameter values for high dynamic range television for use in production and international programme exchange

4 Mode 1: Carriage of 4320-line Source image formats and ancillary data

In the case of 4320-line mapping, the image formats supported shall be as defined in Table 1.

Table 1 – Supported Image sample structures and frame rates

Reference Standard	Image Format	Signal Format Sampling Structure/pixel Depth	Frame Rate
SMPTE ST 2036-1 Rec. ITU-R BT.2100	7680 x 4320	4:2:2 (Y'C _B C _R)/10-bit 4:2:2 (IC _T C _P ^{*2})/10-bit, 4:2:0 (Y'C _B C _R)/10-bit 4:2:0 (IC _T C _P ^{*2})/10-bit	50, 60/1.001 and 60 Progressive
SMPTE ST 2036-1 Rec. ITU-R BT.2100	7680 x 4320	4:4:4 (R'G'B')/10-bit 4:4:4:4 (R'G'B'+A ^{*1})/10-bit	24/1.001, 24, 25, 30/1.001 and 30 Progressive
SMPTE ST 2036-1 Rec. ITU-R BT.2100	7680 x 4320	4:4:4 (Y'C _B C _R)/10-bit 4:4:4:4 (Y'C _B C _R +A ^{*1})/10-bit 4:4:4 (IC _T C _P ^{*2})/10-bit 4:4:4:4 (IC _T C _P ^{*2} +A ^{*1})/10-bit	
SMPTE ST 2036-1 Rec. ITU-R BT.2100	7680 x 4320	4:4:4 (R'G'B')/12-bit	
SMPTE ST 2036-1 Rec. ITU-R BT.2100	7680 x 4320	4:4:4 (Y'C _B C _R)/12-bit 4:4:4 (IC _T C _P) ^{*2} /12-bit	
SMPTE ST 2036-1 Rec. ITU-R BT.2100	7680 x 4320	4:2:2 (Y'C _B C _R)/12-bit 4:2:2 (Y'C _B C _R +A ^{*1})/12-bit 4:2:2 (IC _T C _P) ^{*2} /12-bit 4:2:2 (IC _T C _P ^{*2} +A ^{*1})/12-bit 4:2:0 (Y'C _B C _R)/12-bit 4:2:0 (Y'C _B C _R +A ^{*1})/12-bit 4:2:0 (IC _T C _P) ^{*2} /12-bit 4:2:0 (IC _T C _P ^{*2} +A ^{*1})/12-bit	
Notes:			
*1 Definition of the A channel is application-dependent. An auxiliary component signal designated A or Alpha may optionally accompany the R'G'B', R' _{FS} G' _{FS} B' _{FS} , Y'C _B C _R or IC _T C _P video signal. Interfaces containing the auxiliary component are denoted as R'G'B'+A, Y'C _B C _R +A and IC _T C _P +A. In the cases when the A channel is used for non-picture data, the payload is constrained to 8-bit words maximum			
*2 In accordance with Recommendation ITU-R BT.2100, IC _T C _P sampling is only applied to High Dynamic Range (HDR) progressive image formats.			

4.1 Mapping

The 4320-line image shall be divided into four 2160-line intermediate sub images in accordance with the 2 sample interleave sub-division method as shown in Figure 3.

For 4:2:0 source images, the 10-bit C'_B and C'_R samples in intermediate sub images 3 and 4 are set to the value 200h and the 12-bit C_B and C_R samples in intermediate sub images 3 and 4 are set to the value 800h.

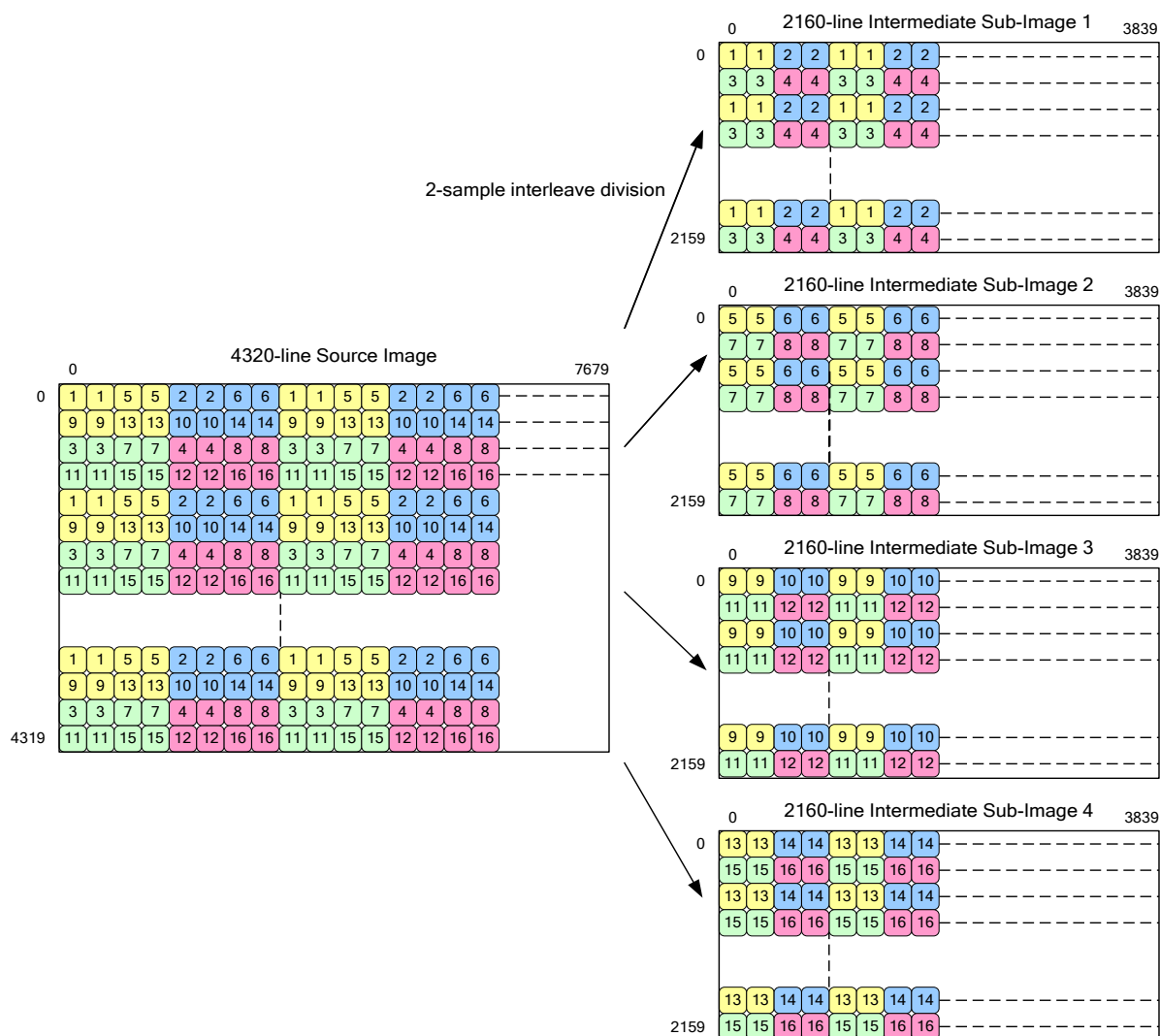


Figure 3 – Two sample division of a 4320-line image to four 2160-line intermediate sub images

Each 2160-line intermediate sub image shall then be divided into four 1080-line sub images and mapped to an 80-bit virtual interface according to SMPTE ST 2082-10 “2160-line Source Image and Ancillary Data Mapping for 12G-SDI” mode 1 “Carriage of 2160-line Source image formats and ancillary data” as illustrated in Figure 4.

Intermediate sub image 1 shall be divided to sub images 1 through 4 and mapped to data streams one through eight.

Intermediate sub image 2 shall be divided to sub images 5 through 8 and mapped to data streams nine through sixteen.

Intermediate sub image 3 shall be divided to sub images 9 through 12 and mapped to data streams seventeen through twenty four.

Intermediate sub image 4 shall be divided to sub images 13 through 16 and mapped to data streams twenty five through thirty two.

NOTE: For 4:2:0 source images, the 10-bit C'_B and C'_R samples in sub images 9 through 16 are set to the value 200h and the 12-bit C'_B and C'_R samples in sub images 9 through 16 are set to the value 800h.

For $IC_T C_P$ formats the mappings for $Y' C'_B C'_R$ formats shall be used with Y' replaced by I , C'_B replaced by C_T and C'_R replaced by C_P .

The thirty two 10-bit data streams so constructed shall each contain timing reference code words (SAV/EAV), line numbers and line based CRC's as defined in SMPTE ST 2082-10 Mode 1 2160-line Mapping.

The thirty two data streams, data stream one through data stream thirty two, shall be combined into a 320-bit virtual interface.

The virtual interface shall contain ancillary data and audio as defined elsewhere in this standard.

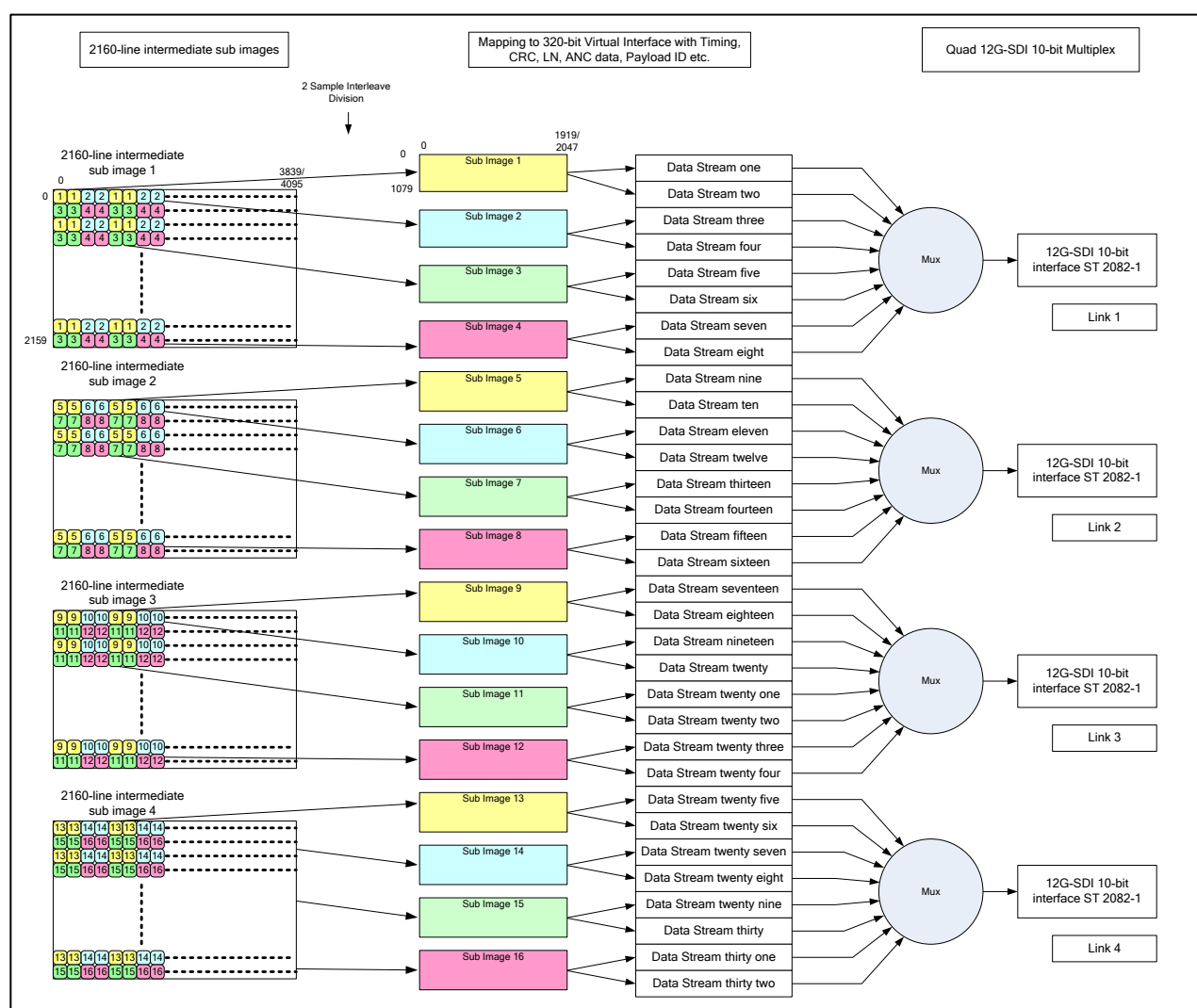


Figure 4 – 2 sample division of the four 2160-line intermediate sub images to sixteen 1080-line sub images, and mapping into a quad-link 12G-SDI interface

4.2 Intermediate Sub Image Mapping (Informative)

Each 2160-line intermediate sub-image is divided to four 1080-line sub-images in accordance with SMPTE ST 2082-10 Mode 1 using the 2 sample interleave sub-division method referenced in SMPTE ST 425-5 “2160-line image division into four sub images”.

Each 1080-line sub image conforms to the SMPTE ST 274 sub image formats shown in Table 2.

Table 2 – 1080-line Sub Image Formats for 4320-line Source Images

Source Image		Sub Image	
Reference SMPTE Standard	Image Format	Reference SMPTE Standard	Image Format
ST 2036-1	7680 × 4320	ST 274	1920 × 1080

Each 1080-line sub-image is mapped into a 20-bit virtual interface consisting of two 10-bit data streams.

Sub image 1 is mapped into data streams one and two.

Sub image 2 is mapped into data streams three and four.

Sub image 3 is mapped into data streams five and six.

Sub image 4 is mapped into data streams seven and eight.

Sub image 5 is mapped into data streams nine and ten.

Sub image 6 is mapped into data streams eleven and twelve.

Sub image 7 is mapped into data streams thirteen and fourteen.

Sub image 8 is mapped into data streams fifteen and sixteen.

Sub image 9 is mapped into data streams seventeen and eighteen.

Sub image 10 is mapped into data streams nineteen and twenty.

Sub image 11 is mapped into data streams twenty one and twenty two.

Sub image 12 is mapped into data streams twenty three and twenty four.

Sub image 13 is mapped into data streams twenty five and twenty six.

Sub image 14 is mapped into data streams twenty seven and twenty eight.

Sub image 15 is mapped into data streams twenty nine and thirty.

Sub image 16 is mapped into data streams thirty one and thirty two

Each of the thirty two 10-bit data streams so constructed contains timing reference code words (SAV/EAV), line numbers and line based CRC's as defined in SMPTE ST 425-5 2160-line Mapping.

4.2.1 4320-line 320-bit Virtual Interface Multiplex Structure (Informative)

The video data words from each sub image are conveyed in the following order in the data streams of the 320-bit virtual interface. The mapping rules for each Mapping Structure are defined in SMPTE ST 425-1:

Mapping Structure 1:

Sub image 1 is mapped into data streams one and two:

data stream one: $Y'0, Y'1, Y'2, Y'3...$

data stream two: $C'_B0, C'_R0, C'_B1, C'_R1...$

Sub image 2 is mapped into data streams three and four:

data stream three: $Y'0, Y'1, Y'2, Y'3...$

data stream four: $C'_B0, C'_R0, C'_B1, C'_R1...$

Sub image 3 is mapped into data streams five and six:

data stream five: $Y'0, Y'1, Y'2, Y'3...$

data stream six: $C'_B0, C'_R0, C'_B1, C'_R1...$

Sub image 4 is mapped into data streams seven and eight:

data stream seven: $Y'0, Y'1, Y'2, Y'3...$

data stream eight: $C'_B0, C'_R0, C'_B1, C'_R1...$

Sub image 5 is mapped into data streams nine and ten:

data stream nine: $Y'0, Y'1, Y'2, Y'3...$

data stream ten: $C'_B0, C'_R0, C'_B1, C'_R1...$

Sub image 6 is similarly mapped into data streams eleven and twelve

Sub image 7 is similarly mapped into data streams thirteen and fourteen

Sub image 8 is similarly mapped into data streams fifteen and sixteen

Sub image 9 is similarly mapped into data streams seventeen and eighteen

Sub image 10 is similarly mapped into data streams nineteen and twenty

Sub image 11 is similarly mapped into data streams twenty one and twenty two

Sub image 12 is similarly mapped into data streams twenty three and twenty four

Sub image 13 is similarly mapped into data streams twenty five and twenty six

Sub image 14 is similarly mapped into data streams twenty seven and twenty eight

Sub image 15 is similarly mapped into data streams twenty nine and thirty

Sub image 16 is similarly mapped into data streams thirty one and thirty two

For a 4:2:0 source images, the 10-bit C'_B and C'_R samples in sub images 9 through 16 are set to the value 200h.

Mapping Structure 2:

Sub image 1 is mapped into data streams one and two:

data stream one: $G'0, R'0, G'1, R'1...$

data stream two: $A0, B'0, A1, B'1...$

Sub image 2 is mapped into data streams three and four:

data stream three: $G'0, R'0, G'1, R'1...$

data stream four: $A0, B'0, A1, B'1...$

Sub image 3 is mapped into data streams five and six:

data stream five: G'0, R'0, G'1, R'1...

data stream six: A0, B'0, A1, B'1...

Sub image 4 is mapped into data streams seven and eight:

data stream seven: G'0, R'0, G'1, R'1...

data stream eight: A0, B'0, A1, B'1...

Sub image 5 is mapped into data streams nine and ten:

data stream nine: G'0, R'0, G'1, R'1...

data stream ten: A0, B'0, A1, B'1...

Sub image 6 is similarly mapped into data streams eleven and twelve

Sub image 7 is similarly mapped into data streams thirteen and fourteen

Sub image 8 is similarly mapped into data streams fifteen and sixteen

Sub image 9 is similarly mapped into data streams seventeen and eighteen

Sub image 10 is similarly mapped into data streams nineteen and twenty

Sub image 11 is similarly mapped into data streams twenty one and twenty two

Sub image 12 is similarly mapped into data streams twenty three and twenty four

Sub image 13 is similarly mapped into data streams twenty five and twenty six

Sub image 14 is similarly mapped into data streams twenty seven and twenty eight

Sub image 15 is similarly mapped into data streams twenty nine and thirty

Sub image 16 is similarly mapped into data streams thirty one and thirty two

Mapping Structure 3:

Bit b9 in every word is the complement of b8. The lists and tables below describe Bits b8 – b0

Sub image 1 is mapped into data streams one and two:

data stream one: R'G'B'0 [11:9], R'G'B'0 [5:3], R'G'B'1 [11:9], R'G'B'1 [5:3]...

data stream two: R'G'B'0 [8:6], R'G'B'0 [2:0], R'G'B'1 [8:6], R'G'B'1 [2:0]...

Sub image 2 is mapped into data streams three and four:

data stream three: R'G'B'0 [11:9], R'G'B'0 [5:3], R'G'B'1 [11:9], R'G'B'1 [5:3]...

data stream four: R'G'B'0 [8:6], R'G'B'0 [2:0], R'G'B'1 [8:6], R'G'B'1 [2:0]...

Sub image 3 is mapped into data streams five and six:

data stream five: R'G'B'0 [11:9], R'G'B'0 [5:3], R'G'B'1 [11:9], R'G'B'1 [5:3]...

data stream six: R'G'B'0 [8:6], R'G'B'0 [2:0], R'G'B'1 [8:6], R'G'B'1 [2:0]...

Sub image 4 is mapped into data streams seven and eight:

data stream seven: R'G'B'0 [11:9], R'G'B'0 [5:3], R'G'B'1 [11:9], R'G'B'1 [5:3]...

data stream eight: R'G'B'0 [8:6], R'G'B'0 [2:0], R'G'B'1 [8:6], R'G'B'1 [2:0]...

Sub image 5 is similarly mapped into data streams nine and ten

Sub image 6 is similarly mapped into data streams eleven and twelve

Sub image 7 is similarly mapped into data streams thirteen and fourteen

Sub image 8 is similarly mapped into data streams fifteen and sixteen

Sub image 9 is similarly mapped into data streams seventeen and eighteen

Sub image 10 is similarly mapped into data streams nineteen and twenty

Sub image 11 is similarly mapped into data streams twenty one and twenty two

Sub image 12 is similarly mapped into data streams twenty three and twenty four

Sub image 13 is similarly mapped into data streams twenty five and twenty six

Sub image 14 is similarly mapped into data streams twenty seven and twenty eight

Sub image 15 is similarly mapped into data streams twenty nine and thirty

Sub image 16 is similarly mapped into data streams thirty one and thirty two

Mapping Structure 4:

Bit b9 in every word is the complement of b8. The lists and tables below describe Bits b8 – b0

Sub image 1 is mapped into data streams one and two:

data stream one:	Bits b8 – b6:	A0 [11:9],	A0 [5:3],	A1 [11:9],	A1 [5:3]...
	Bits b5 – b0:	Y'0 [11:6],	Y'0 [5:0],	Y'1 [11:6],	Y'1 [5:0]...

data stream two:	Bits b8 – b6:	A0 [8:6],	A0 [2:0],	A1 [8:6],	A1 [2:0]...
	Bits b5 – b0:	C'b0 [11:6],	C'b0 [5:0],	C'r0 [11:6],	C'r0 [5:0]...

Sub image 2 is mapped into data streams three and four:

data stream three:	Bits b8 – b6:	A0 [11:9],	A0 [5:3],	A1 [11:9],	A1 [5:3]...
	Bits b5 – b0:	Y'0 [11:6],	Y'0 [5:0],	Y'1 [11:6],	Y'1 [5:0]...

data stream four:	Bits b8 – b6:	A0 [8:6],	A0 [2:0],	A1 [8:6],	A1 [2:0]...
	Bits b5 – b0:	C'b0 [11:6],	C'b0 [5:0],	C'r0 [11:6],	C'r0 [5:0]...

Sub image 3 is mapped into data streams five and six:

data stream five:	Bits b8 – b6:	A0 [11:9],	A0 [5:3],	A1 [11:9],	A1 [5:3]...
	Bits b5 – b0:	Y'0 [11:6],	Y'0 [5:0],	Y'1 [11:6],	Y'1 [5:0]...

data stream six:	Bits b8 – b6:	A0 [8:6],	A0 [2:0],	A1 [8:6],	A1 [2:0]...
	Bits b5 – b0:	C'b0 [11:6],	C'b0 [5:0],	C'r0 [11:6],	C'r0 [5:0]...

Sub image 4 is mapped into data streams seven and eight:

data stream seven:	Bits b8 – b6:	A0 [11:9],	A0 [5:3],	A1 [11:9],	A1 [5:3]...
	Bits b5 – b0:	Y'0 [11:6],	Y'0 [5:0],	Y'1 [11:6],	Y'1 [5:0]...