# SMPTE STANDARD

# Image Format and Ancillary Data Mapping for the Dual Link 3 Gb/s Serial Interface



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## Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operation Manual.

SMPTE ST 425-3 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 Engineering Document. 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.

There is a need in the industry to have an interface for transporting images complying with 4:2:2 and 4:4:4 10 bit and 12-bit image formats defined by SMPTE ST 274, ST 2048-1, ST 2048-2 and ST 2036-1 which can be transported by a dual SMPTE ST 424 serial interfaces. This standard also defines the payload identifier.

# 1 Scope

This standard defines 1080-line and 2160-linemapping formats as described below;

1080-line mapping specifies:

The mapping of the image formats of 1920 × 1080 and 2048 × 1080 pixels listed in Table 2 into four parallel 10-bit data streams (known as data stream one, data stream two, data stream three and data stream four) of a 40-bit virtual interface, followed by the mapping of these four 10-bit data streams onto the Dual Link 3 Gb/s Serial Interface (3G-SDI Link 1 and Link 2) via two 20-bit virtual interfaces.

2160-line mapping specifies:

The mapping of the image formats of 3840 × 2160 and 4096 × 2160 pixels listed in Table 3 into four parallel 10-bit data streams (known as data stream one, data stream two, data stream three and data stream four) of a 40-bit virtual interface, followed by the mapping of these four 10-bit data streams on to the Dual Link 3 Gb/s Serial Interface (3G-SDI Link 1 and Link 2) via two 20-bit virtual interfaces.

This standard also defines the carriage of ancillary data such as the audio data, the audio control packets, the payload identifier and the time code.

It is not necessary for implementations to include support for all formats that are included in this standard. Implementers should 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

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.

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

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

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 372:2011, Dual Link 1.5 Gb/s Digital Interface for 1920 x 1080 and 2048 x 1080 Picture Formats

SMPTE ST 425-1:2011, Source Image Format and Ancillary Data Mapping for the 3 Gb/s Serial Interface

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

SMPTE ST 2036-1:2009, 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

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

# 4 Definition of Terms

This section defines terms used in this document.

**4.1**
**3G-SDI Link 1/ 3G-SDI Link 2**
Each of the two links that together compose the Dual Link 3 Gb/s Serial Interface

**4.2**
**Alpha Channel**
An application dependent auxiliary component that is related to the source image (e.g. R'G'B' or Y'C'$_B$C'$_R$). These interfaces are denoted R'G'B'+A and Y'C'$_B$C'$_R$+A. Key signals as defined in SMPTE RP 157 are one example of an alpha signal.

**4.3**
**Data stream one / data stream two / data stream three / data stream four**
Four parallel 10-bit data streams of a 40-bit virtual interface. Each data stream shall have an interface frequency of 148.5 MHz or 148.5/1.001 MHz.

**4.4**
**HANC**
Horizontal Ancillary Data Space is the Ancillary Data Space located during the horizontal interval of a video line. The expressions HANC or HANC space are used interchangeably throughout the document.

**4.5**
**Mapping Structure**
The term Mapping Structure defines the structure of the virtual interface which the image data are mapped onto. Different mapping structures are used according to the different sampling structures and pixel depths of the images.

The Mapping Structure number, expressed as a roman numeral, changes according to sampling structure and pixel depth. The Mapping Structures I, II, III and IV used in this standard are based on rules defined in SMPTE ST372, as tabulated in Table 1.

The term Level A Mapping Structure 1 used in this standard is based on the rule defined in SMPTE ST 425-1.

**Table 1 – Mapping Structure Cross Reference with SMPTE ST 372**

| Mapping Structure | Section Number of SMPTE ST 372:2011 | SMPTE ST 372 Section Heading |
|---|---|---|
| I | 5.1 | 4:2:2 (Y'C'$_B$C'$_R$)/10-bit Signals at 60, 60/1.001, 50, 48 and 48/1.001 Progressive Frame Rates |
| II | 5.2 | 4:4:4 (R'G'B') and 4:4:4:4 (R'G'B'+A)/10-bit Signals at 30, 30/1.001, 25, 24 and 24/1.001 Frame Rates, PsF and at 60, 60/1.001 and 50 Field Rates |
| | 5.4.2 | 4:4:4 (Y'C'$_B$C'$_R$) and 4:4:4:4 (Y'C'$_B$C'$_R$A)/10-bit Multiplex Structure |
| III | 5.3 | 4:4:4 (R'G'B' or *X'Y'Z'*)/12-bit Signals at 30, 30/1.001, 25, 24 and 24/1.001 Frame Rates, PsF and 4:4:4 (R'G'B')/12-bit Signals at 60, 60/1.001 and 50 Field Rates* |
| | 5.4.3 | 4:4:4 (Y'C'$_B$C'$_R$)/12-bit Multiplex Structure |
| IV | 5.5 | 4:2:2:4 (Y'C'$_B$C'$_R$A)/12-bit Signals at 30, 30/1.001, 25, 24, 24/1.001 Frame Rates, PsF and at 60, 60/1.001 and 50 Field Rates |

Note:* Mapping Structure III used in this document does not apply to4:4:4 (*X'Y'Z'*)/12-bit signals.

**4.6**
**Sub Image**
A sub-division of a source image.

**4.7**
**VANC**
Vertical Ancillary Data Space is the Ancillary Data Space located between SAV and EAV during the vertical interval of a video frame or field. The expressions VANC or VANC space are used interchangeably throughout the document.

# 5 Image Formats

## 5.1 1080-line Source Image Formats

For this interface, the source data shall be an uncompressed 10-bit or 12-bit video signal corresponding to 1080-line source image formats listed in Table 2.

**Table 2 – 1080-line Source Image Formats**

| Mapping Structure (See Table 1) | Reference SMPTE Standard | Image Format | Signal Format Sampling Structure/pixel Depth | Frame Rate |
|---|---|---|---|---|
| II | ST 274 | 1920 × 1080 | 4:4:4 (R'G'B'), 4:4:4:4 (R'G'B' +A)/10-bit | 50, 60/1.001 and 60 Progressive |
| | ST 2048-2 | 2048 × 1080*2 | 4:4:4 (R'G'B'*1), 4:4:4:4 (R'G'B'*1+A)/10-bit | 48/1.001, 48, 50, 60/1.001 and 60 Progressive |
| | ST 274 | 1920 × 1080 | 4:4:4 ($Y'C'_BC'_R$), 4:4:4:4 ($Y'C'_BC'_R$+A)/10-bit | 50, 60/1.001 and 60 Progressive |
| | ST 2048-2 | 2048 × 1080*2 | 4:4:4 ($Y'C'_BC'_R$), 4:4:4:4 ($Y'C'_BC'_R$+A)/10-bit | 48/1.001, 48, 50, 60/1.001 and 60 Progressive |
| III | ST 274 | 1920 × 1080 | 4:4:4 (R'G'B')/12-bit | 50, 60/1.001 and 60 Progressive |
| | ST 2048-2 | 2048 × 1080*2 | 4:4:4 (R'G'B'*1)/12-bit | 48/1.001, 48, 50, 60/1.001 and 60 Progressive |
| | ST 274 | 1920× 1080 | 4:4:4 ($Y'C'_BC'_R$)/12-bit | 50, 60/1.001 and 60 Progressive |
| | ST 2048-2 | 2048× 1080*2 | 4:4:4 ($Y'C'_BC'_R$)/12-bit | 48/1.001, 48, 50, 60/1.001 and 60 Progressive |
| IV | ST274 | 1920 × 1080 | 4:2:2 ($Y'C'_BC'_R$)/12-bit | 50, 60/1.001 and 60 Progressive |
| | ST2048-2 | 2048× 1080*2 | 4:2:2 ($Y'C'_BC'_R$)/12-bit | 48/1.001, 48,50, 60/1.001 and 60 Progressive |
| | ST 2048-2 | 2048× 1080*2 | 4:2:2:4 ($Y'C'_BC'_R$+A)/12-bit | 48/1.001, 48, 50, 60/1.001 and 60 Progressive |

Notes:

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

*2 This is the maximum pixel array, the active image may not fill the maximum array.

### 5.1.1 Source Sample Number Representation

Each line of G', B' and R' or Y', $C'_B$ and $C'_R$ signals consists of a total of 2750, 2640 or 2200 samples each comprising 10 or 12 bits. The source samples are designated 0-2749, 0-2639 or 0-2199. For the 10-bit signals, the individual components of the nth sample are designated by suffixes such as, G'n or Y'n. For 12-bit signals, the most significant 10 bits of the nth sample are designated by suffixes such as G'n:2-11 or Y'n:2-11, and the least significant 2 bits of the nth sample are designated by suffixes such as G'n:0-1 or Y'n:0-1. The least significant 2 bits of the R'G'B' nth sample is designated by suffixes such as R'G'B'n:0-1. The mth bit of each R'G'B' component of the nth sample is designated by a suffix such as G'n:m.

## 5.2 2160-line Source Image Formats

For this interface, the source data shall be an uncompressed 10-bit video signal corresponding to 2160-line image formats in Table 3.

**Table 3 – 2160-line Source Image Formats**

| Reference SMPTE Standard | Image Format | Signal Format Sampling Structure/Pixel Depth | Frame Rate |
|---|---|---|---|
| ST 2036-1 | 3840×2160 | 4:2:2 ($Y'C'_BC'_R$), 4:2:0 ($Y'C'_BC'_R$)/10-bit | 24/1.001, 24, 25, 30/1.001 and 30 Progressive |
| ST 2048-1 | 4096×2160 | 4:2:2 ($Y'C'_BC'_R$)/10-bit | 24/1.001, 24, 25, 30/1.001 and 30 Progressive |

### 5.2.1 Source Sample Number Representation

Each line of Y', $C'_B$ and $C'_R$ signals consists of a total of 3840 or 4096 samples each comprising 10 bits. The source samples are designated 0-3839 or 0-4095. The individual components of the nth sample are designated by suffixes such as Y'n, $C'_B$n and $C'_R$n. $C'_B$ and $C'_R$ signals shall each be horizontally subsampled by a factor of two with respect to the Y' component in the case of a 4:2:2 system. $C'_B$ and $C'_R$ components shall be co-sited with even-numbered samples.

## 5.3 Image Mapping Overview

The source images are mapped onto a 40-bit virtual interface, consisting of four 10-bit data streams — data stream one, data stream two, data stream three and data stream four.

The 40-bit virtual interface is divided into two 20-bit virtual interfaces, each as defined in SMPTE ST 425-1. Data stream one and data stream two compose data stream one and data stream two, respectively, of the first 20-bit virtual interface. Data stream three and data stream four compose data stream one and data stream two, respectively, of the second 20-bit virtual interface.

The first and second 20-bit virtual interfaces are then multiplexed into two serial bit streams 3G-SDI Link 1 and 3G-SDI Link 2, respectively, according to SMPTE ST 424. For further information, see the Annex "Level A Mapping Compared to Level B Mapping" of SMPTE ST 425-1.

### 5.3.1 1080-line Image System Overview

In the case of 1080-line mapping, the source data are the source image signals defined in SMPTE ST 274 and SMPTE ST 2048-2 listed in Table 2. The 1080-line mapping is shown in Figure 1.

With the Level A mapping, the source image is first divided into Sub Image 1 and Sub Image 2 in accordance with the Mapping Structure rules II, III and IV shown in Table 1. Each Sub Image is then mapped into two 10-bit data streams according to the rule defined in Mapping Structure 1.Sub Image 1 is

mapped into data stream one and data stream two. Sub Image 2 is mapped into data stream three and data stream four.

With the Level B-DL mapping, the source image is first divided alternately by line into Sub Image 1 and Sub Image 2 in accordance with the Mapping Structure rule I. Each Sub Image is then mapped into two 10-bit data streams in accordance with the Mapping Structure rules II, III and IV shown in Table 1. Sub Image 1 is mapped into data stream one and data stream two. Sub Image 2 is mapped into data stream three and data stream four.

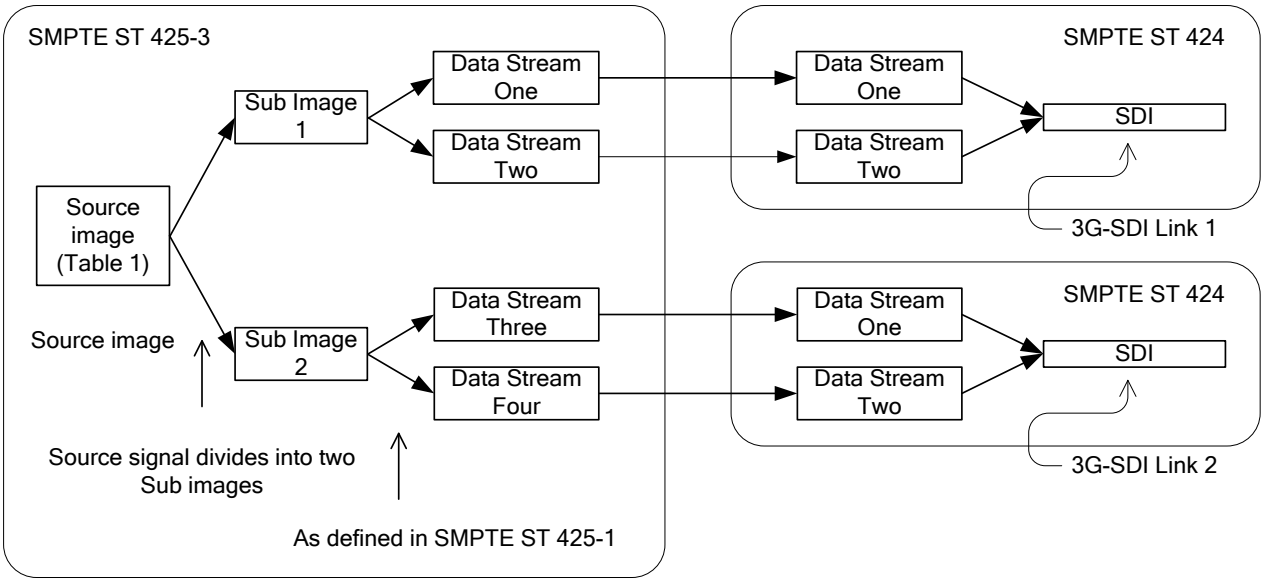


**Figure 1 – Signal Flow of Dual Link 3 Gb/s Serial Interface of 1080-line Source Image**

### 5.3.2 2160-line Image System Overview

In the case of 2160-line mapping, the source data are the source image signals defined in SMPTE ST 2036-1 and SMPTE ST 2048-1 listed in Table 3. The 2160-line mapping is shown in Figure 2.

The source image is first divided into four Sub Images. All of the 10-bit data words of Sub Image 1 are mapped into data stream one. Similarly, Sub Images 2 through 4 are mapped into data streams two through four, respectively.

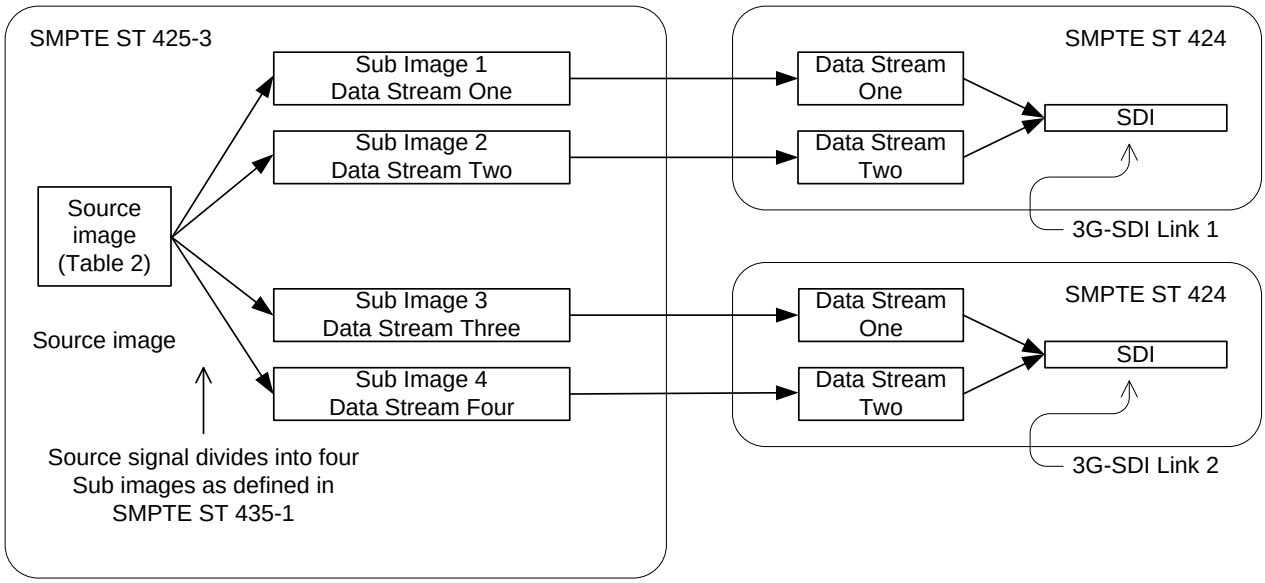


**Figure 2– Signal Flow of Dual Link 3 Gb/s Serial Interface of 2160-line Source Image**

### 5.4 Number of Audio Channels

Up to 64 audio channels sampled at 32 kHz, 44.1 kHz or 48 kHz may be mapped into the virtual interface. At 96-kHz sampling, up to 32 audio channels may be mapped into the virtual interface. The maximum number of audio channels that can be mapped into the available HANC space of the data streams varies in accordance with the source image format and frame rate as shown in Table 4.

**Table 4 – Number of Audio Channels supported Source Image Format, Frame Rate and Audio Sampling Rate**

| Image Format | Frame Rate | Maximum number of audio channels at 32-kHz, 44.1-kHz or 48-kHz sampling | Maximum number of audio channels at 96-kHz sampling |
|---|---|---|---|
| 1920x1080 | 50, 60/1.001 and 60 Progressive | Up to 64 channels | Up to 32 channels |
| 2048x1080 | 48/1.001,48 and 50 Progressive | Up to 64 channels | Up to 32 channels |
| | 60/1.001 and 60 Progressive | Up to 32 channels | Up to 16 channels |
| 3840x2160 | 25, 30/1.001 and 30 Progressive | Up to 64 channels | Up to 32 channels |
| 4096x2160 | 24/1.001,24 and 25 Progressive | Up to 64 channels | Up to 32 channels |
| | 30/1.001 and 30 Progressive | Up to 32 channels | Up to 16 channels |

# 6 1080-line Level A Mapping

This section defines Level A image and ancillary data mapping for 1080-line image formats listed in Table 2.

## 6.1 Level A Mapping – 1080-line Source Image

The 1080-line source images listed in Table 2 shall be divided into two Sub Images in accordance with the Mapping Structure rules II, III and IV.

Each Sub Image shall then be mapped into two 10-bit data streams as defined in Level A Mapping Structure 1. Sub Image 1 shall be mapped into data stream one and data stream two. Sub Image 2 shall be mapped into data stream three and data stream four. The Level A mapping is shown in Figure 3.

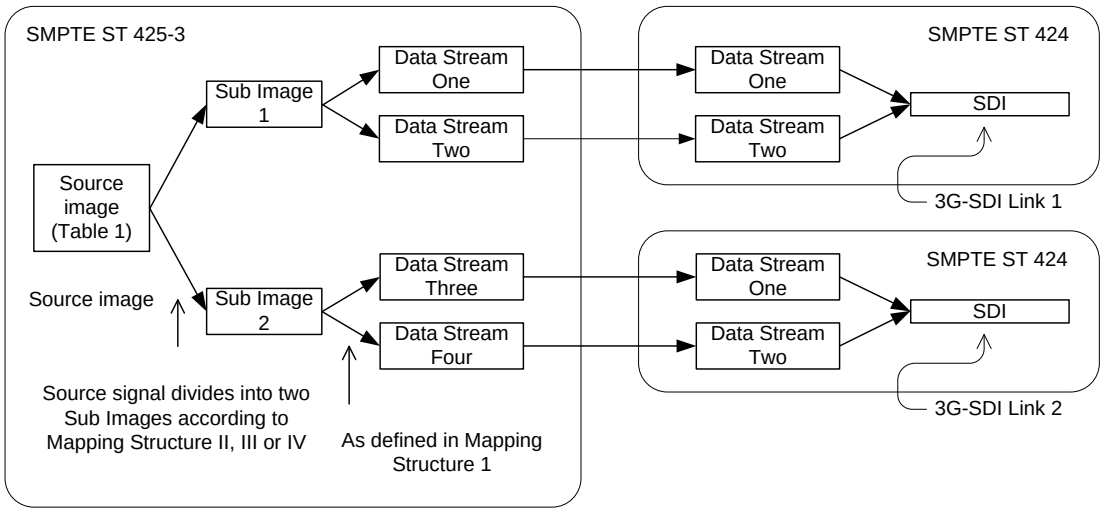


**Figure 3 – Overview of 1080-line Level A Mapping**

### 6.1.1 Mapping Structure II – 4:4:4 (R'G'B')/(Y'C'$_B$C'$_R$) and 4:4:4:4 (R'G'B'+A)/(Y'C'$_B$C'$_R$+A)/10-bit Signals

Sub Image 1 shall consist of the G' samples and the even numbered B' and R' samples of the Source Image.

Sub Image 2 shall consist of the Alpha samples (if present) and the odd numbered B' and R' samples from the Source Image.

If Alpha samples are not present, they shall be replaced with the value 040h.

| | SOURCE SAMPLE NUMBER | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Sub Image 1 | G' | G' | G' | G' | G' | G' |
| | B' | B' | B' | B' | B' | B' |
| | R' | R' | R' | R' | R' | R' |
| Sub Image 2 | A | A | A | A | A | A |

**Figure 4 – 4:4:4:4 (R′G′B′+A)/10-bit — Sub Image separation using Mapping Structure rule II**

The Mapping Structure of the virtual interface onto which the 4:4:4 ($Y'C'_BC'_R$) and the 4:4:4:4 ($Y'C'_BC'_R$+A)/10-bit image data are mapped shall be as defined in this section, Section 6.1.1.1, and Section 6.1.1.1.1, except that:

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

the B' samples shall be replaced with $C'_B$ samples;

and the R' samples shall be replaced with $C'_R$ samples.

#### 6.1.1.1 Multiplex Structure

Sub Image 1:

data stream one: The data words Y'0, Y'1, Y'2, Y'3… in Level A Mapping Structure 1 data stream one shall be replaced by G'0, G'1, G'2, G'3… from Figure 4, respectively.

data stream two: The data words $C'_B0$, $C'_R0$, $C'_B1$, $C'_R1$…. in Level A Mapping Structure 1 data stream two shall be replaced by B'0, R'0, B'2, R'2…from Figure 4, respectively.

Sub Image 2:

data stream three: The data words Y'0, Y'1, Y'2, Y'3… in Level A Mapping Structure 1 data stream one shall be replaced by A0, A1, A2, A3 …from Figure 4, respectively.

data stream four: The data words $C'_B0$, $C'_R0$, $C'_B1$, $C'_R1$…. in Level A Mapping Structure 1 data stream two shall be replaced by B'1, R'1, B'3, R'3…from Figure 4, respectively.

Thus the video data words shall be conveyed in the following order in the data streams:

data stream one: G'0, G'1, G'2, G'3…

data stream two: B'0, R'0, B'2, R'2…

data stream three: A0, A1, A2, A3 …

data stream four: B'1, R'1, B'3, R'3…

##### 6.1.1.1.1 **3G-SDI Link Multiplex Structure** (Informative)

Following the data stream assignment specified in Section 9, and serialization according to SMPTE ST 424, the 3G-SDI data streams are conveyed in the following order:

3G-SDI Link 1 data stream:

B'0, G'0, R'0, G'1, B'2, G'2, R'2, G'3 …

3G-SDI Link 2 data stream:

B'1, A0, R'1, A1, B'3, A2, R'3, A3 …

### 6.1.2 Mapping Structure III – 4:4:4 (R'G'B')/($Y'C'_BC'_R$)/12-bit Signals

Sub Image 1 shall consist of the most significant 10 bits of all of the G' samples and the most significant 10 bits of the even numbered B' and R' samples of the Source Image.

Sub Image 2 shall consist of the two least significant bits of all of the G', B' and R' samples and the most significant 10 bits of the odd numbered B' and R' samples from the Source Image.

| | SOURCE SAMPLE NUMBER | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Sub Image 1 | G':2-11 | G':2-11 | G':2-11 | G':2-11 | G':2-11 | G':2-11 |
| | B':2-11 | B':2-11 | B':2-11 | B':2-11 | B':2-11 | B':2-11 |
| | R':2-11 | R':2-11 | R':2-11 | R':2-11 | R':2-11 | R':2-11 |
| Sub Image 2 | R'G'B':0-1 | R'G'B':0-1 | R'G'B':0-1 | R'G'B':0-1 | R'G'B':0-1 | R'G'B':0-1 |

**Figure 5 – 4:4:4 (R′G′B′)/12-bit — Sub Image separation using Mapping Structure rule III**

The Mapping Structure of the virtual interface onto which the 4:4:4 (Y'C'$_B$C'$_R$)/12-bit image data are mapped shall be as defined in this section, Section 6.1.2.1, Section 6.1.2.1.1, and Section 6.1.2.2, except that:

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

the B' samples shall be replaced with C'$_B$ samples;

and the R' samples shall be replaced with C'$_R$ samples.

### 6.1.2.1 Multiplex Structure

Sub Image 1:

data stream one: The data words Y'0, Y'1, Y'2, Y'3… in Level A Mapping Structure 1 data stream one shall be replaced by G'0:2-11, G'1:2-11, G'2:2-11, G'3:2-11 …from Figure 5, respectively.

data stream two: The data words C'$_B$0, C'$_R$0, C'$_B$1, C'$_R$1…. in Level A Mapping Structure 1 data stream two shall be replaced by B'0:2-11, R'0:2-11, B' 2:2-11, R'2:2-11 …from Figure 5, respectively.

Sub Image 2:

data stream three: The data words Y'0, Y'1, Y'2, Y'3… in Level A Mapping Structure 1 data stream one shall be replaced by R'G'B'0:0-1, R'G'B'1:0-1, R'G'B'2:0-1, R'G'B'3:0-1 …from Figure 5, respectively.

data stream four: The data words C'$_B$0, C'$_R$0, C'$_B$1, C'$_R$1…. in Level A Mapping Structure 1 data stream two shall be replaced by B'1:2-11, R'1:2-11, B' 3:2-11, R'3:2-11 …from Figure 5, respectively.

Thus the video data words shall be conveyed in the following order in the data streams:

data stream one: G'0:2-11, G'1:2-11, G'2:2-11, G'3:2-11 …

data stream two: B'0:2-11, R'0:2-11, B' 2:2-11, R'2:2-11 …

data stream three: R'G'B'0:0-1, R'G'B'1:0-1, R'G'B'2:0-1, R'G'B'3:0-1 …

data stream four: B'1:2-11, R'1:2-11, B' 3:2-11, R'3:2-11 …

#### 6.1.2.1.1 3G-SDI Link Multiplex Structure (Informative)

Following the data stream assignment specified in Section 9 and serialization according to SMPTE ST 424, the 3G-SDI data streams are conveyed in the following order:

3G-SDI Link 1 data stream:

B'0:2-11, G'0:2-11, R'0:2-11, G'1:2-11, B'2:2-11, G'2:2-11, R'2:2-11, G'3:2-11 …

3G-SDI Link 2 data stream:

B'1:2-11, G'B'R'0:0-1, R'1:2-11, G'B'R'1:0-1, B'3:2-11, G'B'R'2:0-1, R'3:2-11, G'B'R'3:0-1…

### 6.1.2.2 R'G'B'n:0-1 Data Mapping

Mapping of the least significant 2 bits from R', G' and B' onto data stream three shall be as shown in Table 5.

**Table 5 – R'G'B'n:0-1 mapping onto data stream three**

| | Bit Number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Word | 9 (MSB) | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 (LSB) |
| | $\overline{B8}$ | EP | G'n:1 | G'n:0 | B'n:1 | B'n:0 | R'n:1 | R'n:0 | Res | Res |

Notes:

1 MSB: most significant bit.

2 LSB: least significant bit.

3 B8 is the even parity for B7 through B0.

4 B9 is the complement of B8.

5 B0 and B1 are the reserved bits (Reserved bits shall be set to 0 until defined).

### 6.1.3 Mapping Structure IV – 4:2:2(Y'C'$_B$C'$_R$) and 4:2:2:4(Y'C'$_B$C'$_R$+A)/12-bit Signals

Sub Image 1 shall consist of the most significant 10 bits of all of the Y' samples and the most significant 10 bits of the even numbered C'$_B$ and C'$_R$ samples of the Source Image.

Sub Image 2 shall consist of the least significant 2 bits of Y', C'$_B$, C'$_R$ samples at even-numbered sample points, and the least significant 2 bits of Y' (only) at odd-numbered sample points, plus the A (alpha) samples if present (see Table 6 and Table 7).

If Alpha samples are not present, they shall be replaced with the value 040h.

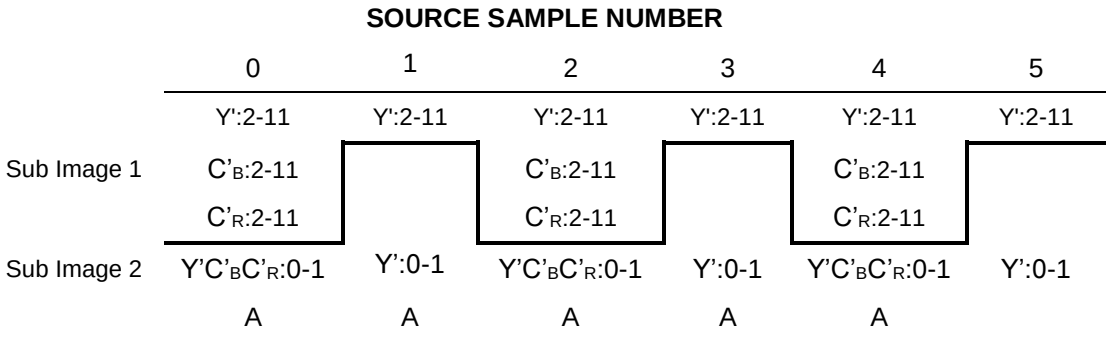


**Figure 6 – 4:2:2:4 (Y'C'$_B$C'$_R$+A)/12-bit — Sub Image separation using Mapping Structure rule IV**

#### 6.1.3.1 Multiplex Structure

Sub Image 1:

data stream one: The data words Y'0, Y'1, Y'2, Y'3… in Level A Mapping Structure 1 data stream one shall be replaced by Y'0:2-11, Y'1:2-11, Y'2:2-11, Y'3:2-11 …from Figure 6, respectively.

data stream two: The data words C'$_B$0, C'$_R$0, C'$_B$1, C'$_R$1…. in Level A Mapping Structure 1 data stream two shall be replaced by C'$_B$0:2-11, C'$_R$0:2-11, C'$_B$ 2:2-11, C'$_R$2:2-11…from Figure 6, respectively.

Sub Image 2:

data stream three: The data words Y'0, Y'1, Y'2, Y'3… in Level A Mapping Structure 1 data stream one shall be replaced by Y'C'$_B$C'$_R$0:0-1, Y'1:0-1, Y'C'$_B$C'$_R$2:0-1, Y'3:0-1 …from Figure 6, respectively.

data stream four: The data words C'$_B$0, C'$_R$0, C'$_B$1, C'$_R$1…. in Level A Mapping Structure 1 data stream two shall be replaced by A0, A1, A2, A3….from Figure 6, respectively.

Thus the video data words shall be conveyed in the following order in the data streams:

data stream one: Y'0:2-11, Y'1:2-11, Y'2:2-11, Y'3:2-11 …

data stream two: C'$_B$0:2-11, C'$_R$0:2-11, C'$_B$ 2:2-11, C'$_R$2:2-11 …

data stream three: Y'C'$_B$C'$_R$0:0-1, Y'1:0-1, Y'C'$_B$C'$_R$2:0-1, Y'3:0-1 …

data stream four: A0, A1, A2, A3 …

##### 6.1.3.1.1 3G-SDI Link Multiplex Structure (Informative)

Following the data stream assignment specified in Section 9 and serialization according to SMPTE ST 424, the 3G-SDI data streams are conveyed in the following order:

3G-SDI Link 1 data stream:

C'$_B$0:2-11, Y'0:2-11, C'$_R$0:2-11, Y'1:2-11, C'$_B$ 2:2-11, Y'2:2-11, C'$_R$2:2-11, Y'3:2-11 …

3G-SDI Link 2 data stream:

A0, Y'C'$_B$C'$_R$0:0-1, A1, Y'1:0-1, A2, Y'C'$_B$C'$_R$2:0-1, A3, Y'3:0-1 …

### 6.1.3.2 Y'C'$_B$C'$_R$n:0-1, Y'n;0-1 Data Mapping

Mapping of the least significant 2 bits from the even-numbered samples of Y', C'$_B$ and C'$_R$, and the least significant 2 bits from the odd-numbered samples of Y' (only), onto data stream three shall be as shown in Table 6 (even-numbered samples) and Table 7 (odd-numbered samples).

**Table 6 – Y'C'$_B$C'$_R$n:0-1 mapping onto data stream three**

| | Bit Number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Word | 9 (MSB) | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 (LSB) |
| | $\overline{B8}$ | EP | Y'n:1 | Y'n:0 | C'$_B$n:1 | C'$_B$n:0 | C'$_R$n:1 | C'$_R$n:0 | Res | Res |

Notes:

1 MSB: most significant bit.

2 LSB: least significant bit.

3 B8 is the even parity for B7 through B0.

4 B9 is the complement of B8.

5 B0 and B1 are the reserved bits (Reserved bits shall be set to 0 until defined).

**Table 7 – Y' n:0-1 mapping onto data stream three**

| | Bit Number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Word | 9 (MSB) | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 (LSB) |
| | $\overline{B8}$ | EP | Y'n:1 | Y'n:0 | Res | Res | Res | Res | Res | Res |

Notes:

1 MSB: most significant bit.

2 LSB: least significant bit.

3 B8 is the even parity for B7 through B0.

4 B9 is the complement of B8.

5 B0 through B5 are the reserved bits (Reserved bits shall be set to 0 until defined).

## 6.2 Ancillary Data

When present, ancillary data shall first be mapped into the ancillary data space of the data stream pair consisting of data streams one and two according to the Level A ancillary data mapping rules defined in SMPTE ST 425-1. Any remaining data shall then be mapped onto the data stream pair consisting of data streams three and four with data stream three replacing data stream one, and data stream four replacing data stream two. Data space requirements and locations for each data service are defined by their respective application documents. In some cases, it is required by specific applications that ancillary data be mapped into all four data streams ( e.g. Payload Identifier.)

Note: The Mapping Structure rules II, III, and IV defined in Section 6.1 apply only to the image data. The timing and ancillary data mapping for all Level A formats is as defined in the Level A sections of SMPTE ST 425-1.

Ancillary data mapped into the Luma (Y') data channel shall be mapped to data stream one or data stream three as appropriate. Ancillary data mapped into the Color-Difference (C'$_B$, C'$_R$) data channel shall be mapped to data stream two or data stream four as appropriate.

### 6.2.1 Audio Data

When present, audio data shall be mapped into the HANC space of data streams one, two, three and four, according to the Level A audio mapping rules defined in SMPTE ST 425-1.

The audio data shall be mapped into the data stream pair consisting of data streams one and two first and any remaining data shall then be mapped into the data stream pair consisting of data streams three and four.

In some applications, for example, to allow independent monitoring of audio, audio data on the data stream pair one and two may be duplicated on the data stream pair three and four. Audio channel usage shall be further signalled using the payload identifier as defined in Section 6.2.3 of this document.

The audio clock phase data as defined in the section “CLK (audio clock phase data)” of SMPTE ST 299-1 shall be calculated at a clock frequency of 148.5 MHz or 148.5/1.001 MHz as defined in SMPTE ST 425-1.

#### 6.2.1.1 Number of Audio Channels

Up to 64 audio channels sampled at 32 kHz, 44.1 kHz or 48 kHz maybe mapped into data streams one, two, three and four of the virtual interface. At 96-kHz sampling, up to 32 audio channels maybe mapped into the virtual interface.

The maximum number of audio channels that can be mapped into the available ancillary data space of each data stream pair varies in accordance with the video format and the video frame rate as shown in Table 4.

In the case where the data stream pair three and four is carrying a duplicate of the audio on the data stream pair one and two, the audio data and control packets shall be an exact replica of the audio carried on the data stream pair one and two – specifically the audio on the data stream pair three and four shall use the same audio groups as applied to the audio on the data stream pair one and two.

##### 6.2.1.1.1 Carriage of up to 64 Channels of Audio at up to 48-kHz Sampling

For audio at up to 48-kHz sampling embedded into 2048 x 1080 image formats at frame rates of 60/1.001 or 60, the audio data and control packets for the first 16 channels, shall be mapped into data stream pair one and two. The audio data and control packets for the second 16 channels, shall be mapped into data stream pair three and four. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 to 4)

For audio at up to 48-kHz sampling, embedded into all other 1080-line image formats shown in Table 4, the audio data and control packets and extended audio data and control packets for the first 32 channels, shall be mapped into data stream pair one and two. The audio data and control packets and extended audio data and control packets for the second 32 channels, shall be mapped into data stream pair three and four. The first 16 channels in each data stream pair shall be mapped in conformance with SMPTE ST 299-1 (audio groups 1 to 4), and the second 16 channels in each data stream pair shall be mapped in conformance with SMPTE ST 299-2 (audio groups 5 to 8).

##### 6.2.1.1.2 Carriage of up to 32 Channels of Audio at 96-kHz Sampling

For audio at 96-kHz sampling embedded into 2048 x 1080 image formats at frame rates of 60/1.001or 60, the audio data and control packets for the first 8 channels, shall be mapped into data stream pair one and two. The audio data and control packets for the second 8 channels, shall be mapped into data stream pair three and four. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

For audio at 96-kHz sampling embedded into all other image formats shown in Table 4, the audio data and control packets for the first 16 channels, shall be mapped into data stream pair one and two. The audio data and control packets for the second 16 channels shall be mapped into the data stream pair three and four. The first 8 channels in each data stream pair shall be mapped in conformance with SMPTE ST 299-1 (audio groups 1 to 4), and the second 8 channels in each data stream pair shall be mapped in conformance with SMPTE ST 299-2 (audio groups 5 to 8).

### 6.2.2 Time Code Data

When present, the time code shall be mapped into the HANC space of data stream one according to the Level A ancillary data mapping rules defined in SMPTE ST 425-1, and shall be in conformance with SMPTE ST 12-2.

The time code may also be mapped onto data stream three, in which case the corresponding Time Address values shall be identical.

### 6.2.3 Payload Identifier

The payload identifier data structure shall be in conformance with SMPTE ST 352 and shall be mapped into data streams one, two, three and four in accordance with the Level A mapping rules defined in SMPTE ST 425-1.

#### 6.2.3.1 Payload Identifier Structure

Table 8 shows the payload identifier definitions for 1080-line Video Payloads for Level A Mapping. As defined in SMPTE ST 352, the payload identifier consists of 4 bytes where each byte has a separate significance. The first byte of the payload identifier has the highest significance and subsequent bytes define lower order video and ancillary payload information.

The recommended location for the payload identifier is defined in SMPTE ST 425-1.

**Table 8 – Payload Identifier Definitions for 1080-line Video Payloads for Level A Mapping on a Dual-link 3 Gb/s (nominal) Serial Interface**

<table>
<tr><th>Bits</th><th>Byte 1</th><th>Byte 2</th><th>Byte 3</th><th>Byte 4</th></tr>
<tr><td>Bit 7</td><td>1</td><td>Progressive transport (1)</td><td>Aspect Ratio<br>16:9 (1) or Unknown (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 6</td><td>0</td><td>Progressive picture(1)</td><td>Horizontal sampling<br>1920 (0) or 2048 (1)</td><td>Link assignment<br>3G-SDI Link 1(0)<br>3G-SDI Link 2 (1)</td></tr>
<tr><td>Bit 5</td><td>0</td><td>Reserved (0)</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 4</td><td>1</td><td>Reserved (0)</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 3</td><td>0</td><td rowspan="4">Picture rate<br>(as per Table 2 of SMPTE ST 352)<br>Perrmitted values are:<br>48/1.001 Frame Rate (4h),<br>48 Frame Rate (8h),<br>50 Frame Rate (9h),<br>60/1.001 Frame Rate (Ah),<br>60 Frame Rate (Bh),<br>Other Values are Reserved</td><td rowspan="4">Sampling structure<br>(as per Table 3 of SMPTE ST 352)<br>Permitted values are:<br>4:4:4Y’/C’<sub>B</sub>/C’<sub>R</sub> (1h),<br>4:4:4G’/B’/R’ (2h),<br>4:2:2:4Y’/C’<sub>B</sub>/C’<sub>R</sub> /A (4h),<br>4:4:4:4Y’/C’<sub>B</sub>/C’<sub>R</sub>/A (5h),<br>4:4:4:4G’/B’/R’/A (6h),<br>2048-2 FS (7h),<br>4:2:2:4 Y’/C’<sub>B</sub>/C’<sub>R</sub> /D (8h),<br>4:4:4:4 Y’/C’<sub>B</sub>/C’<sub>R</sub> /D (9h),<br>4:4:4:4G’/B’/R’/D (Ah),<br>Other values are Reserved</td><td>Reserved (0)</td></tr>
<tr><td>Bit 2</td><td>1</td><td>Audio – 3G-SDI Link 2,<br>3G-SDI Link 2 carries additional channels or audio not present (0)<br>3G-SDI Link 2 carries a copy of 3G-SDI Link 1 audio (1)</td></tr>
<tr><td>Bit 1</td><td>0</td><td rowspan="2">Bit depth<br>10-bit (1h),<br>12-bit (2h),<br>Other values are Reserved</td></tr>
<tr><td>Bit 0</td><td>0</td></tr>
</table>

#### 6.2.3.2 Byte 1 – Digital Interface and Payload Identification

Byte 1 of the payload identifier identifies the video payload and the digital interface and shall be as defined below.

Byte 1 shall be set to [94h] for the Level A Mapping for 1080-line image formats listed in Table 2.

#### 6.2.3.3 Byte 2 – Picture Rate and Scanning Method

Byte 2 of the payload identifier shall be used to identify the picture and transport scanning methods and the picture rate.

Bit 7 shall be set to 1h (progressive transport).

Bit 6 shall be set to 1h (progressive picture).

Bits b5 to b4 shall be set to 0h (reserved).

Bits b3 to b0 shall be used to identify the picture rate in Hz in accordance with Table 2 of SMPTE ST 352 and shall only use the values as permitted for the image formats in Table 2.

#### 6.2.3.4 Byte 3 – Sampling Structure, Aspect Ratio and Horizontal Size

Byte 3 of the payload identifier shall be used to identify the aspect ratio, horizontal pixel array size, and sampling structure of the video payload.

Bit 7 shall be used to identify the aspect ratio such that:

b7 = 0h identifies an unknown aspect ratio Sub Image

b7 = 1h identifies a 16:9 aspect ratio Sub Image

Bit 6 shall be used to identify the number of active Luma/R'G'B' samples for the Sub Image such that:

b6 = 0h identifies 1920 active Luma/R'G'B' samples

b6 = 1h shall identifies 2048 active Luma/R'G'B' samples

Bits b5 to b4 shall be set to 0h (reserved).

Bits b3 to b0 shall be used to identify the sampling structure in accordance with Table 3 of SMPTE ST 352 and shall only use the values as permitted for image formats in Table 2.

#### 6.2.3.5 Byte 4 – 3G Link Identification and Quantization Bit Depth

Byte 4 of the payload identifier shall be used to identify the 3G Link, and bit depth of the sample quantization.

Bits b7 shall be set to 0h (reserved).

Bit 6shall be used to identify the link assignment such that:

b6 = 0h identifies 3G-SDI Link 1

b6 =1h identifies 3G-SDI Link 2

Bits b5 to b3 shall be set to 0h (reserved).

For the 3G-SDI Link 1, bit b2 shall be reserved and set to (0h)

For the3G-SDI Link 2, bit b2 shall signal the nature of any audio data carried in 3G-SDI Link 2 such that:

0h identifies that audio if present in the 3G-SDI Link 2 carries additional audio channels

1h identifies that the 3G-SDI Link 2 carries a copy of the 3G-SDI Link 1 audio

Bits b1to b0 shall be used to identify the bit depth of the sample quantization such that:

1h identifies quantization using 10-bit per sample

2h identifies quantization using 12-bit per sample

Other values are reserved.

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

# 7 1080-line Level B Dual-Link Mapping

This section defines Level B-DL image and ancillary data mapping for 1080-line source image listed in Table 2.

## 7.1 1080-line Source Image

The 1080-line source images listed in Table 2 shall be divided alternately by line into two Sub Images listed in Table 9 in accordance with Mapping Structure rule I.

Each Sub Image is then mapped into two 10-bit data streams using the Mapping Structure rules II, III and IV. Sub Image 1 shall be mapped into data stream one and data stream two. Sub Image 2 shall be mapped into data stream three and data stream four. Figure 7 gives an overview of the Level B mapping.

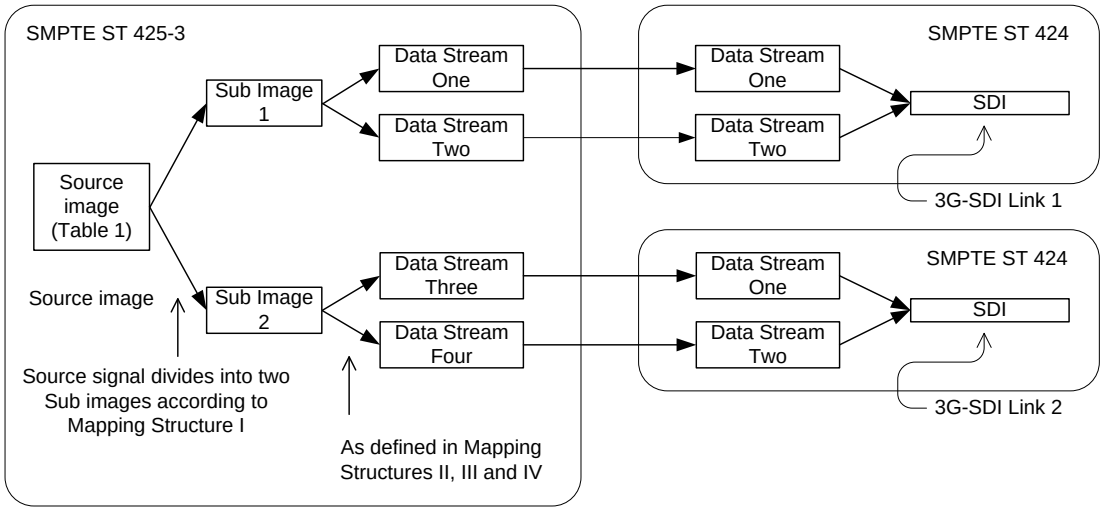


**Figure 7 – Overview of 1080-line Level B mapping**

**Table 9 – Sub Image Formats for1080-line Source Image (interlaced transport*2)**

| Mapping Structure (See Table 1) | Reference SMPTE Standard | Sub Image Format | Signal Format Sampling Structure/Pixel Depth | Frame Rate |
|---|---|---|---|---|
| II | ST 274 | 1920 × 1080 | 4:4:4 (R'G'B'), 4:4:4:4 (R'G'B' +A)/10-bit | 25, 30/1.001 and 30 |
| | ST 2048-2 | 2048 × 1080 | 4:4:4 (R'G'B'*1), 4:4:4:4 (R'G'B'*+A)/10-bit | 24/1.001, 24, 25, 30/1.001 and 30 |
| | ST 274 | 1920 × 1080 | 4:4:4 ($Y'C'_BC'_R$), 4:4:4:4 ($Y'C'_BC'_R$+A)/10-bit | 25, 30/1.001 and 30 |
| | ST 2048-2 | 2048 × 1080 | 4:4:4 ($Y'C'_BC'_R$), 4:4:4:4 ($Y'C'_BC'_R$+A)/10-bit | 24/1.001, 24, 25, 30/1.001 and 30 |
| III | ST 274 | 1920 × 1080 | 4:4:4 (R'G'B')/12-bit | 25, 30/1.001 and 30 |
| | ST 2048-2 | 2048 × 1080 | 4:4:4 (R'G'B'*1)/12-bit | 24/1.001, 24, 25, 30/1.001 and 30 |
| | ST 274 | 1920× 1080 | 4:4:4 ($Y'C'_BC'_R$)/12-bit | 25, 30/1.001 and 30 |
| | ST 2048-2 | 2048× 1080 | 4:4:4 ($Y'C'_BC'_R$)/12-bit | 24/1.001, 24, 25, 30/1.001 and 30 |
| IV | ST 274 | 1920 × 1080 | 4:2:2 ($Y'C'_BC'_R$)/12-bit | 25, 30/1.001 and 30 |
| | ST 2048-2 | 2048× 1080 | 4:2:2 ($Y'C'_BC'_R$)/12-bit | 24/1.001, 24,25, 30/1.001 and 30 |
| | ST 2048-2 | 2048× 1080 | 4:2:2:4 ($Y'C'_BC'_R$+A)/12-bit | 24/1.001, 24, 25, 30/1.001 and 30 |

Notes:

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

*2 The transport scanning method is the "interlaced transport". Therefore, the digital interface Line Number of each Sub Image is defined in in the equations below and illustrated in Figure 8.

The relationship between the digital interface Line Number and the picture source line number are calculated by the following equations. Figure 8 is reproduced from SMPTE ST 372 and is included here for the convenience of the reader.

M: Digital interface Line Number of Sub Image

N: Picture source line number

Line number of Sub Image1:

(1) $1 \leqq M \leqq 562$

$M = N/2$ where N= 2,4,…,1122,1124

(2) $563 \leqq M \leqq 1125$

$M = (N+1125)/2$ where N= 1,3,…,1123,1125

Line number of Sub Image2:

(1) $1 \leqq M \leqq 562$

M = (N-1)/2  where N= 3,5,…,1123,1125

(2) 563 ≦ M ≦ 1124

M = (N+1124)/2  where N= 2,4,…,1122,1124

(3) M = 1125

M = 1125  where N= 1

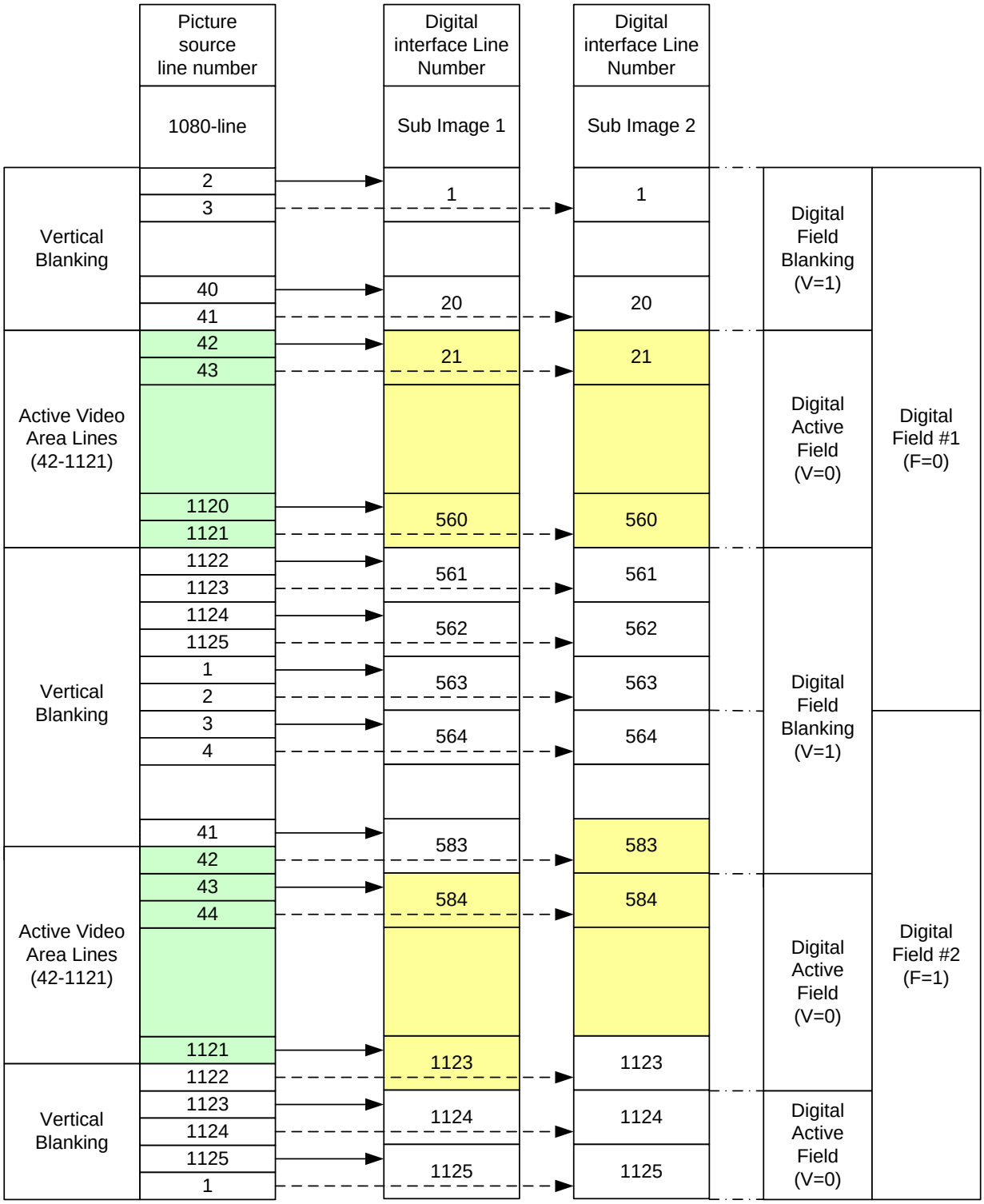


**Figure 8 – 1080P-Sub Image1/2 Line Interleaving and Line Numbering** (Informative)

The Line Number in Sub Image1 and Sub Image2 shall reference the digital interface Line Number, and not the picture source line number.

Note: Sub Image 1 is comprised of half of the lines of two consecutive source images, and Sub Image 2 is comprised of the remaining half of the lines of these two consecutive Sub Images.

### 7.1.1 Mapping Structure II – 4:4:4 (R'G'B')/(Y'C'$_B$C'$_R$) and 4:4:4:4 (R'G'B'+A)/(Y'C'$_B$C'$_R$+A)/10-bit Signals

Sub Image 1 and Sub Image 2 shall each be mapped onto two data streams using Mapping Structure rule II as shown in Table 9.

Mapping of 4:4:4:4 (R'G'B'+A)/10-bit signals is shown in Figure 9.

In the case of 4:4:4 (R'G'B')/10-bit signals, A (alpha) data in Figure 9 is replaced with 40h ($64_{10}$).

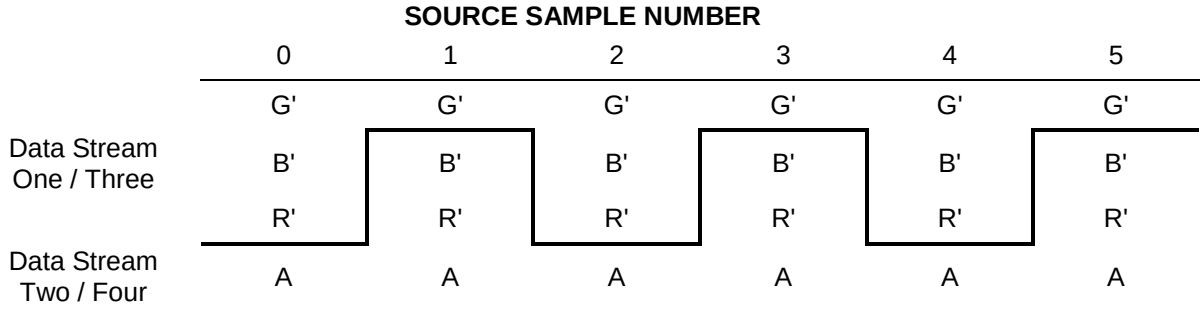


**Figure 9 – 4:4:4:4 (R′G′B′+A)/10-bit — Data stream separation using Mapping Structure rule II**

The Mapping Structure of the virtual interface onto which the 4:4:4 (Y'C'$_B$C'$_R$) and the 4:4:4:4 (Y'C'$_B$C'$_R$+A)/10-bit image data are mapped shall be as defined in this section, Section 7.1.1.1, and Section 7.1.1.1.1, except that:

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

the B' samples shall be replaced with C'$_B$ samples;

and the R' samples shall be replaced with C'$_R$ samples.

#### 7.1.1.1 Multiplex Structure

The video data words shall be conveyed in the following order in Mapping Structure II data streams:

Sub Image 1:

data stream one: B'0, G'0, R'0, G'1, B'2, G'2, R'2, G'3 …from Figure 9

data stream two: B'1, A0, R'1, A1, B'3, A2, R'3, A3 …from Figure 9

Sub Image 2:

data stream three: B'0, G'0, R'0, G'1, B'2, G'2, R'2, G'3 …from Figure 9

data stream four: B'1, A0, R'1, A1, B'3, A2, R'3, A3 …from Figure 9

#### 7.1.1.1.1 3G-SDI Link Multiplex Structure (Informative)

Following the data stream assignment specified in Section 9 and serialization according to SMPTE ST 424, the 3G-SDI data streams are conveyed in the following order:

3G-SDI Link 1 data stream:

B’1, B’0, A’0, G’0, R’1, R’0, A1, G’1, B’3, B’2, A2, G’2, R’3, R’2, A3, G’3 …

3G-SDI Link 2 data stream:

B’1, B’0, A’0, G’0, R’1, R’0, A1, G’1, B’3, B’2, A2, G’2, R’3, R’2, A3, G’3 …

### 7.1.2 Mapping Structure III – 4:4:4 (R’G’B’)/(Y’C’$_B$C’$_R$)/12-bit Signals

Sub Image 1 and Sub Image 2 shall each be mapped onto two data streams using Mapping Structure rule III as shown in Table 9.

Mapping of 4:4:4 (R’G’B’)/12-bit signals is shown in Figure 10.

Mapping of R’G’B’n:0-1 for 4:4:4 (R’G’B’)/12-bit signals onto data stream two and four is as shown in Table 10.

| | SOURCE SAMPLE NUMBER | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 |
| Data Stream One / Three | G':2-11 | G':2-11 | G':2-11 | G':2-11 | G':2-11 | G':2-11 |
| | B':2-11 | B':2-11 | B':2-11 | B':2-11 | B':2-11 | B':2-11 |
| | R':2-11 | R':2-11 | R':2-11 | R':2-11 | R':2-11 | R':2-11 |
| Data Stream Two / Four | R'G'B':0-1 | R'G'B':0-1 | R'G'B':0-1 | R'G'B':0-1 | R'G'B':0-1 | R'G'B':0-1 |

**Figure 10 – 4:4:4 (R′G′B′)/12-bit — Data stream separation using Mapping Structure rule III**

**Table 10 – R’G’B’n:0-1 mapping onto data stream two and four**

| | Bit Number | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Word** | **9** (MSB) | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 (LSB) |
| | $\overline{B8}$ | EP | G’n:1 | G’n:0 | B’n:1 | B’n:0 | R’n:1 | R’n:0 | Res | Res |

Notes:

1 MSB: most significant bit.

2 LSB: least significant bit.

3 B8 is the even parity for B7 through B0.

4 B9 is the complement of B8.

5 B0 and B1 are the reserved bits (Reserved bits shall be set to 0 until defined).

The Mapping Structure of the virtual interface onto which the 4:4:4 (Y'C'$_B$C'$_R$)/12-bit image data are mapped shall be defined in this section, Section 7.1.2.1, and Section 7.1.2.1.1, except that:

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

the B' samples shall be replaced with C'$_B$ samples;

and the R' samples shall be replaced with C'$_R$ samples.

#### 7.1.2.1 Multiplex Structure

The video data words shall be conveyed in the following order in Mapping Structure III data streams:

Sub Image 1:

data stream one: B'0:2-11, G'0:2-11, R'0:2-11, G'1:2-11, B'2:2-11, G'2:2-11, R'2:2-11, G'3:2-11…from Figure 10.

data stream two: B'1:2-11,R'G'B'0:0-1,R'1:2-11, R'G'B'1:0-1,B'3:2-11, R'G'B'2:0-1,R'3:2-11,R'G'B'3:0-1…from Figure 10.

Sub Image 2:

data stream three: B'0:2-11, G'0:2-11, R'0:2-11, G'1:2-11, B'2:2-11, G'2:2-11, R'2:2-11, G'3:2-11…from Figure 10.

data stream four: B'1:2-11,R'G'B'0:0-1,R'1:2-11,R'G'B'1:0-1,B'3:2-11,R'G'B'2:0-1,R'3:2-11,R'G'B'3:0-1…from Figure 10.

#### 7.1.2.1.1 3G-SDI Link Multiplex Structure (Informative)

Following the data stream assignment specified in Section 9 and serialization according to SMPTE ST 424, the 3G-SDI data streams are conveyed in the following order:

3G-SDI Link 1 data stream:

B'1:2-11. B'0:2-11,R'G'B'0:0-1, G'0:2-11,R'1:2-11, R'0:2-11,R'G'B'1:0-1, G'1:2-11 …

3G-SDI Link 2 data stream:

B'1:2-11. B'0:2-11,R'G'B'0:0-1, G'0:2-11,R'1:2-11, R'0:2-11,R'G'B'1:0-1, G'1:2-11 …

### 7.1.3 Mapping Structure IV – 4:2:2 (Y'C'$_B$C'$_R$) and 4:2:2:4 (Y'C'$_B$C'$_R$+A)/12-bit Signals

Sub Image 1 and Sub Image 2 shall each be mapped onto two data streams using Mapping Structure rule IV as shown in Table 9.

Mapping of 4:2:2:4 (Y'C'$_B$C'$_R$+A)/12-bit signals is shown in Figure 11.

In the case of 4:2:2 (Y'C'$_B$C'$_R$)/12-bit signals, A (alpha) data in Figure 11 is replaced with 40h ($64_{10}$).

Mapping of the even-numbered samples of Y'C'$_B$C'$_R$n:0-1 and the odd-numbered samples of Y'n:0:1 onto data stream two and four is as shown in Table 11 and Table 12, respectively.

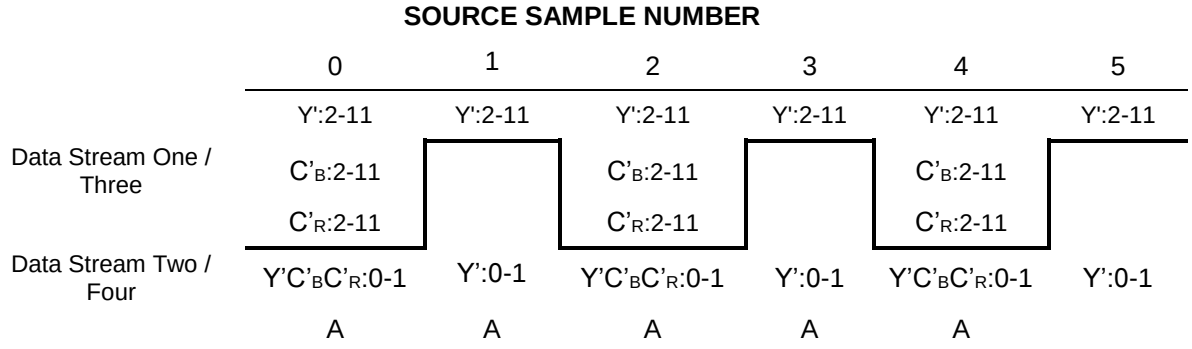


**Figure 11 – 4:2:2:4 (Y'C'$_B$C'$_R$+A)/12-bit — Data stream separation using Mapping Structure rule IV**

**Table 11 – Y'C'$_B$C'$_R$n:0-1 and Y'n:0-1 mapping onto data stream two and four**

| Word | Bit Number 9 (MSB) | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 (LSB) |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\overline{B8}$ | EP | Y'n:1 | Y'n:0 | C'$_B$n:1 | C'$_B$n:0 | C'$_R$n:1 | C'$_R$n:0 | Res | Res |

Notes:
1 MSB: most significant bit.
2 LSB: least significant bit.
3 B8 is the even parity for B7 through B0.
4 B9 is the complement of B8.
5 B0 and B1 are the reserved bits (Reserved bits shall be set to 0 until defined).

**Table 12 – Y'n:0-1 mapping onto data stream two and four**

| Word | Bit Number 9 (MSB) | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 (LSB) |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\overline{B8}$ | EP | Y'n:1 | Y'n:0 | Res | Res | Res | Res | Res | Res |

Notes:
1 MSB: most significant bit.
2 LSB: least significant bit.
3 B8 is the even parity for B7 through B0.
4 B9 is the complement of B8.
5 B0 through B5 are the reserved bits (Reserved bits shall be set to 0 until defined).

#### 7.1.3.1 Multiplex Structure

The video data words shall be conveyed in the following order in Mapping Structure IV data streams:

Sub Image 1:

data stream one: C'$_B$0:2-11,Y'0:2-11,C'$_R$0:2-11,Y'1:2-11C'$_B$ 2:2-11,Y'2:2-11,C'$_R$2:2-1, Y'3:2-11 …from Figure 11.

data stream two: A0,Y'C'$_B$C'$_R$0:0-1,A1,Y'1:0-1,A2,Y'C'$_B$C'$_R$2:0-1,A3,Y'3:0-1 …
from Figure 11.

Sub Image 2:

data stream three: C'$_B$0:2-11,Y'0:2-11C'$_R$0:2-11,Y'1:2-11C'$_B$ 2:2-11,Y'2:2-11,C'$_R$2:2-1,
Y'3:2-11 …from Figure 11.

data stream four: A0,Y'C'$_B$C'$_R$0:0-1,A1,Y'1:0-1,A2,Y'C'$_B$C'$_R$2:0-1,A3,Y'3:0-1 …
from Figure 11.

#### 7.1.3.1.1 3G-SDI Link Multiplex Structure (Informative)

Following the data stream assignment specified in Section 9 and serialization according to SMPTE ST 424, the 3G-SDI data streams are conveyed in the following order:

3G-SDI Link 1 data stream:

A0, C'$_B$0:2-11, Y'C'$_B$C'$_R$0:0-1, Y'0:2-11, A1, C'$_R$0:2-11, Y'1:0-1, Y'1:2-11, A2, C'$_B$ 2:2-11, Y'C'$_B$C'$_R$2:0-1, Y'2:2-11, A3, C'$_R$2:2-11, Y'3:0-1, Y'3:2-11…

3G-SDI Link 2 data stream:

A0, C'$_B$0:2-11, Y'C'$_B$C'$_R$0:0-1, Y'0:2-11, A1, C'$_R$0:2-11, Y'1:0-1, Y'1:2-11, A2, C'$_B$ 2:2-11, Y'C'$_B$C'$_R$2:0-1,Y'2:2-11,A3,C'$_R$2:2-11,Y'3:0-1,Y'3:2-11…

### 7.2 Ancillary Data

When present, the ancillary data shall be mapped into the HANC or the VANC space of data streams one, two, three and four, in accordance with the SMPTE ST 372 ancillary data mapping rules.

Ancillary data packets are mapped into either the Luma (Y') data channel or the Color-Difference (C'$_B$, C'$_R$) data channel. On each data stream, the Luma (Y') data channel and the Color-Difference (C'$_B$, C'$_R$) data channel are interleaved as shown in the Figure "Interleaved data stream" of the section "Serial Data Format" in SMPTE ST 292-1 that SMPTE ST 372 refers to, and this layout is inherited by the level B mapping rule.

Unless otherwise stated, the ancillary data shall be mapped into data stream one first and any remaining data shall then be mapped onto data stream two; then into data stream three and any remaining data into data stream four. Data space requirements and locations for each data service are defined by their respective application documents. In some cases, it is required by specific applications that ancillary data be mapped into all four data streams ( e.g. Payload Identifier).

### 7.2.1 Audio Data

When present, audio data shall be mapped into the HANC space of data streams one, two, three and four and shall be in conformance with SMPTE ST 299-1.

Audio control packets are mapped into the Luma (Y') at a channel on each data stream.

Audio data packets are mapped into the Color-Difference (C'$_B$,C'$_R$) data channel on each data stream.

Audio control and data packets shall be mapped into data stream one first and any remaining data shall then be mapped onto data stream two; then into data stream three and any remaining data into data stream four.

In some applications, for example, to allow independent monitoring of audio, audio data on data stream one may be duplicated on data stream three and audio on data stream two, if present, may be duplicated on data stream four. Audio channel usage shall be further signalled using the payload identifier as defined in Section 7.2.3 of this document.

The audio clock phase data as defined in the section “CLK (audio clock phase data)” of SMPTE ST 299-1 shall be calculated at the clock frequency of 74.25 (/1.001) MHz.

#### 7.2.1.1 Number of Audio Channels

Up to 64 audio channels sampled at 32 kHz, 44.1 kHz or 48 kHz may be mapped into data streams one, two, three and four of the virtual interface. At 96-kHz sampling, up to 32 audio channels may be mapped into the virtual interface.

The maximum number of audio channels that can be mapped into the available HANC space of the data streams varies in accordance with the source image format and frame rate as shown in Table 4.

In the case where data stream three is carrying a duplicate of the audio on data stream one, and where data stream four is carrying a duplicate of the audio on data stream two, the audio data and control packets shall be an exact replica of the audio carried the data stream pair one and two, respectively – specifically the audio on the data stream three shall use the same audio groups as applied to the audio on data stream one and the audio on data stream four shall use the same audio groups as applied to the audio on data stream two.

##### 7.2.1.1.1 Carriage of up to 64 Channels of Audio at up to 48-kHz Sampling

For audio at up to 48-kHz sampling embedded into 2048 x 1080 image formats at frame rates of 60/1.001or 60, the audio data and control packets for the first 8 channels, shall be mapped into data stream one. The audio data and control packets for the second 8 channels, shall be mapped into data stream two. The audio data and control packets for the third 8 channels, shall be mapped into data stream three. The audio data and control packets for the fourth 8 channels, shall be mapped into data stream four. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 and 2).

For audio at up to 48-kHz sampling embedded into all other 1080-line image formats shown in Table 4, the audio data and control packets for the first 16 channels shall be mapped into data stream one. The audio data and control packets for the second 16 channels shall be mapped into data stream two. The audio data and control packets for the third 16 channels shall be mapped into data stream three. The audio data and control packets for the fourth 16 channels shall be mapped into data stream four. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

##### 7.2.1.1.2 Carriage of up to 32 Channels of Audio at 96-kHz Sampling

For audio at 96-kHz sampling embedded into 2048 x 1080 image formats at frame rates of 60/1.001or 60, the audio data and control packets for the first 4 channels shall be mapped into data stream one. The audio data and control packets for the second 4 channels shall be mapped into data stream two. The audio data and control packets for the third 4 channels shall be mapped into data stream three. The audio data and control packets for the fourth 4 channels shall be mapped into data stream four. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 and 2).

For audio at 96-kHz sampling embedded into all other image formats shown in Table 4, the audio data and control packets for the first 8 channels shall be mapped into data stream one. The audio data and control packets for the second 8 channels shall be mapped into data stream two. The audio data and control packets for the third 8 channels shall be mapped into data stream three. The audio data and control packets for the fourth 8 channels shall be mapped into data stream four. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

### 7.2.2 Time Code Data

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

The time code may also be mapped onto data stream two, three and four, in which case the corresponding Time Address values shall be identical.

The time code formatting shall follow the SMPTE ST12-2 rules for PsF video. The time code represents the source image time code and not the Sub Image time code.

### 7.2.3 Payload Identifier

The payload identifier data structure shall be in conformance with SMPTE ST 352 and shall be mapped into HANC of the Luma (Y') data channel of each data stream one, two, three and four in accordance with the Level B-DL mapping rules defined in SMPTE ST 425-1.

#### 7.2.3.1 Payload Identifier Structure

Table 13 shows the payload identifier definitions for 1080-line Video Payloads for Level B-DL Mapping. The payload identifier shall be 4 bytes where each byte has a separate significance. The first byte of the payload identifier shall have the highest significance and subsequent bytes shall define lower order video and ancillary payload information.

The recommended location for the payload identifier is defined in SMPTE ST 425-1.

**Table 13 – Payload Identifier Definitions for 1080-line Video Payloads for Level B Dual-Link Mapping on a Dual-link 3 Gb/s (nominal) Serial Interface**

<table>
<tr><th>Bits</th><th>Byte 1</th><th>Byte 2</th><th>Byte 3</th><th>Byte 4</th></tr>
<tr><td>Bit 7</td><td>1</td><td>Interlacedtransport (0)</td><td>Reserved (0)</td><td rowspan="2">Channel assignment<br>Data stream one on 3G-SDI Link 1(0h)<br>Data stream two on3G-SDI Link 1(1h)<br>Data stream three on3G-SDI Link 2 (2h)<br>Data stream four on3G-SDI Link 2 (3h)</td></tr>
<tr><td>Bit 6</td><td>0</td><td>Progressive picture(1)</td><td>Horizontal sampling<br>1920 (0) or 2048 (1)</td></tr>
<tr><td>Bit 5</td><td>0</td><td>Reserved (0)</td><td>Aspect Ratio<br>16:9 (1) or Unknown (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 4</td><td>1</td><td>Reserved (0)</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 3</td><td>0</td><td rowspan="5">Picture rate<br>(as per Table 2 of SMPTE ST 352)<br>Perrmitted values are:<br>48/1.001 Frame Rate (4h),<br>48 Frame Rate (8h),<br>50 Frame Rate (9h),<br>60/1.001 Frame Rate (Ah),<br>60 Frame Rate (Bh),<br>Other Values are Reserved.</td><td rowspan="5">Sampling structure<br>(as per Table 3 of SMPTE ST 352)<br>Permitted values are:<br>4:4:4Y'/C'B/C'R (1h),<br>4:4:4G'/B'/R' (2h),<br>4:2:2:4Y'/C'B/C'R /A (4h),<br>4:4:4:4Y'/C'B/C'R/A (5h),<br>4:4:4:4G'/B'/R'/A (6h),<br>2048-2 FS (7h),<br>4:2:2:4 Y'/C'B/C'R /D (8h),<br>4:4:4:4 Y'/C'B/C'R /D (9h),<br>4:4:4:4G'/B'/R'/D (Ah)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 2</td><td>1</td><td>Audio – 3G-SDI Link 2,<br>3G-SDI Link 2 carries additional channels or audio not present (0)<br>3G-SDI Link 2 carries a copy of 3G-SDI Link 1 audio (1)</td></tr>
<tr><td>Bit 1</td><td>0</td><td rowspan="2">Bit depth<br>10-bit (1h),12-bit (2h),<br>Other values are Reserved</td></tr>
<tr><td>Bit 0</td><td>1</td></tr>
</table>

#### 7.2.3.2 Byte 1 - Digital Interface and Payload Identification

Byte 1 of the payload identifier identifies the video payload and the digital interface and shall be as defined below.

Byte 1 shall be set to [95h] for the Level B-DL Mapping for 1080-line image formats listed in Table 2.

#### 7.2.3.3 Byte 2 – Picture Rate and Scanning Method

Byte 2 of the payload identifier shall be used to identify the picture and transport scanning methods and the picture rate.

Bit 7 shall be set to 0h (Interlaced transport).

Bit 6 shall be set to 1h (progressive picture).

Bits b5 to b4 shall be set to 0h (reserved).

Bits b3 to b0 shall be used to identify the picture rate in Hz in accordance with Table 2 of SMPTE ST 352 and shall only use the values as permitted for image formats in Table 2.

#### 7.2.3.4 Byte 3 – Sampling Structure, Aspect Ratio and Horizontal Size

Byte 3 of the payload identifier shall be used to identify the aspect ratio, horizontal pixel array size, and sampling structure of the video payload.

Bit 7 shall be set to 0h (reserved).

Bit 6 shall be used to identify the number of active Luma/R'G'B' samples for the Sub Image such that:

b6 = 0h identifies 1920 active Luma/R'G'B' samples

b6 = 1h shall identifies 2048 active Luma/R'G'B' samples

Bit 5 shall be used to identify the aspect ratio such that:

b5 = 0h identifies unknown aspect ratio Sub Image

b5 = 1h identifies a 16:9 aspect ratio Sub Image

Bit 4 shall be set to 0h (reserved).

Bits b3 to b0 shall be used to identify the sampling structure in accordance with Table 3 of SMPTE ST 352 and shall only use the values as permitted for image formats in Table 2.

#### 7.2.3.5 Byte 4 – Channel Assignment and Quantization Bit Depth

Byte 4 of the payload identifier shall be used to identify the channel assignment, and bit depth of the sample quantization.

Bitsb7 to b6 shall be used to identify channel assignment such that

0h shall identify data stream one on 3G-SDI Link 1

1h shall identify data stream two on 3G-SDI Link 1

2h shall identify data stream three on 3G-SDI Link 2

3h shall identify data stream four on 3G-SDI Link 2

Bits b5 to b3 shall be set to 0h (reserved).

For the 3G-SDI Link 1, bit b2 shall be reserved and set to (0h)

For the 3G-SDI Link 2, bit b2 shall signal the nature of any audio data carried in 3G-SDI Link 2 such that:

0h identifies that audio if present in the 3G-SDI Link 2 carries additional audio channels.

1h identifies that the 3G-SDI Link 2 carries a copy of the 3G-SDI Link 1 audio

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

1h identifies quantization using 10-bit per sample

2h identifies quantization using 12-bit per sample

Other values are reserved.

Note: In the case where the bit depth field indicates 12-bit per sample, it should be noted that these bits have been mapped into a 10-bit interface.

# 8 2160-line Mapping

This section defines image and ancillary data mapping for 2160-line image formats listed in Table 3

## 8.1 Mapping of 2160-line Source Image

The 2160-line source images listed in Table 3 shall be divided into four Sub Images as listed in Table 14 in accordance with the 2-sample interleave division rule as defined in SMPTE ST 435-1. Figure 12 illustrates the 2-sample interleave division rule. Even lines of the source image are divided into the Sub Image 1 and 2 as per 2 consecutive horizontal samples and odd lines of the source image are divided into the Sub Image 3 and 4 as per 2 consecutive horizontal samples.

Each Sub Image shall then be mapped into one of four data streams each of which complies with the 1.5 Gb/s data stream defined in SMPTE ST 292-1, in accordance with SMPTE ST 435-1. Figure 2 gives an overview of the 2160-line mapping.

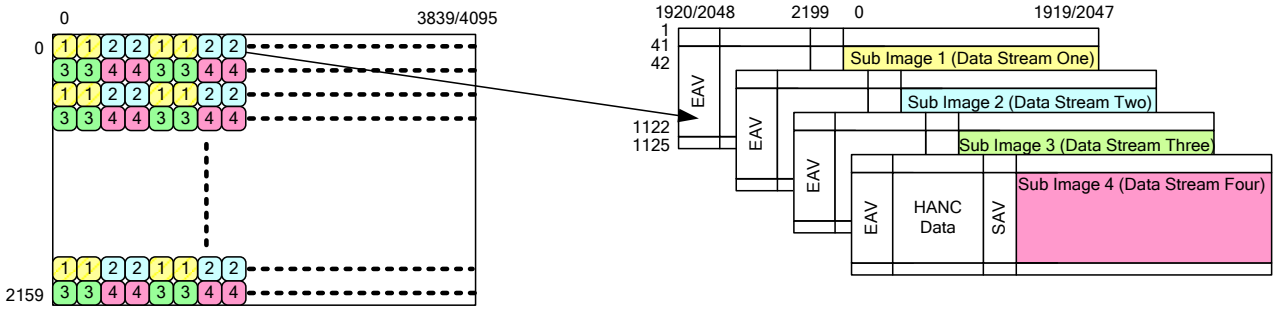


**Figure 12 – 2-sample interleave division to Sub Image 1 through 4**

**Table 14 – Sub Image Formats for 2160-line Source Image**

| Reference SMPTE Standard | Image Format | Signal Format Sampling Structure/Pixel Depth | Frame Rate |
|---|---|---|---|
| ST274 | 1920 × 1080 | 4:2:2 (Y'C'$_B$C'$_R$)/10-bit | 24/1.001, 24, 25, 30/1.001 and 30 Progressive |
| ST2048-2 | 2048× 1080 | 4:2:2 (Y'C'$_B$C'$_R$)/10-bit | 24/1.001, 24, 25, 30/1.001 and 30 Progressive |

### 8.1.1 Multiplex Structure

The video data words shall be conveyed in the following order in the data streams:

Sub Image 1 shall be mapped into data stream one:

data stream one: C'$_B$0, Y'0, C'$_R$0, Y'1, C'$_B$4, Y'4, C'$_R$4, Y'5…from even lines as per Figure 12.

Sub Image 2 shall be mapped into data stream two:

data stream two: C'$_B$2, Y'2, C'$_R$2, Y'3, C'$_B$6, Y'6, C'$_R$6, Y'7…from even lines as per Figure 12.

Sub Image 3shall be mapped into data stream three:

data stream three: C'$_B$0, Y'0, C'$_R$0, Y'1, C'$_B$4, Y'4, C'$_R$4, Y'5…from odd lines as per Figure 12.

Sub Image 4 shall be mapped into data stream four:

data stream four: C'$_B$2, Y'2, C'$_R$2, Y'3, C'$_B$6, Y'6, C'$_R$6, Y'7…from odd lines as per Figure 12.

#### 8.1.1.1 3G-SDI Link Multiplex Structure (Informative)

Following the data stream assignment specified in Section 9 and serialization according to SMPTE ST 424, the 3G-SDI data streams are conveyed in the following order:

3G-SDI Link 1 data stream:

C'$_B$2, C'$_B$0, Y'2, Y'0, C'$_R$2, C'$_R$0, Y'3, Y'1, C'$_B$6, C'$_B$4, Y'6, Y'4, C'$_R$6, C'$_R$4, Y'7, Y'5 …

3G-SDI Link 2 data stream:

C'$_B$2, C'$_B$0, Y'2, Y'0, C'$_R$2, C'$_R$0, Y'3, Y'1, C'$_B$6, C'$_B$4, Y'6, Y'4, C'$_R$6, C'$_R$4,Y'7, Y'5 …

### 8.2 Ancillary Data

When present, ancillary data shall be mapped into the HANC or the VANC space of data streams one, two, three and four, in accordance with the SMPTE ST 292-1 ancillary data mapping rules. The HANC and VANC spaces of each Sub Image are defined in the reference standard for each Sub Image format as shown in Table 14.

Ancillary data packets are mapped into either the Luma (Y') data channel or the Color-Difference (C'$_B$, C'$_R$) data channel. On each data stream, the layout of the Luma (Y') data channel and the Color-Difference (C'$_B$, C'$_R$) data channel is as shown in the Figure "Interleaved data stream" of SMPTE ST 292-1.

Unless otherwise stated, the ancillary data shall be mapped into data stream one first and any remaining data shall then be mapped onto data stream two; then into data stream three and any remaining data into data stream four. Data space requirements and locations for each data service are defined by their respective application documents. In some cases, it is required by specific applications that ancillary data be mapped into all four data streams (e.g. Payload Identifier).

### 8.2.1 Audio Data

When present, audio data shall be mapped into the HANC space of data streams one, two, three and four and shall be in conformance with SMPTE ST 299-1.

Audio control packets are mapped into the Luma (Y') data channel on each data stream.

Audio data packets are mapped into the Color-Difference ($C'_B$,$C'_R$) data channel on each data stream.

Audio control and data packets shall be mapped into data stream one first and any remaining data shall then be mapped onto data stream two; then into data stream three and any remaining data into data stream four.

In some applications, for example to allow independent monitoring of audio, audio data on data stream one may be duplicated on data stream three and audio on data stream two, if present, may be duplicated on data stream four. Audio channel usage shall be further signalled using the payload identifier as defined in Section 8.2.3 of this document.

The audio clock phase data as defined in the section "CLK (audio clock phase data)" of SMPTE ST 299-1 shall be calculated at a clock frequency of 74.25 MHz or 74.25/1.001 MHz.

#### 8.2.1.1 Number of Audio Channels

Up to 64 audio channels sampled at 32 kHz, 44.1 kHz or 48 kHz may be mapped into data streams one, two, three and four of the virtual interface. At 96-kHz sampling, up to 32 audio channels may be mapped into the virtual interface.

The maximum number of audio channels that can be mapped into the available HANC space of the data streams varies in accordance with the source image format and frame rate as shown in Table 14.

In the case where data stream three is carrying a duplicate of the audio on data stream one and where data stream four is carrying a duplicate of the audio on data stream two, the audio data and control packets shall be an exact replica of the audio carried the data stream pair one and two respectively – specifically the audio on the data stream three shall use the same audio groups as applied to the audio on data stream one and the audio on data stream four shall use the same audio groups as applied to the audio on data stream two.

##### 8.2.1.1.1 Carriage of up to 64 Channels of Audio at up to 48-kHz Sampling

For audio at up to 48-kHz sampling embedded into 4096 x 2160 image formats at frame rates of 60/1.001 or 60, the audio data and control packets for the first 8 channels, shall be mapped into data stream one. The audio data and control packets for the second 8 channels, shall be mapped into data stream two. The audio data and control packets for the third 8 channels, shall be mapped into data stream three. The audio data and control packets for the fourth 8 channels, shall be mapped into data stream four. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 and 2)

For audio at up to 48-kHz sampling embedded into all other 2160-line image formats shown in Table 4, the audio data and control packets for the first 16 channels shall be mapped into data stream one. The audio data and control packets for the second 16 channels shall be mapped into data stream two. The audio data

and control packets for the third 16 channels shall be mapped into data stream three. The audio data and control packets for the fourth 16 channels shall be mapped into data stream four. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 to 4)

#### 8.2.1.1.2 Carriage of up to 32 Channels of Audio at 96-kHz Sampling

For audio at 96-kHz sampling embedded into 4096 x 2160 image formats at frame rates of 60/1.001 or 60, the audio data and control packets for the first 4 channels shall be mapped into data stream one. The audio data and control packets for the second 4 channels shall be mapped into data stream two. The audio data and control packets for the third 4 channels shall be mapped into data stream three. The audio data and control packets for the fourth 4 channels shall be mapped into data stream four. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 and 2)

For audio at 96-kHz sampling embedded into all other 2160-line image formats shown in Table 4, the audio data and control packets for the first 8 channels shall be mapped into data stream one. The audio data and control packets for the second 8 channels shall be mapped into data stream two. The audio data and control packets for the third 8 channels shall be mapped into data stream three. The audio data and control packets for the fourth 8 channels shall be mapped into data stream four. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 to 4)

### 8.2.2 Time Code Data

When present, the time code data shall be mapped into the HANC space of the Luma (Y') data channel data channel of data stream one and shall be in conformance with SMPTE ST 12-2.

The time code may also be mapped onto data stream three, in which case the corresponding Time Address values shall be identical.

The time code formatting shall follow the SMPTE ST12-2 rules for progressive or PsF video according to the transport of Sub Image format in Table 14.

### 8.2.3 Payload Identifier

The payload identifier data structure shall be in conformance with SMPTE ST 352 and shall be mapped into HANC of the Luma (Y') data channel of each data streams one, two, three and four in accordance with the mapping rules defined in SMPTE ST 292-1.

#### 8.2.3.1 Payload Identifier Structure

Table 15 shows the payload identifier definitions for 2160-line Video Payloads. The payload identifier shall be 4 bytes where each byte has a separate significance. The first byte of the payload identifier shall have the highest significance and subsequent bytes shall define lower order video and ancillary payload information.

The recommended location for the payload identifier is defined in SMPTE ST 425-1.

**Table 15 – Payload Identifier Definitions for 2160-line Video Payload Mapping on a Dual-link 3 Gb/s (nominal) Serial Interface**

<table>
<tr><th>Bits</th><th>Byte 1</th><th>Byte 2</th><th>Byte 3</th><th>Byte 4</th></tr>
<tr><td>Bit 7</td><td>1</td><td>Progressive transport (1)</td><td>Reserved (0)</td><td rowspan="2">Channel assignment<br>Data stream one on 3G-SDI Link 1(0h)<br>Data stream two on 3G-SDI Link 1(1h)<br>Data stream three on 3G-SDI Link 2 (2h)<br>Data stream four on 3G-SDI Link 2 (3h)</td></tr>
<tr><td>Bit 6</td><td>0</td><td>Progressive picture(1)</td><td>Horizontal sampling<br>1920 (0) or 2048 (1)</td></tr>
<tr><td>Bit 5</td><td>0</td><td>Reserved (0)</td><td>Aspect Ratio<br>16:9 (1) or Unknown (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 4</td><td>1</td><td>Reserved (0)</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 3</td><td>0</td><td rowspan="4">Picture rate<br>(as per Table 2 of SMPTE ST 352)<br>Perrmitted values are:<br>24/1.001 Frame Rate (2h),<br>24 Frame Rate (3h),<br>25 Frame Rate (5h),<br>30/1.001 Frame Rate (6h),<br>30 Frame Rate (7h),<br>Other Values are Reserved</td><td rowspan="4">Sampling structure<br>(as per Table 3 of SMPTE ST 352)<br>Permitted values are:<br>4:2:2Y’/C’<sub>B</sub>/C’<sub>R</sub> (0h),<br>4:2:0 (3h)<br>2048-2 FS (7h),</td><td>Reserved (0)</td></tr>
<tr><td>Bit 2</td><td>1</td><td>Audio – 3G-SDI Link 2,<br>3G-SDI Link 2 carries additional channels or audio not present (0)<br>3G-SDI Link 2 carries a copy of 3G-SDI Link 1 audio (1)</td></tr>
<tr><td>Bit 1</td><td>1</td><td rowspan="2">Bit depth<br>10-bit (1h)<br>Other values are Reserved</td></tr>
<tr><td>Bit 0</td><td>0</td></tr>
</table>

#### 8.2.3.2 Byte 1 – Digital Interface and Payload Identification

Byte 1 of the payload identifier identifies the video payload and the digital interface and shall be as defined below.

Byte 1 shall be set to [96h] for the Mapping for 2160-line image formats listed in Table 3.

#### 8.2.3.3 Byte 2 – Picture Rate and Scanning Method

Byte 2 of the payload identifier shall be used to identify the picture and transport scanning methods and the picture rate.

Bit 7 shall be set to 1h (progressive transport).

Bit 6 shall be set to 1h (progressive picture).

Bit 5 and 4 shall be set to 0h (reserved).

Bits b3 to b0 shall be used to identify the picture rate in Hz in accordance with Table 2 of SMPTE ST 352 and shall only use the values as permitted for image formats in Table 3.

#### 8.2.3.4 Byte 3 – Sampling Structure, Aspect Ratio and Horizontal Size

Byte 3 of the payload identifier shall be used to identify the aspect ratio, horizontal pixel array size, and sampling structure of the video payload.

Bit 7 shall be set to 0h (reserved).

Bit 6 shall be used to identify the number of active Luma/R’G’B’ samples for the Sub Image such that:

b6 = 0h identifies 1920 active Luma/R'G'B' samples

b6 = 1h shall identifies 2048 active Luma/R'G'B' samples

Bit 5 shall be used to identify the aspect ratio such that:

b5 = 0h identifies unknown aspect ratio Sub Image

b5 = 1h identifies a 16:9 aspect ratio Sub Image

Bit 4 shall be set to 0h (reserved).

Bits b3 to b0 shall be used to identify the sampling structure in accordance with Table 3 of SMPTE ST 352 and shall only use the values as permitted for image formats in Table 3.

#### 8.2.3.5 Byte 4 – Sub Image Identification and Quantization Bit Depth

Byte 4 of the payload identifier shall be used to identify the Sub Image, and bit depthof the sample quantization.

Bits b7 to b6 shall be used to identify Sub Image channel assignment such that:

0h shall identify data stream one on3G-SDI Link 1

1h shall identify data stream two on 3G-SDI Link 1

2h shall identify data stream three on 3G-SDI Link 2

3h shall identify data stream four on3G-SDI Link 2

Bits b5 to b3 shall be set to 0h (reserved).

For the 3G-SDI Link 1, bit b2 shall be reserved and set to (0h)

For the3G-SDI Link 2, bit b2 shall signal the nature of any audio data carried in 3G-SDI Link 2 such that:

0h identifies that audio if present in the 3G-SDI Link 2 carries additional audio channels.

1h identifies that the 3G-SDI Link 2 carries a copy of the 3G-SDI Link 1 audio

Bits b1to b0 shall be used to identify the bit depth of the sample quantization such that:

1h identifies quantization using 10-bit per sample

Other values are reserved.

## 9 Data Stream Assignment for 3G-SDI Link 1 and 3G-SDI Link 2

Data stream one and data stream two shall be mapped to 3G-SDI Link 1 and shall be assigned to data stream one and data stream two of ST 424.

Data stream three and data stream four shall be mapped to 3G-SDI Link 2 and shall be assigned to data stream one and data stream two of ST 424.

### 9.1 3G-SDI Link 1/ 3G-SDI Link 2 Interface Timing

The timing difference between the EAV / SAV of 3G-SDI Link 1 and 3G-SDI Link 2 shall not exceed 400 ns at the source. This difference should be taken into consideration when designing systems and destination equipment input stages.

## 10 Levels of Operation (Informative)

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

Level A –1080-line Level A Mapping

Level B –1080-line Level B Dual-Link Mapping

Level C –2160-line Mapping

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

# Annex A Bibliography (Informative)

SMPTE ST 12-1:2014, Time and Control Code

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

SMPTE ST 424:2012, 3 Gb/s Signal/Data Serial Interface

SMPTE ST 2051:2014, Two-Frame Marker for 48(/1.001)-Hz, 50-Hz and 60(/1.001)-Hz Progressive Digital Video Signals on 1.5 Gb/s and 3 Gb/s Interfaces

SMPTE RP 157:2012, Key and Alpha Signals

# Annex B Square Division of 2160-Image Formats (Informative)

This Annex describes the square division approach for 2160-line image formats listed in Table 3 used by some existing fielded products.

The 2160-line source images listed in Table 3 are divided into four Sub Images listed in Table 14 in accordance with the square division rule as defined in SMPTE ST 435-1 and illustrated in Figure B.1.

Each Sub Image is then mapped into four data streams, each of which complies with the 1.5 Gb/s basic stream as defined in SMPTE ST 435-1 and illustrated in Figure B.2.

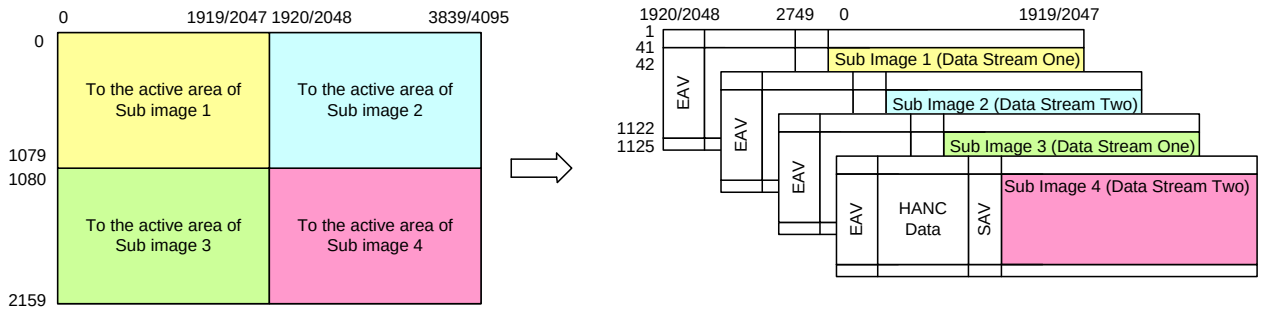


**Figure B.3 – Square division to Sub Image 1 through 4**

When present, ancillary data packets are mapped into the HANC or the VANC spaces of each data stream in accordance with the SMPTE ST 292-1 ancillary data mapping rules. The HANC and VANC spaces of each Sub Image are defined in the reference standard for each Sub Image format as shown in Table 14.

Ancillary data packets are mapped into either the Luma (Y') data channel or the Color-Difference ($C'_B$, $C'_R$) data channel. On each data stream, the layout of the Luma (Y') data channel and the Color-Difference ($C'_B$, $C'_R$) data channel is as shown in the Figure “Interleaved data stream” of SMPTE ST 292-1.

The ancillary data packets are mapped into data stream one first, and any remaining data are then mapped onto data stream two, then into data stream three, and any remaining data into data stream four.

## B.1 Quad 1.5 Gb/s Serial Digital Interface Mapping

In some existing implementations, the four data streams for the 1080-line Sub Images (required to transport a complete 2160-line source image) are serialized according to SMPTE ST 292-1 and output as 1.5 Gb/s serial digital interface.

The payload identifier defined in SMPTE ST 292-1 for 1080-line Video Payloads on a 1.5 Gb/s serial digital interface (reproduced here in Table B.1 for the convenience of the reader) is inserted into all four data streams. The payload identifier is mapped into HANC of the Luma (Y') data channel of each data stream in accordance with the mapping rules defined in SMPTE ST 292-1.

**Table B.2– Payload Identifier Definitions for 1080-line Video Payloads for HD-SDI Mapping on a 1.5 Gb/s (nominal) Serial Digital Interface**

<table>
<tr><th>Bits</th><th>Byte 1</th><th>Byte 2</th><th>Byte 3</th><th>Byte 4</th></tr>
<tr><td>Bit 7</td><td>1</td><td>Interlaced (0) or progressive transport (1)</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 6</td><td>0</td><td>Progressive picture(1)</td><td>Horizontal sampling<br>1920 (0) or 2048 (1)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 5</td><td>0</td><td>Reserved (0)</td><td>Aspect Ratio<br>16:9 (1) or Unknown (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 4</td><td>0</td><td>Reserved (0)</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 3</td><td>0</td><td rowspan="4">Picture rate<br>(as per Table 2 of SMPTE ST 352)<br>Perrmitted values are:<br>24/1.001 Frame Rate (2h),<br>24 Frame Rate (3h),<br>25 Frame Rate (5h),<br>30/1.001 Frame Rate (6h),<br>30 Frame Rate (7h),</td><td rowspan="4">Sampling structure<br>(as per Table 3 of SMPTE ST 352)<br>Permitted values are:<br>4:2:2Y’/C’<sub>B</sub>/C’<sub>R</sub> (0h),<br>4:2:0 (3h)<br>2048-2 FS (7h)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 2</td><td>1</td><td>Reserved (0)</td></tr>
<tr><td>Bit 1</td><td>0</td><td>Reserved (0)</td></tr>
<tr><td>Bit 0</td><td>1</td><td>Bit depth<br>10-bit (1h)</td></tr>
</table>

## B.2 Dual 3 Gb/s Level B Dual-Stream Mapping

The data streams from Sub Image 1 and Sub Image 2 are mapped into the 20-bit Virtual Interface defined in SMPTE ST 425-1, in accordance with the Level B-DS (Dual Stream) mapping rules. The data streams from Sub Image 3 and Sub Image 4 are mapped into a second 20-bit Virtual Interface defined in SMPTE ST 425-1, in accordance with the Level B-DS (Dual Stream) mapping rules.

The payload identifier defined in SMPTE ST 425-1 for 2 x 1080-line Video Payloads on a Level B-DS serial interface (reproduced here in Table B.3 for the convenience of the reader) is inserted into all four data streams. The payload identifier is mapped into HANC of the Luma (Y') data channel of each data stream in accordance with the Level B-DS mapping rules defined in SMPTE ST 425-1.

Each of the two 20-bit virtual interfaces (required to transport a complete 2160-line source image) are then multiplexed into a serial bit stream according to SMPTE ST 424.

**Table B.4 – Payload Identifier Definitions for 1080-line Video Payloads for Level B Dual-Stream Mapping of 2 x HD SDI Mapped on 3 Gb/s (nominal) Serial Interface**

<table>
<tr><th>Bits</th><th>Byte 1</th><th>Byte 2</th><th>Byte 3</th><th>Byte 4</th></tr>
<tr><td>Bit 7</td><td>1</td><td>Interlaced (0) or progressive transport (1)</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 6</td><td>0</td><td>Progressive picture(1)</td><td>Horizontal sampling<br>1920 (0) or 2048 (1)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 5</td><td>0</td><td>Reserved (0)</td><td>Aspect Ratio<br>16:9 (1) or Unknown (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 4</td><td>0</td><td>Reserved (0)</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 3</td><td>1</td><td rowspan="4">Picture rate<br>(as per Table 2 of SMPTE ST 352)<br>Perrmitted values are:<br>24/1.001 Frame Rate (2h),<br>24 Frame Rate (3h),<br>25 Frame Rate (5h),<br>30/1.001 Frame Rate (6h),<br>30 Frame Rate (7h),</td><td rowspan="4">Sampling structure<br>(as per Table 3 of SMPTE ST 352)<br>Permitted values are:<br>4:2:2Y’/C’<sub>B</sub>/C’<sub>R</sub> (0h),<br>4:2:0 (3h)<br>2048-2 FS (7h)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 2</td><td>1</td><td>Reserved (0)</td></tr>
<tr><td>Bit 1</td><td>0</td><td>Reserved (0)</td></tr>
<tr><td>Bit 0</td><td>0</td><td>Bit depth<br>10-bit (1h)</td></tr>
</table>

# Annex C Document Road Map (Informative)

This road map shows the relationships through SMPTE ST 425-3, its reference documents and bibliographies.