SMPTE ST 125:2013
Revision of SMPTE 125M-1995
Replacement of SMPTE 267M-1995
Replacement of SMPTE RP 175-1995

SMPTE STANDARD

SDTV Component Video Signal Coding 4:4:4 and 4:2:2 for 13.5 MHz and 18 MHz Systems

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Approved
September 25, 2013

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 Part XIII of its Operations Manual.

SMPTE ST 125 was prepared by Technology Committee 10E.

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.

This standard replaces previous versions of SMPTE ST 125, SMPTE ST 267 and SMPTE RP 175. In addition, 625-line values have been included. The parallel representation of the digital signal has been made an informative Annex, reflecting past implementation practice.

This standard is backwards compatible with the previous version of SMPTE ST 125 and SMPTE ST 267. The 625-line characteristics for 13.5 MHz sampling is backwards compatible with Recommendation ITU-R BT.601 625-line values are often included in brackets.

1 Scope

This standard defines the digital video coding for 4:4:4 and 4:2:2 color spaces and a virtual parallel interface for 525/625-line interlaced systems. Two luma sampling rates are defined: 13.5 MHz and 18 MHz. The virtual parallel signal interface format is required as the source for the 10 bit serial interface defined in SMPTE ST 259.

Annex D covers video coding for the 4:4:4:4 member of the family, including multiplexing details for “dual channel” operation.

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 which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the Recommendations indicated below.

Recommendation ITU-R BT.601-7, Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide Screen 16:9 Aspect Ratios

Recommendation ITU-R BT.1700, Characteristics of Composite Video Signals for Conventional Analogue Television Systems

4 Video Data Signal Format — Encoding/Analog Timing Parameters

Spectral characteristics of signals to be encoded shall be bandwidth-constrained to minimize aliasing. Suggested filter characteristics are described in Annex B, Figures B.1 through B.4.

4.1 4:4:4 Encoding Characteristics for 13.5 MHz and 18 MHz Systems

Table 1a – 4:4:4 Encoding Parameters 13.5 MHz and 18 MHz Systems

Parameters	525-line, 60/1.001 field/s systems		625-line, 50 field/s systems	
Sampling frequency for each signal	13.5 MHz	18 MHz	13.5 MHz	18 MHz
Coded signals	These values are obtained from the gamma pre-corrected signals Y' = 0.299R' + 0.587G' + 0.114B' C'_R = 0.713 (R'--Y') = 0.500R' -- 0.419G' -- 0.081B' C'_B = 0.564 (B'--Y') = 0.500B' -- 0.169R' -- 0.331G'			
Number of samples per total line for Y',C'_B,C'_R,R',G',B'	858 (Active 720)	1144 (Active 960)	864 (Active 720)	1152 (Active 960)
Sampling structure	Orthogonal, line, field and frame repetitive. The three sampling structures to be coincident, and also coincident with the luma sampling structure of the 4:2:2 member.			
Form of coding	Uniformly quantized PCM, 10 bits per sample			
Correspondence between video signal levels and the quantization levels for each sample –Y', R', G', B',	$877_{(10)}$ quantization levels with the black level corresponding to level $64_{(10)}$ and the peak white level corresponding to level $940_{(10)}$			
Each color-difference signal	$897_{(10)}$ quantization levels with zero signal corresponding to level $512_{(10)}$			

4.2 4:2:2 Encoding Characteristics for 13.5 MHz and 18 MHz Systems

Table 1b – 4:2:2 Encoding Parameters 13.5 MHz and 18 MHz Systems

Parameter	Value			
Coded signals:	These values are obtained from the gamma pre-corrected signals Y' = 0.299R' + 0.587G' + 0.114B' C'_R = 0.713 (R'--Y') = 0.500R' -- 0.419G' -- 0.081B' C'_B = 0.564 (B'--Y') = 0.500B' -- 0.169R' -- 0.331G'			
Number of samples per line:	13.5 MHz Sampling 525	625	18 MHz sampling 525	625
– luma (Y')	858 (Active 720)	864 (Active 720)	1144 (Active 960)	1152 (Active 960)
– each color-difference signal (C'_R, C'_B)	429 (Active 360)	432 (Active 360)	572 (Active 480)	576 (Active 480)
– total number of samples	1716	1728	2288	2304
Sampling structure:	Orthogonal: line, field, and frame repetitive; C'_R and C'_B samples are cosited with odd (1st, 3rd, 5th) samples in each line.			
– luma (Y')	13.5 MHz sampling 13.5 MHz		18 MHz sampling 18 MHz	
– each color-difference signal (C'_R, C'_B)	6.75 MHz		9 MHz	
Form of coding	Uniformly quantized PCM 10 bits per sample			
Correspondence between video signal levels and the quantization levels Luma (Y'):	$877_{(10)}$ quantization levels with the black level corresponding to level $64_{(10)}$ and the peak white level corresponding to level $940_{(10)}$			
Color difference signal Levels (C'_R, C'_B):	$897_{(10)}$ quantization levels with zero signal corresponding to level $512_{(10)}$			
Note: *8-bit systems complying with previous versions of this standard can exist*				

Construction of the Luma and color-difference signals contained in tables 1a and 1b shall conform to the detailed text contained in Recommendation ITU-R BT.601, Section 2.

4.3 Analog Horizontal Timing Relationship — 13.5 MHz 4:2:2 (625-Line Values are in Parenthesis)

Figure 1a and Table 1c define the relationship between video signal in the digital and analog domains for 525/625-line systems. Analog Sync shall be as defined in Recommendation ITU-R BT.1700. Figure 1b shows the multiplex structure.

Transmitted during each active line are 1440 multiplexed luma and color-difference values: 720 luma, 360 C'_R, and 360 C'_B values.

Eight of the remaining 276 (288) interface clock intervals are used to transmit synchronizing information; the other 268 (280) interface clock intervals may be used to carry optional ancillary information.

The first of these 1716 (1728) interface clock intervals is designated line word 0 for the purpose of reference only. The 1716 (1728) sample words per total line are therefore numbered 0 through 1715 (1727). Intervals 0 through 1439, inclusive, contain video data. The interface clock intervals occurring during digital blanking are designated 1440 through 1715 (1727).

Intervals 1440 through 1443 are reserved for the (End-Of-Active-video) EAV timing reference described in Section 5.3. Intervals 1712 (1724) through 1715 (1727) are reserved for the (Start-Of-Active-video) SAV timing reference described in Section 5.3.

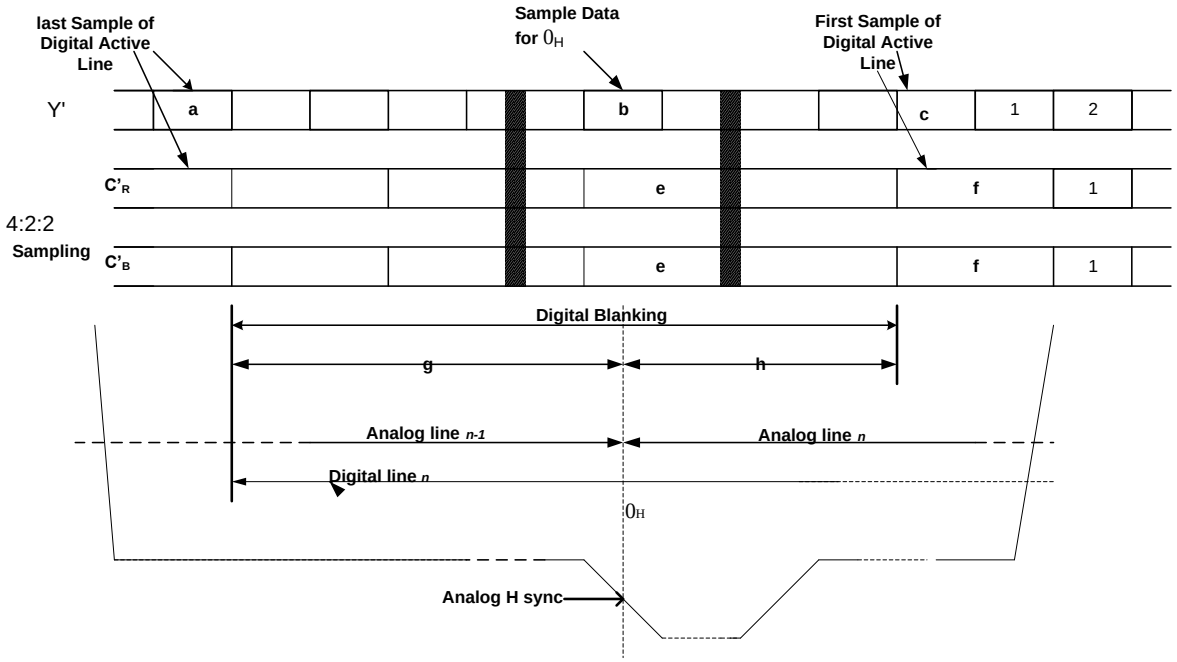


Figure 1a – Analog Horizontal sync relationship

Note: Table 1c provides exact sample numbers for the various standards.

Table 1c – Timing Analog Sync / Digital Sample number

Parameter	13.5 MHz Sampling		18 MHz Sampling	
	525 Lines	625 Lines	525 Lines	625 Lines
a - Last Y' sample- Active line	Sample 719 Note: *Sampling instants are sample Number +1.*		Sample 959 Note: *Sampling instants are sample Number +1.*	
b - 0_H Analog reference	The half-amplitude point of the leading (falling) edge of the analog horizontal sync signal shall be coincident with a Y' sample which would be conveyed by sample 736.	The half-amplitude point of the leading (falling) edge of the analog horizontal sync signal shall be coincident with a Y' sample which would be conveyed by sample 732.	The half-amplitude point of the leading (falling) edge of the analog horizontal sync signal shall fall between samples 981 and 982.	The half-amplitude point of the leading (falling) edge of the analog horizontal sync signal shall be coincident with a Y' sample which would be conveyed by sample 976.
c -First Y' sample- Active line	Sample 0			
d - Last C'_R/C'_B sample- Active line	Sample 359		Sample 479	
e - C'_R/C'_B -0_H analog reference. The Y' sample reference “a” is the normative reference point.	The half-amplitude point of the leading (falling) edge of the analog horizontal sync signal shall be coincident with a C'_R/C'_B sample 368.	The half-amplitude point of the leading (falling) edge of the analog horizontal sync signal shall be coincident with a C'_R/C'_B sample 366.	The half-amplitude point of the leading (falling) edge of the analog horizontal sync signal shall fall between C'_R/C'_B sample 490 and 491.	The half-amplitude point of the leading (falling) edge of the analog horizontal sync signal shall be coincident with C'_R/C'_B sample 488.
f - First C'_R/C'_B sample - active line	Sample 0			
g - Sample period between last active line sample to 0_H	16 T	12 T	21.5 T	16 T
h - 0_H to first active line sample	122 T	132 T	162.5 T	176 T

T= Luma sampling period

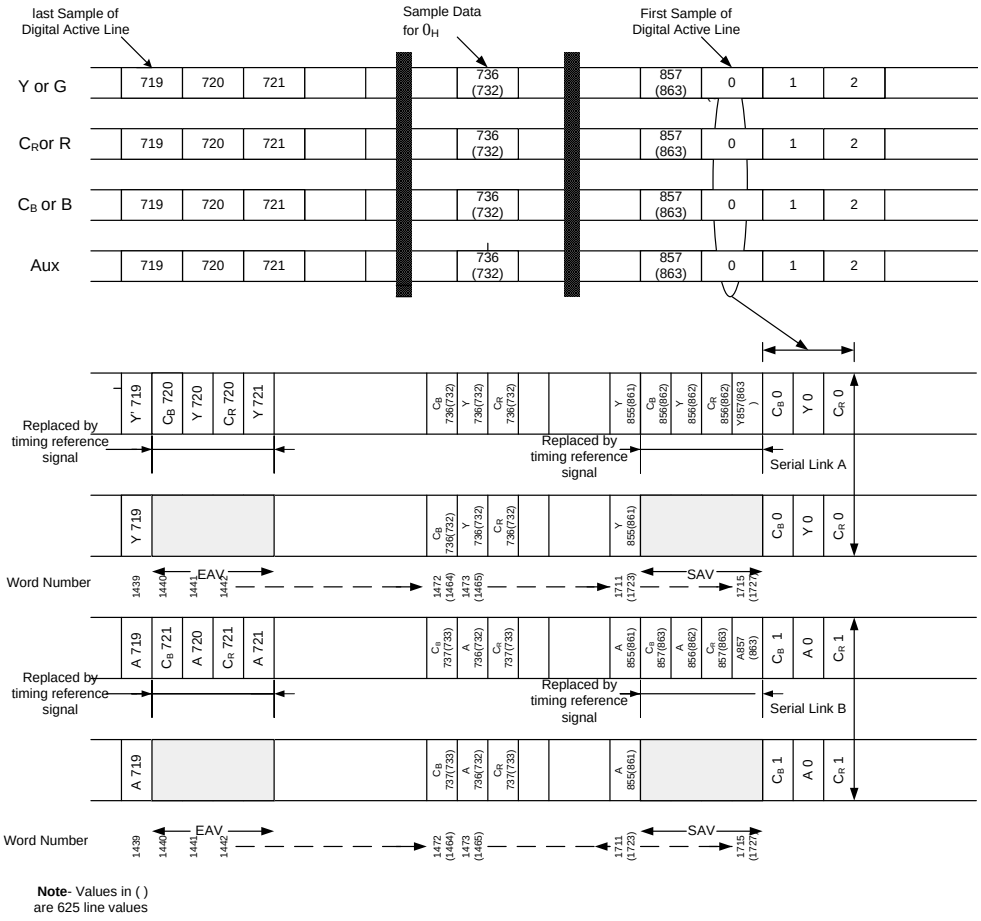


Figure 1b – Multiplex structure — 13.5 MHz sampling

4.4 Analog Horizontal Timing Relationship — 18 MHz 4:2:2 (625-Line Values are in Parenthesis)

Figure 1a shows the relationship between the video signal in the digital and analog domains for 525/625 line systems. Figure 1c shows the multiplex structure.

Transmitted during each active line are 1920 multiplexed luma and color-difference, C'_R/C'_B values, 960 luma, 480 C'_R, and 480 C'_B values.

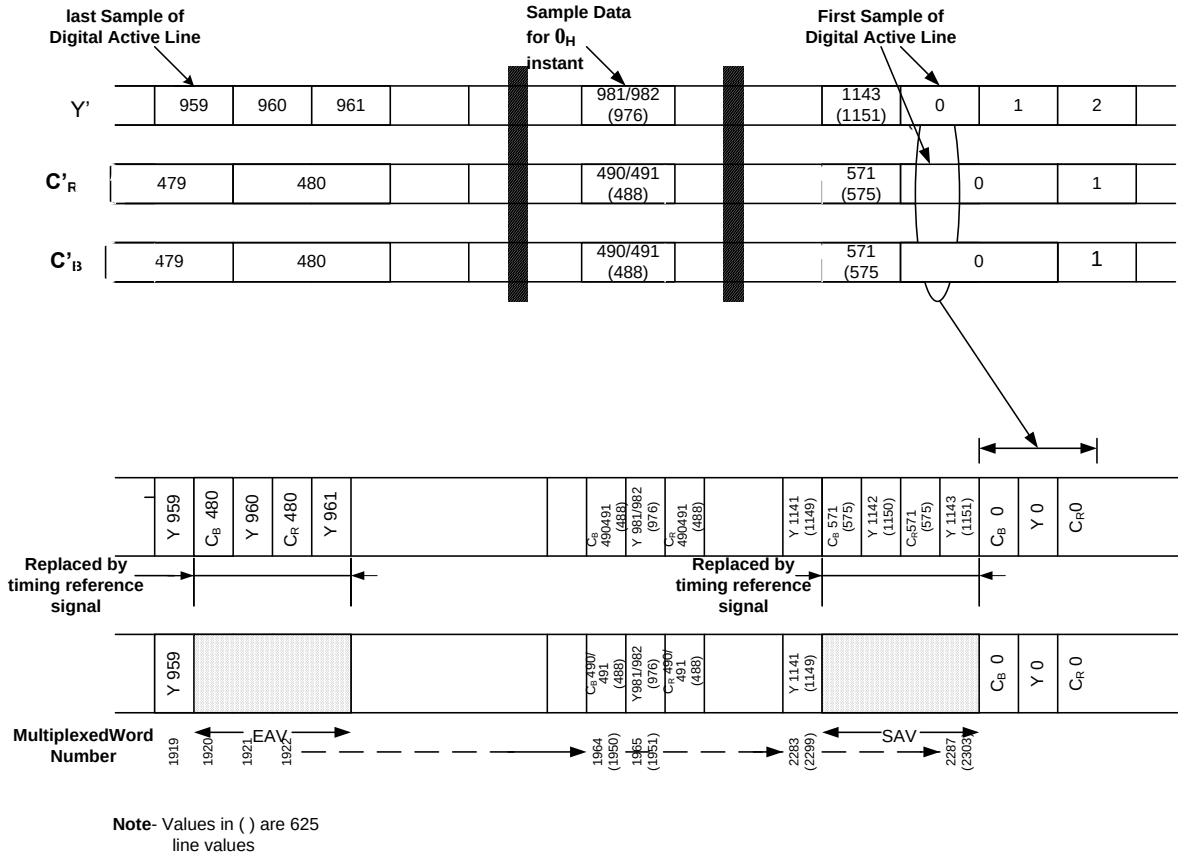
Eight of the remaining 368 (384) interface clock intervals are used to transmit synchronizing information; the other 360 (376) interface clock intervals may be used to carry ancillary information.

The first of these 2288 (2304) interface clock intervals is designated line word 0 for the purpose of reference only. The 2288 (2304) sample words per total line are therefore numbered 0 through 2287(2303). Intervals 0 through 1919, inclusive, contain video data. The interface clock intervals occurring during digital horizontal blanking are designated 1920 through 2287 (2303).

Intervals 1920 through 1923 are reserved for the EAV timing reference described in Section 5.3. Intervals 2284 (2300) through 2287 (2303) are reserved for the SAV timing reference described in Section 5.3.

The half-amplitude point of the leading (falling) edge of the analog horizontal sync signal shall be halfway between the sample points that would be conveyed by luma samples 981 and 982 if carried across the interface for 525 line systems. The 0_H point for 625 line systems falls on sample 976.

Note: The 0_H sampling point is determined by maintaining the exact center of the picture between 13.5 MHz and 18 MHz sampling systems.



Note- Values in ( ) are 625 line values

Figure 1c – Multiplex structure 18 MHz sampling

5 Video Data Signal Format

The definitions contained in this section refer to the signal format of a virtual parallel interface. In previous revisions of this standard a physical parallel interface was defined.

Current practice is for the serial interface defined in SMPTE ST 259 to be the preferred interface. The virtual parallel interface signal format shall be the source of the signal data for the serial interface. The virtual parallel interface shall have the same data format as that of the physical parallel interface.

Data lines of the virtual parallel interface are designated DATA (0) through DATA (9). The group of 10 signals is identified by placing parentheses around the range of subscripts included, as DATA (0-9). When 8-bit signals are conveyed by the virtual parallel interface, DATA (2-9) shall be used and DATA (0-1) shall be set to zero. DATA (9) is always the most significant bit.

Note: Monochrome operation at 30/1.001 Hz or 25 Hz frame rate can be achieved by setting the color-difference signals C'_B and C'_R to $200h_{(10)}$.

5.1 Data Signal Format

Data is transmitted across the virtual interface on 10 data pairs: DATA (0-9). DATA (9) is the most significant bit (MSB) of the $1024_{(10)}$ levels, $1016_{(10)}$ are used to express quantized signal values (digital levels $4_{(10)}$ through $1019_{(10)}$ or 004h through 3FBh in the hexadecimal representation) of the 10-bit word. Digital levels $0_{(10)}$ to $3_{(10)}$ and $1020_{(10)}$ to $1023_{(10)}$ (000h to 003h and 3FCh to 3FFh in the hexadecimal representation) indicate timing references.

5.2 Multiplex Structure

The video data words shall be conveyed as a 27 Mword/s multiplex for 13.5 MHz sampling and 36 Mword/s multiplex for 18 MHz in the following order:

$$C'_B\ Y'\ C'_R\ [Y']\ C'_B...$$

where the three words $C'_B\ Y'\ C'_R$ refer to cosited samples, the following word [Y'] being an isolated luma-only sample. The C'_B and C'_R samples are cosited with the first and subsequent alternate Y' samples (0, 2, 4...) on each line. (See figures 1b and 1c.) The first video data word in each active line period shall be C'_B.

5.3 Timing Reference Signals — Video

Figure 1c and Table 1c define the position of the timing reference signals with respect to horizontal blanking in the multiplexed data stream. It is implicit that the timing reference signals are contiguous with the video data, when present, and continue through the vertical blanking interval.

Each timing reference signal consists of a four-word hexadecimal sequence in the following format:

3FF 000 000 XYZ

Note: Because of the existence of both 8-bit and 10-bit data implementations, for detection purposes all values in the ranges 000h-003h and 3FCh-3FFh are considered equivalent to 000h and 3FFh, respectively.

The first three words are a fixed preamble. The fourth word shall contain information defining:

- even field {field 2} identification;
- state of vertical blanking;
- state of horizontal blanking.

Figure 2 is a spatial representation of the timing reference signals during a television frame. Assignment of bits within the fourth word is shown in Table 3. Values for F and V change in the EAV associated with the blanking interval of the line number indicated. P0, P1, P2, and P3 have states dependent on states of bits F, V, and H according to Table 3. Lines are numbered from 1 through 525(625) as shown in Figure 2. Vertical blanking in the digital interface is in full-line increments. EAV and SAV are the digital horizontal synchronization signals and occur on every line.

Line numbers for 525/625 systems are defined by Recommendation ITU-R BT.1700.

The interval starting at EAV and ending with SAV is the digital horizontal blanking period as shown in Figure 2.

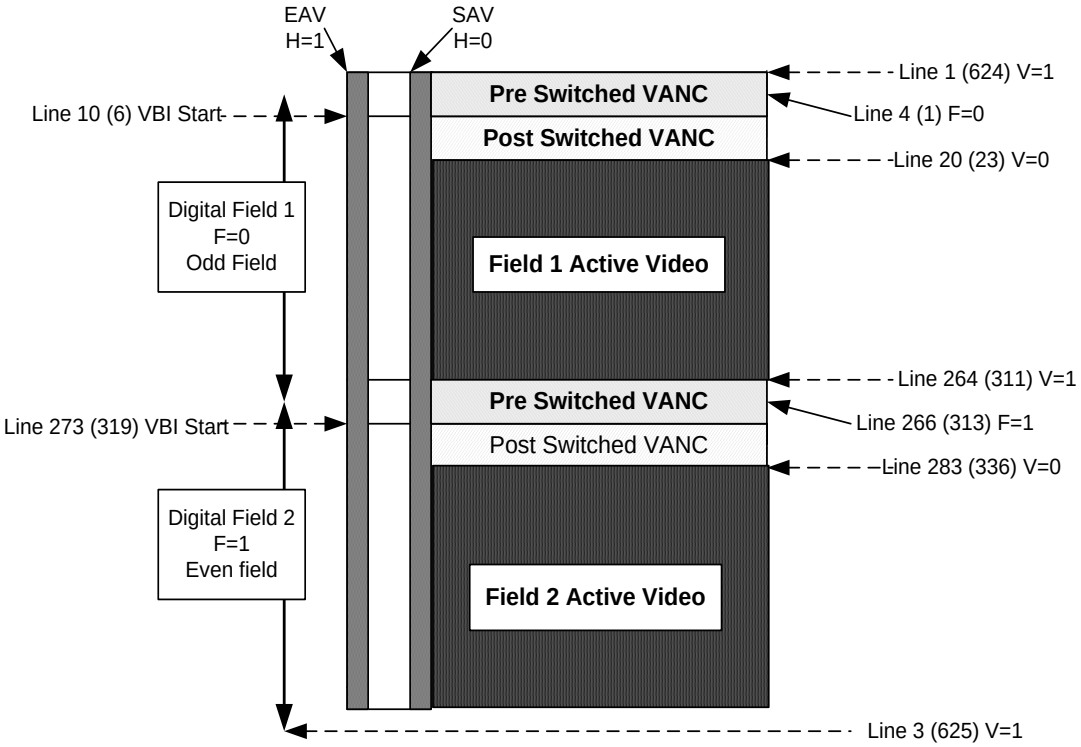


Figure 2 -- Timing reference signal, Payload and ANC data locations

5.4 Active Video Payload

The active video payload consists of the video signal to be displayed. The active payload shall have the following formatting and timing characteristics as defined in Table 2.

Table 2 – Video Payload Timing and formatting

System	525		625	
Value	13.5 MHz	18 MHz	13.5 MHz	18 MHz
0_H to picture center in µ sec (Derived value)	35.666		36.407	
Active line number of samples	720	960	720	960
Horizontal sample number prior to picture center	359	479	359	479
Horizontal sample number following picture center	360	480	360	480
Range of active lines	Field 1 20-263 Field 2 283-525		Field 1 23-310 Field 2 336-623	
Picture center Vertical location	The center point is between Field 2, Line 404 and Field 1, Line 142		The center point is between Field 1, Line, 167 and Field 2, Line 480	
Source Pixel Array	720x485	960x485	720x576	960x576

Table 3 – Timing reference signals

Bit number	First Word FFF	Second Word 000	Third Word 000	Fourth Word XYZ	
9	1	0	0	1	Fixed
8	1	0	0	F	F = 0 during field 1
					F = 1 during field 2
7	1	0	0	V	V = 0 during active video
					V = 1 during vertical blanking
6	1	0	0	H	H = 1 for EAV H = 0 for SAV
5	1	0	0	P3	
4	1	0	0	P2	
3	1	0	0	P1	See Table 4
2	1	0	0	P0	
1	1	0	0	0	
0	1	0	0	0	

Notes:

1 Some equipment can only sense the eight most significant bits.

2 The H, V, and F bits (bits 6-8) provide all the necessary information. Bits 2-5 provide error detection and correction information.

3 The protection bits allow correction of all single-bit errors and detection of two-bit errors.

Table 4 – Protection bit states

Bit 9	8	7	6	5	4	3	2	1	0
	F	V	H	P3	P2	P1	P0		
1	0	0	0	0	0	0	0	0	0
1	0	0	1	1	1	0	1	0	0
1	0	1	0	1	0	1	1	0	0
1	0	1	1	0	1	1	0	0	0
1	0	0	0	0	1	1	1	0	0
1	0	0	1	1	0	1	1	0	0
1	1	1	0	1	1	0	0	0	0
1	1	1	1	0	0	0	1	0	0

6 Ancillary data signal format- optional

Ancillary data may be inserted in any portion of the virtual parallel interface not occupied by timing reference signals or active video data (see Sections 6.1, 6.2, and 6.3). Data carried within horizontal blanking is termed “HANC data” and data carried within the active line portion of vertical blanking period is termed “VANC data”. Carriage of ancillary data in the ancillary data space is as described in SMPTE ST 291-1.

Note: Those areas are commonly referred to as “HANC data space” and “VANC data space.”

Small blocks of data, less than 268 (280) words in total length for 13.5 MHz sampling and 360 (376) words in total length for 18 MHz sampling, including the HANC data header sequence (as described in Section 6.1), can be transmitted within the horizontal blanking period on every line.

VANC data may be inserted in lines 1-19 and 264-282 for 525 Line systems, and lines 624-22 and 311-335 for 625 line systems. Large blocks of data, up to 1440 words in total length for 13.5 MHz sampling and up to 1920 words in total length for 18 MHz sampling, including the VANC data header, may be transmitted within the interval starting with the end of SAV and terminating with the beginning of EAV.

The VANC data space is divided into two sectors, Pre-Switched VANC data space, and Post-Switched VANC data space, excluding two lines (the switching line and the following line).

The Pre-Switched VANC data space is intended to convey information linked to the video or audio preceding the line of the switch point.

The post-switched VANC data space is intended to convey information linked to the video or audio following the next line of the switch point.

For 525-line systems, the switch point shall be lines 10 and 273, for 625-line systems shall be lines 6 and 319.

Data words not used to transmit ancillary data shall have the following values:

-- words corresponding to Y' samples shall have the value 040h;

-- words corresponding to C'_B and C'_R samples shall have the value 200h.

6.1 Digital Vertical Interval Time Code and Video Index — Optional

The use of Digital Vertical Interval Time Code (DVITC) and Video index are deprecated in favor of SMPTE ST12-2 ATC and SMPTE ST 2016 AFD, respectively. New implementations should use those methods.

6.1.1 DVITC

This signal, if present, is carried by the luma data in the active portion of lines 14(19) and 277(332).

6.1.2 Video Index

This signal, if present, is carried by the color-difference data in the active portion of lines 14(19) and 277(332)[1] A total of 90 8-bit data words is represented serially by DATA (2) of the 720 color-difference samples of the active portion of the line for 13.5 MHz sampling. A total of 90 8-bit data words are represented serially by DATA (2) of the 960 color-difference samples of the active portion of the line for 18 MHz sampling.

The first color-difference word of the active portion of the line (word 0 of the multiplexed signal, normally a C'_B sample) represents the least significant bit (bit 0) of video index word 0. The second color-difference word represents bit 1 of the same word, etc. The last color-difference word of the active portion of the line (word 1438 of the multiplexed signal, normally a C'_R sample) represents the most significant bit (bit 7) of video index word 89 for 13.5 MHz sampling.

The color-difference word 1438 of the active portion of the multiplexed signal (normally a C'_R sample) represents the most significant bit (bit 7) of video index word 89 for 18 MHz sampling.

For all samples, a value of $204h_{(10)}$ represents a binary one for the appropriate video index bit, and a value of $200_{(10)}$ represents a binary zero for the appropriate video index bit.

[1] Some legacy equipment might not use the recommended lines for carriage of DVITC and Video index.

7 Standard Compliance

Any published material indicating compliance with this standard should be written in such a manner that the sampling structure, sampling rate, and line rate standards supported are indicated.

Annex A Bibliography (Informative)

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 12-1:2008) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 12M-1-2008). Documents with the same root number (e.g. 12-1) and publication year (e.g. 2008) are functionally identical.

SMPTE ST12-1:2008, Television — Time and Control Code

SMPTE ST12-2:2008, Television — Transmission of Time Code in the Ancillary Data Space

SMPTE ST 170-2004, Television — Composite Analog Video Signal- NTSC for Studio Applications

SMPTE ST 259-2008, Television — SDTV Digital Signal/Data Serial Digital interface

SMPTE ST 266:2012, SD 4:2:2 Digital Component Systems — Digital Vertical Interval Time Code

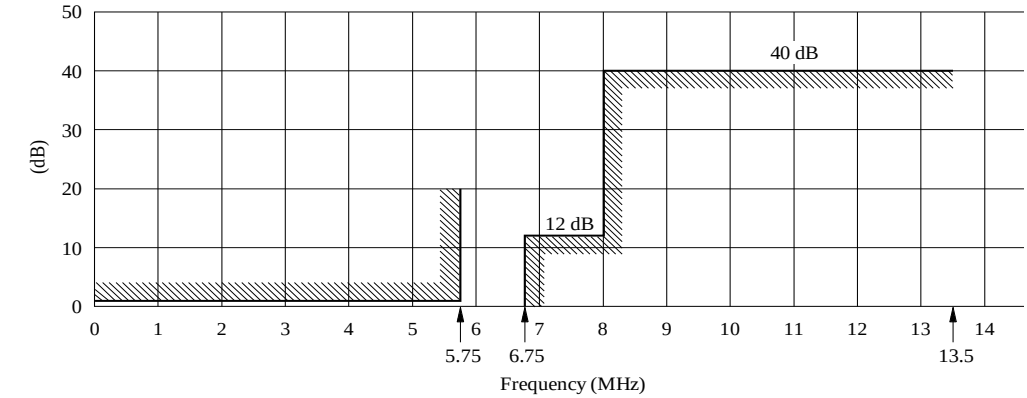
SMPTE ST 291-1:2011, Ancillary Data Packet and Space Formatting

SMPTE RP 168:2009, Definition of Vertical Interval Switching Point for Synchronous Video Switching

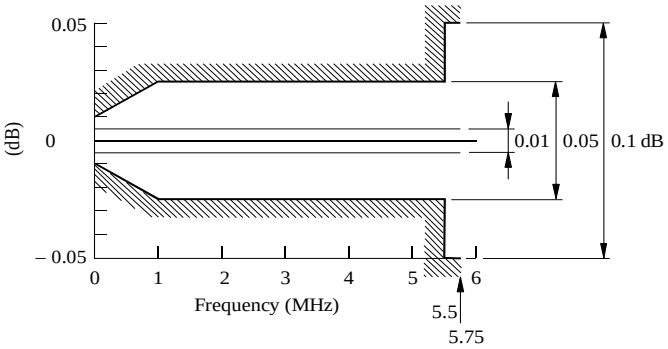
Recommendation ITU-R BT.799-4, Interface for Digital Component Video Signals in 525-Line and 625-Line Television Systems Operating at the 4:4:4 Level of Recommendation ITU-R BT.601

SECTION XIII – SMPTE ENGINEERING Operations Manual, August 2013

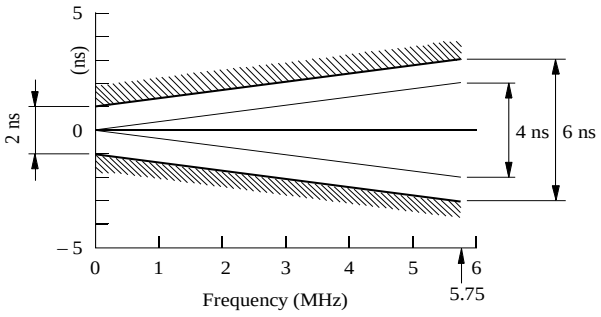
Annex B Filter Templates (Informative)



a) Template for insertion loss/frequency characteristic



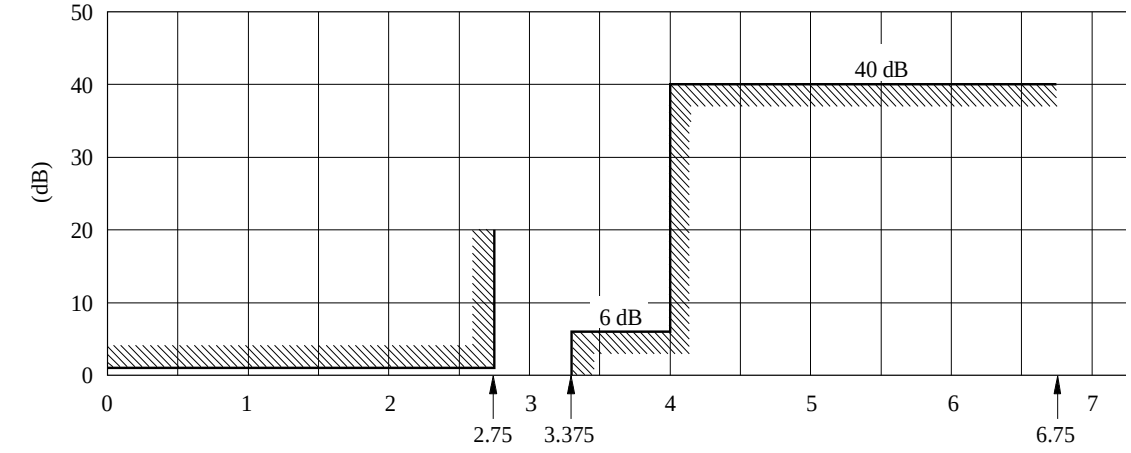
b) Passband ripple tolerance



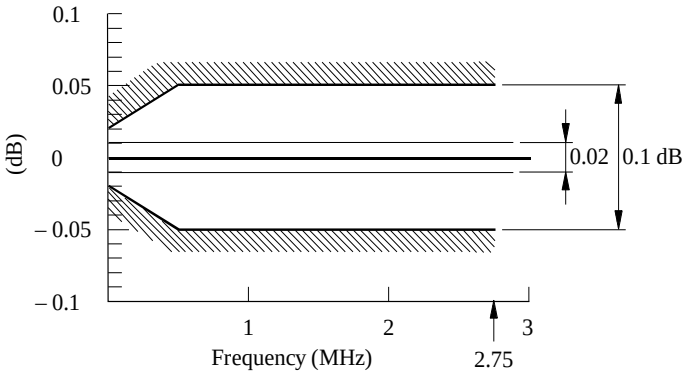
c) Passband group-delay tolerance

Note 1 – The lowest indicated values in b) and c) are for 1 kHz (instead of 0 MHz).

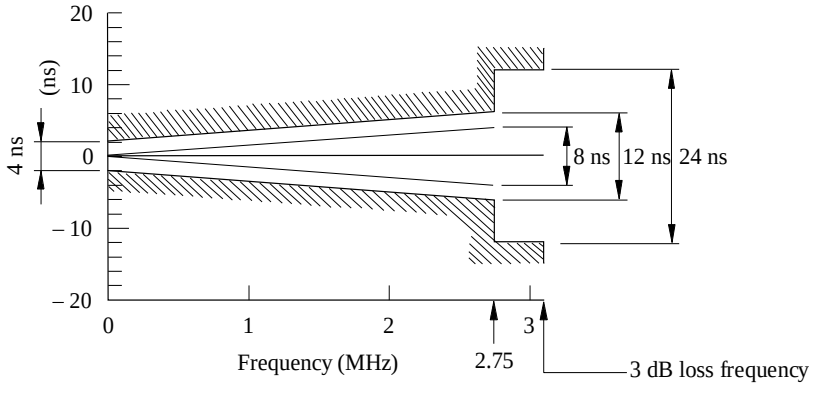
Figure B.1 – R',G',B',Y' filtering Characteristics for 13.5 MHz Systems



a) Template for insertion loss/frequency characteristic



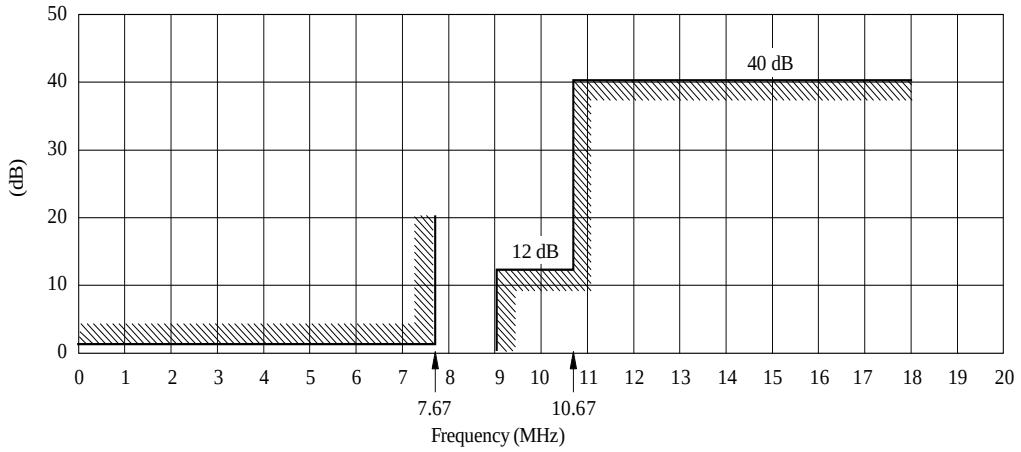
b) Passband ripple tolerance



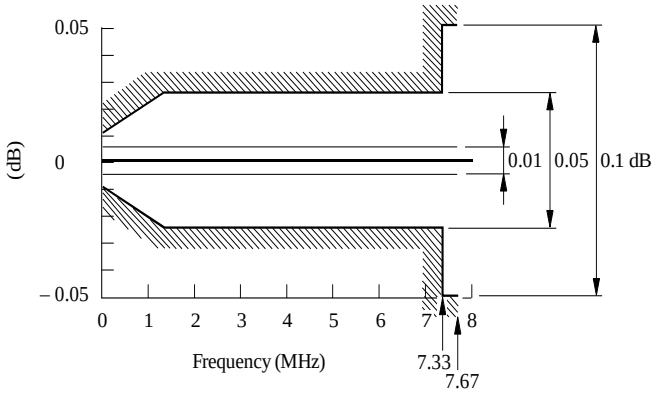
c) Passband group-delay tolerance

Note 1 – The lowest indicated values in b) and c) are for 1 kHz (instead of 0 MHz).

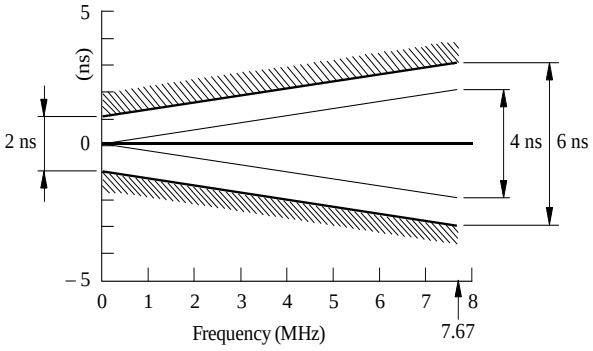
Figure B.2 – Color-Difference Signal filtering Characteristics for 6.75 MHz



a) Template for insertion loss/frequency characteristic



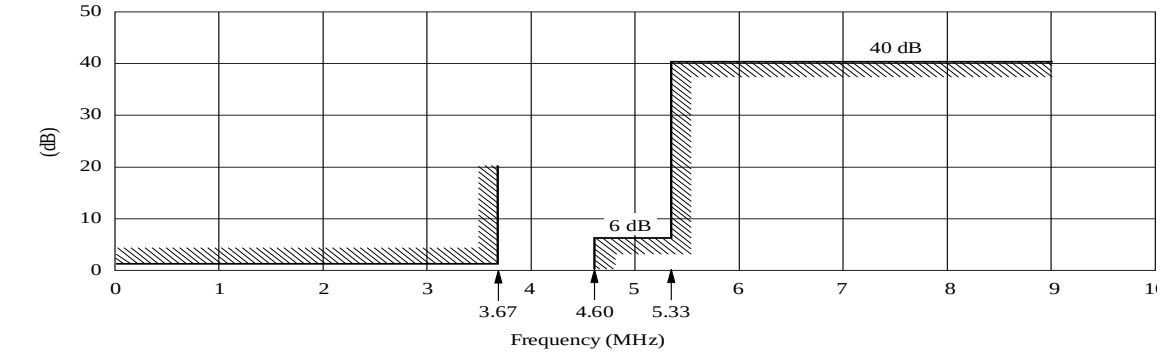
b) Passband ripple tolerance



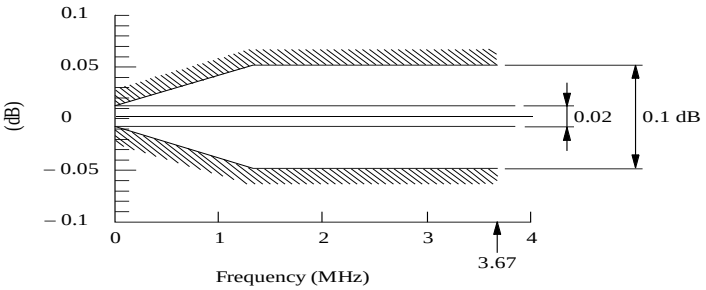
c) Passband group-delay tolerance

Note 1 – The lowest indicated values in b) and c) are for 1 kHz (instead of 0 MHz).

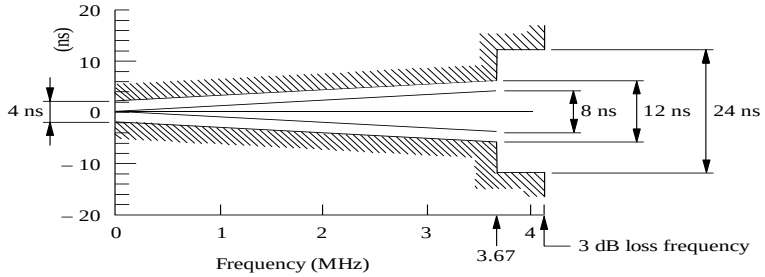
Figure B.3 – R',G',B', Y' filter Characteristics Sampling at 18 MHz



a) Template for insertion loss/frequency characteristic



b) Passband ripple tolerance



c) Passband group-delay tolerance

Note 1 – The lowest indicated values in b) and c) are for 1 kHz (instead of 0 MHz).

Figure B. 4 – Color-Difference signal filter characteristics for 9 MHz

Annex C Error Detection and Correction in the Video Timing Reference Signal
(Informative)

Table C.1 enables single-bit errors in the fourth code words of EAV and SAV to be corrected. Double errors, and some multiple bit errors, are detected but not corrected. The table gives corrected values for bits 8, 7, and 6 where possible. Multiple errors are denoted by asterisks.

Table C.1 – Correction of single-bit errors in the fourth code words of EAV and SAV

Received P3 – P0	Received bits 8, 7, and 6 (F, V, and H)							
	000	001	010	011	100	101	110	111
0000	000	000	000	*	000	*	*	111
0001	000	*	*	111	*	111	111	111
0010	000	*	*	011	*	101	*	*
0011	*	*	010	*	100	*	*	111
0100	000	*	*	011	*	*	110	*
0101	*	001	*	*	100	*	*	111
0110	*	011	011	011	100	*	*	011
0111	100	*	*	011	100	100	100	*
1000	000	*	*	*	*	101	110	*
1001	*	001	010	*	*	*	*	111
1010	*	101	010	*	101	101	*	101
1011	010	*	010	010	*	101	010	*
1100	*	001	110	*	110	*	110	110
1101	001	001	*	001	*	001	010	*

Annex D Data Formatting for 4:4:4:4 Component Video Signals (Dual Link)
(Normative)

D.1 Overview

This Annex describes a means of interconnecting digital video equipment via 2 serial digital interfaces operating in the 525/60[2] or 625/50 mode and complying with the 4:4:4 sampling and encoding parameters, with a nominal sampling frequency of 13.5 MHz. Provision is made to carry a fourth, auxiliary, channel as part of the signal multiplex, yielding 4:4:4:4 (or 4x4) overall.

The interface is primarily defined to convey signals having luma, color difference, and auxiliary components. Signals having green, red, blue, and auxiliary components may be conveyed alternatively. This is a 10-bit interface, however, provision has been made to interconnect all signals with 8 or 10-bit precision.

The interface consists of two unidirectional interconnections between one device and another. These interconnections carry the data corresponding to the television signal and associated data. The two interconnections are referred to as link A and link B. Link A carries all the main channel luma samples plus those C'_B and C'_R samples which are located at even-numbered sample points. Link B contains the samples of the auxiliary channel (most commonly used for, but not restricted to, key signal information) and the C'_B and C'_R samples from the odd-numbered sample points.

Although it is common to refer to link A as 4:2:2 and link B as 2:2:4, it must be noted that link A is not a true 4:2:2 signal because the color-difference data it contains were sampled at 13.5 MHz to obtain a 4x4 signal, rather than at 6.75 MHz as specified in this standard. Therefore, if an attempt is made to use link A as a conventional 4:2:2 signal, there can be aliasing in the subsampled color-difference signals. This quasi-4:2:2 channel could be used for non-critical monitoring, the full 4x4 signal must be correctly filtered and subsampled before critical use.

D.2 4x4 Component Signal Source

The input source for generating the two component digital signals shall be a 4x4 signal as described in this standard and sampled at 13.5 MHz. The fourth, auxiliary channel is considered to be a Y' or G channel. See Table 1a of this standard for 13.5 MHz data formatting details.

The samples of each of the four signals shall be cosited at each of the 858 sample points on every line for 525 line signals, and 864 sample points for 625 line signals.

D.3 Analog Waveform to Digital DataTiming Relationship — 525 Lines (625)

D.3.1 Samples

3432 (3456) samples form a complete horizontal line. For the active period of the line, 2880 samples are obtained. These samples consist of 720 samples each of the Y', C'_B, C'_R, and A (auxiliary) signals. The points are designated 0-857 and the individual samples are designated by suffixes such as ‘‘sample 135C'_R’’ or ‘‘sample 429Y'’.

[2] The field rate is 60/1.001.

D.3.2 Data Streams

The 3432(3456) total samples are separated into two data streams, each consisting of 1716(1728) samples, 1440 of which represent the active line area. Link A's data stream contains all the Y' channel samples plus the even-numbered (0, 2, 4, etc.) samples from the C'_B and C'_R channels. Link B's data stream contains the odd numbered (1, 3, 5, etc.) samples from the C'_B and C'_R channels plus all the A-channel samples (see Figure D.1).

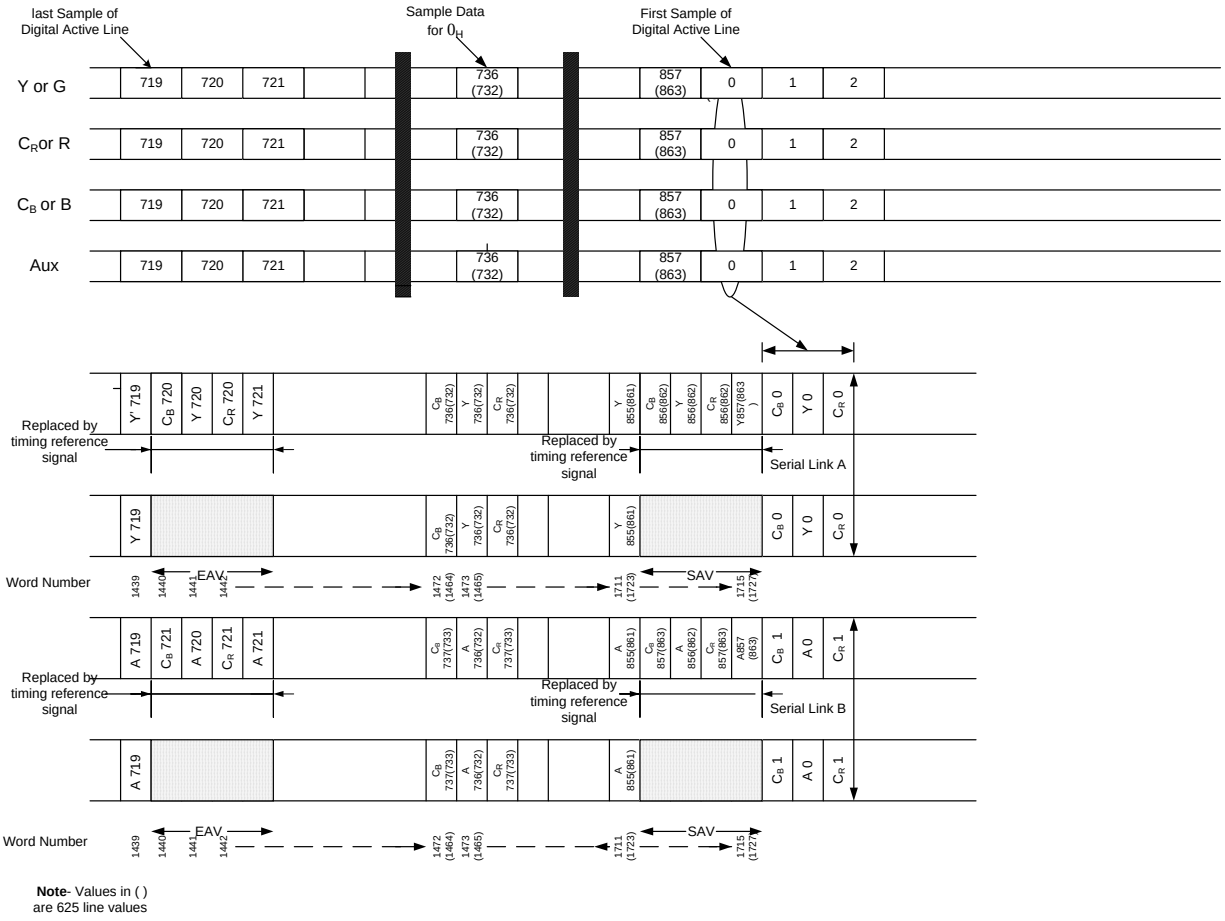


Figure D.1 – Multiplex Structure 525 Lines (625 Lines)

D.3.3 Clock Intervals

Each horizontal line contains 1716 (1728) clock intervals, 1440 in the active video area and 276 (288) in horizontal blanking. The first of these 1716 (1728) clock intervals is designated line word zero for purposes of reference only. The 1716 (1728) sample points per line are numbered 0-1715 (0-1727). Intervals 0-1439, inclusive, contain active video. The interface clock intervals occurring during digital horizontal blanking are designated 1440-1715 (1449-1728). Eight clock intervals in horizontal blanking are used to transmit synchronizing information. The remaining 268 (280) interface clock intervals may be used to carry optional

ancillary information. Intervals 1440-1443 are reserved for the EAV timing reference. Intervals 1712-1715 (1724-1727) are reserved for the SAV timing reference as described in Section 5.3.

D.3.4 Horizontal Sync Relationship

Defined by Section 4.3 of this standard.

D.3.5 Line Numbering in the Digital Picture Frame

Figure 2 of this standard shows the relationship between the line numbers in the digital picture frame and the digital signaling.

D.3.6 Multiplex Structure

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

Link A data stream: $0C'_B$, 0Y', $0C'_R$, 1Y', $2C'_B$, 2Y', $2C'_R$, 3Y'

Link B data stream: $1C'_B$, 0A, $1C'_R$, 1A, $3C'_B$, 2A, $3C'_R$, 3A

See Figures D.2 and D.3.

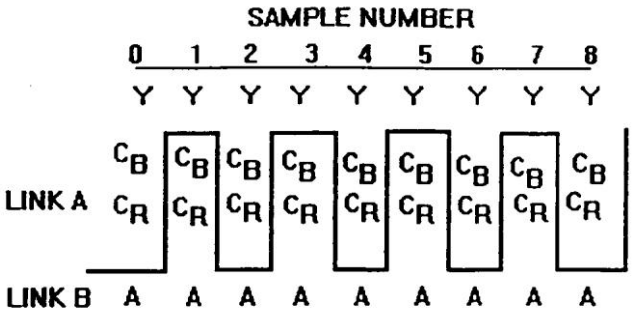


Figure D.2 – Link content representation for Y', C'_B, C'_R, A

D.4 Timing Reference Signals — Video

D.4.1 Position

Figure D.1 shows the position of the timing reference signals with respect to horizontal blanking in the multiplexed data stream. It is implicit that the timing reference signals are contiguous with the video data, when present, and continue through the vertical blanking interval.

Each timing reference signal consists of a four-word sequence in the following format: 3FF 000 000 PQR. The first three words are a fixed preamble. The fourth word shall contain information defining even field (field 2) identification.

D.4.2 Signal Timing Considerations

The timing differential between the two links should not exceed 400 ns at the source. This differential should be taken into consideration when designing systems and destination equipment input stages.

D.4.3 Auxiliary Signal

If the auxiliary (A) signal is not used, the values of the auxiliary channel samples should all be set to black ($64_{(10)}$). If the auxiliary channel is used for a key signal, that signal shall conform to SMPTE RP 157.

D.5 GBRA Signals

D.5.1 Multiplex Structure

When GBRA signals are present, the samples shall be located as follows:

– The G signal shall occupy the Y sample locations.

– The B signal shall occupy the C_B sample locations.

– The R signal shall occupy the C_R sample locations.

– The A signal shall occupy the A sample locations.

Link A data stream: 0B, 0G, 0R, 1G, 2B, 2G, 2R, 3G

Link B data stream: 1B, 0A, 1R, 1A, 3B, 2A, 3R, 3A

See Figure D.3.

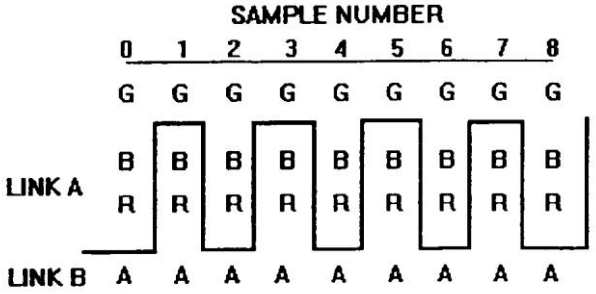


Figure D.3 – Link content representation for GBRA

Annex E Possible Implementations — Encoding/Decoding Matrices (Informative)

Figures E.1 and E.2 show possible implementations of encoding and decoding matrices for the luma and color difference components.

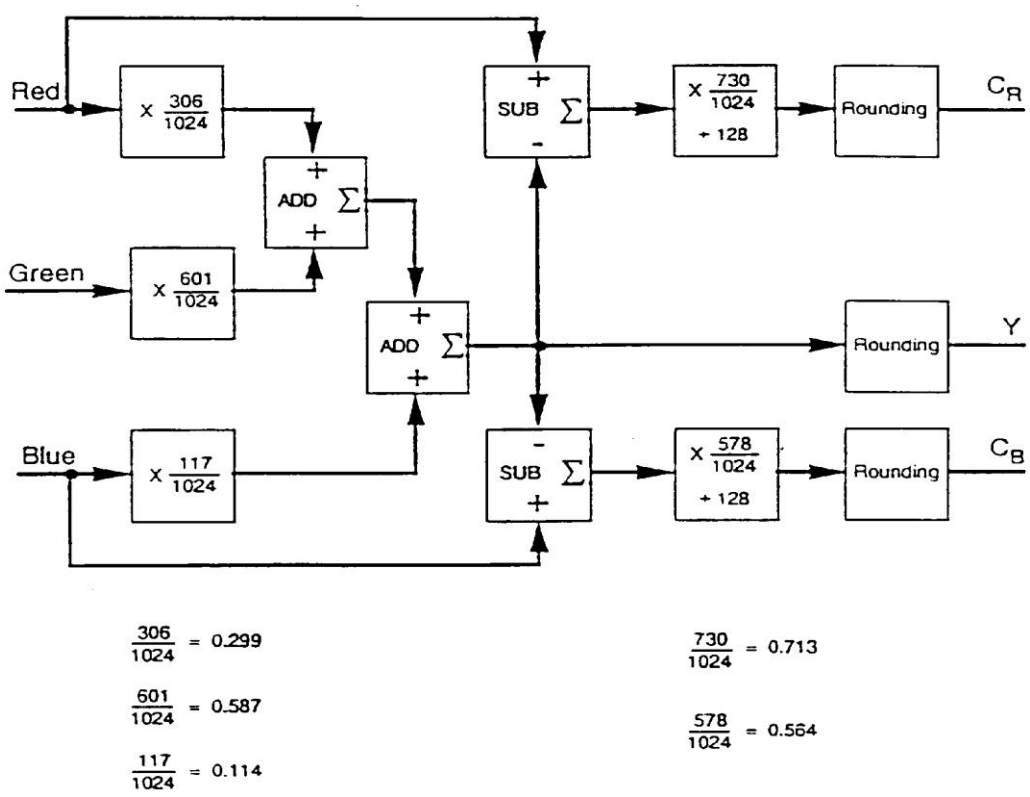


Figure E.1 – Matrix G', B', R' / Y', C'_B, C'_R

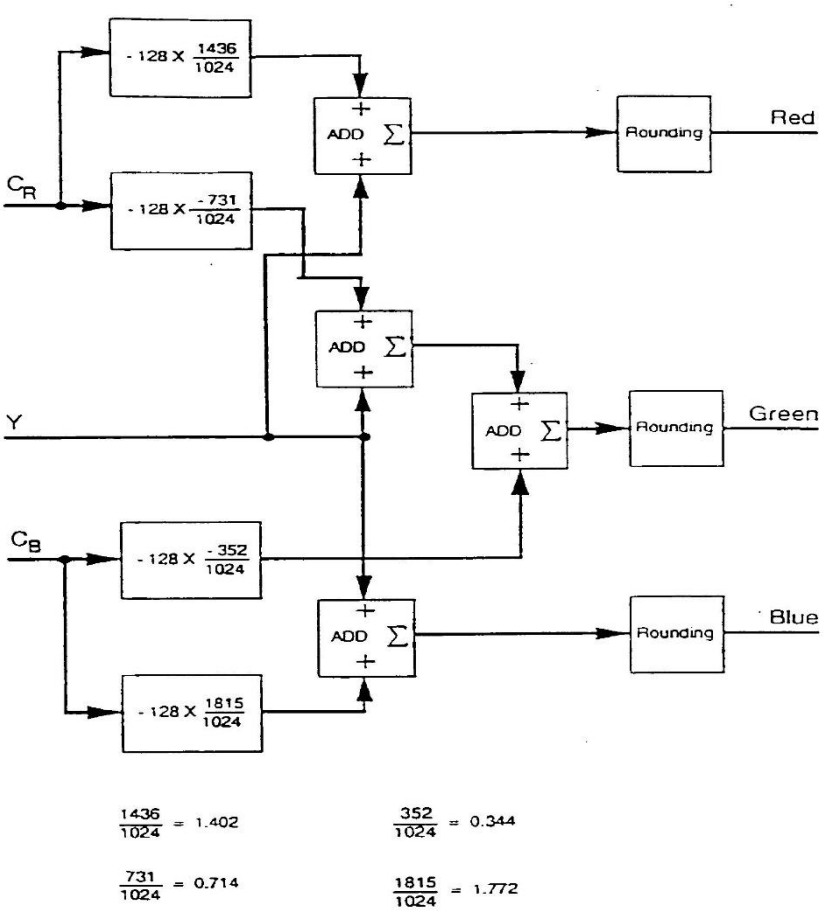


Figure E.2 – Matrix Y', C'_B, C'_R / G', B', R'