

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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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	
	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.

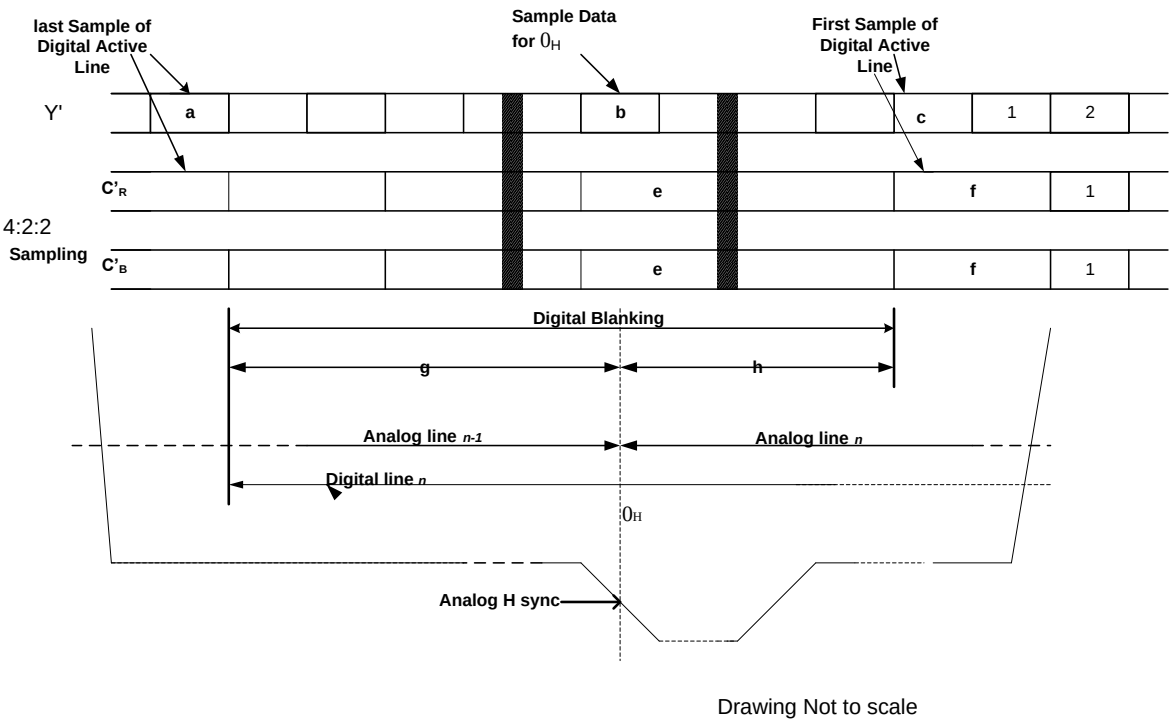


Figure 1a – Analog Horizontal sync relationship

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: <i>Sampling instants are sample Number +1.</i>		Sample 959 Note: <i>Sampling instants are sample Number +1.</i>	
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

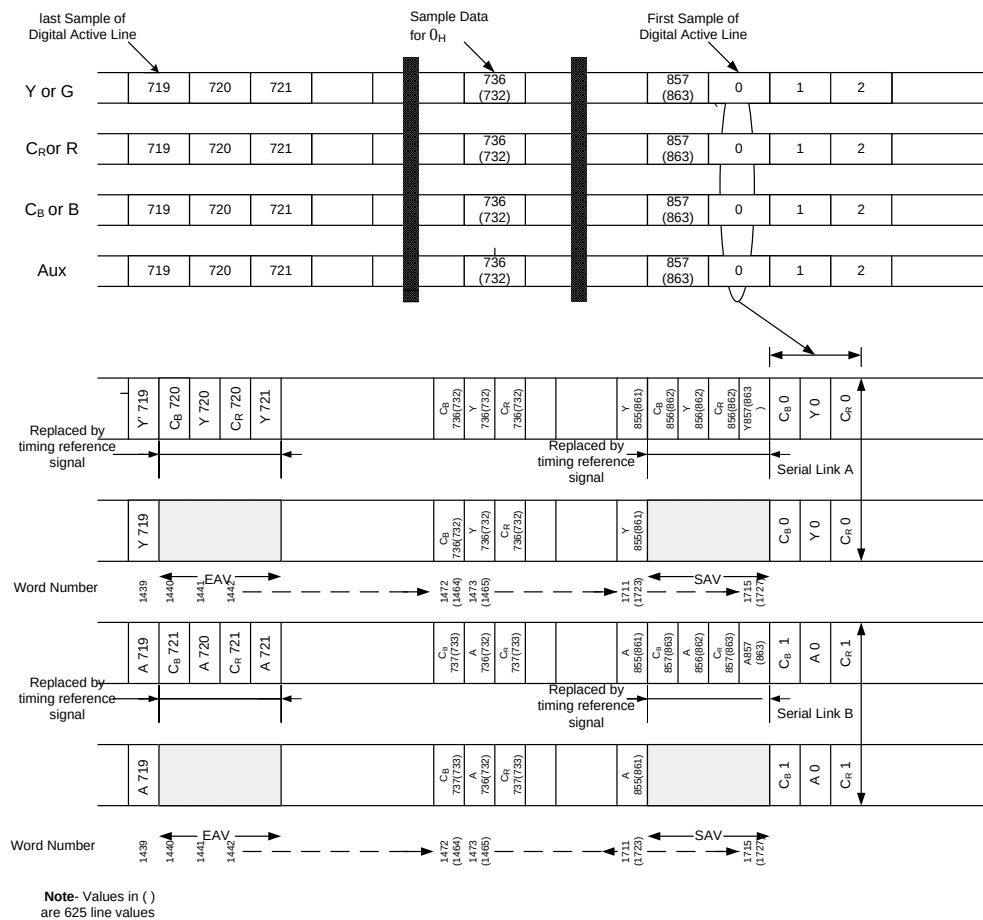


Figure 1b – Multiplex structure — 13.5 MHz sampling

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.