

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



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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally recognized standard 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.

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SMPTE Standard 274M was prepared by Technology Committee N26.

1 Scope

1.1 This standard defines a family of image sample structures for the representation of stationary or moving two-dimensional images sampled temporally at a constant frame rate and having an image format (sample structure) of 1920 x 1080 and an aspect ratio of 16:9 as given in Table 1. This standard specifies:

- R'G'B' color encoding;
- R'G'B' analog and digital representation;
- Y'P'_BP'_R color encoding, analog representation and analog interface; and
- Y'C'_BC'_R color encoding and digital representation

An auxiliary component A may optionally accompany R'G'B' and Y'C'_BC'_R; these interfaces are denoted R'G'B'A and Y'C'_BC'_R A. The "A" component if present shall have the same characteristics as the Y' or G' channel.

1.2 This standard specifies multiple frame and field rate formats (Table 1) and eight-bit, ten-bit and twelve-bit systems. It is not necessary for an implementation to support all formats to be compliant with this standard. However, an implementation must state which of the formats are supported. Interfaces for twelve-bit systems require more than a single link.

NOTE – For international program interchange, constrained parameters as defined in ITU-R BT 709 shall be used.

1.3 Annex A of this standard defines the segmented frame interface for progressive signals using the 1920x1080 sampling structure.

Table 1 – Image sample structure and frame rates

System No.	System nomenclature	Luminance or R'G'B' samples per active line (S/AL)	Active lines per frame (AL/F)	Frame rate (Hz)	Interface sampling frequency fs (MHz)	Luminance sample periods per total line (S/TL)	Total lines per frame
1	1920 x 1080/60/P	1920	1080	60	148.5	2200	1125
2	1920 x 1080/59.94/P	1920	1080	$\frac{60}{1.001}$	$\frac{148.5}{1.001}$	2200	1125
3	1920 x 1080/50/P	1920	1080	50	148.5	2640	1125
4	1920 x 1080/60/I	1920	1080	30	74.25	2200	1125
5	1920 x 1080/59.94/I	1920	1080	$\frac{30}{1.001}$	$\frac{74.25}{1.001}$	2200	1125
6	1920 x 1080/50/I	1920	1080	25	74.25	2640	1125
7	1920 x 1080/30/P	1920	1080	30	74.25	2200	1125
8	1920 x 1080/29.97/P	1920	1080	$\frac{30}{1.001}$	$\frac{74.25}{1.001}$	2200	1125
9	1920 x 1080/25/P	1920	1080	25	74.25	2640	1125
10	1920 x 1080/24/P	1920	1080	24	74.25	2750	1125
11	1920 x 1080/23.98/P	1920	1080	$\frac{24}{1.001}$	$\frac{74.25}{1.001}$	2750	1125

NOTE – Throughout this standard, references to signals represented by a single letter, e.g., R', G' and B', are equivalent to the nomenclature in earlier documents of the form E'_R, E'_G, and E'_B, which, in turn, refer to signals to which the transfer characteristics given in Section 6 have been applied. Such signals are commonly described as being gamma corrected.

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.

3 Normative References

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

CIE Publication 15:2004, Colorimetry, Third Edition

IEC 61169-8 (2007-02)¹, Radio Frequency Connectors, Part 8: Sectional Specification — R.F. Coaxial Connectors with Inner Diameter of Outer Conductor 6,5 mm (0,256 in) with Bayonet Lock — Characteristics Impedance 50 Ohm (Type BNC), Annex A (Normative) — Information for Interface Dimensions of 75 Ohm Characteristic Impedance Connector with Unspecified Reflection Factor

SMPTE 291M-2006, Television — Ancillary Data Packet and Space Formatting

SMPTE RP 160-1997, Three-Channel Parallel Analog Component High-Definition Video Interface

¹ Please note that the title of this normative reference may be misleading. This standard requires the use of the 75-ohm connector defined in this reference.

4 General

4.1 The specification of a system claiming compliance with this standard shall state:

- which of the systems of Table 1 are implemented;
- which of the signal interfaces are implemented ($R'G'B'$, $Y'P'_BP'_R$, $Y'C'_BC'_R$, $R'G'B'A$ or $Y'C'_BC'_RA$); and
- whether the digital representation employs uniformly quantized (linear), PCM, 8 bits, 10 bits or 12 bits.

4.2 A 10-bit or 12-bit codeword, when converted to a smaller number of sampling bits, should either be rounded or truncated. An eight-bit or ten-bit codeword, when converted to a larger number of sampling bits, should have either two or four padding bits added.

5 Image Structure

5.1 The 1920x1080 image structure defined in this standard shall be mapped onto an interface that contains 1125 total lines as shown in Figures 1 and 2. The Interface sampling frequency shall be maintained to a tolerance of ± 10 ppm.

5.2 A frame shall comprise the indicated total number of lines; each line at the interface shall be of equal duration determined by the interface sampling frequency and the luminance samples per total line (S/TL).

Raster pixel representation at the interface shall be presented from left to right, and in the raster shall be presented from top to bottom. Lines are numbered in time sequence according to the raster structure described in Section 7 and shown in Figures 1 and 2.

5.3 Timing instants in each line shall be defined with respect to a horizontal datum denoted by 0_H which is established by horizontal synchronizing (sync) information in Sections 9 and 10. Each line shall be represented by a number of samples, equally spaced, as indicated by the column S/TL in Table 1. The time between any two adjacent sample instants is called the reference clock interval T.

5.4 A progressive system shall convey 1080 active picture lines per frame in order from top to bottom.

5.5 An interlaced system shall capture the image, as a first field then as a second field, in which the lines of each field have twice the vertical spatial sampling pitch of the frame. Lines in the second field shall be displaced vertically by the vertical sampling pitch and the line timing shall be delayed temporally by half the frame time from the lines in the first field.

The first field shall convey 540 active lines, starting with the top picture line of the frame. The second field shall convey 540 active picture lines, ending with the bottom picture line of the frame.

6 System Colorimetry

6.1 Equipment should be designed in accordance with the colorimetric analysis and opto-electronic transfer function defined in this section. This corresponds to ITU-R BT.709. Designers and users should be aware that some legacy material in this format was originally created using the SMPTE 240M standard, which has different colorimetry. However, the differences between the two are so small that they can be ignored, except for precision test materials.

6.2 Picture information shall be linearly represented by red, green and blue tristimulus values (RGB), lying in the range 0 (reference black) to 1 (reference white), whose colorimetric attributes are based upon reference primaries with the following chromaticity coordinates, in conformance with ITU-R BT.709, and whose reference white conforms to CIE D65 as defined by CIE 15:

	CIE <i>x</i>	CIE <i>y</i>
Red primary	0.640	0.330
Green primary	0.300	0.600
Blue primary	0.150	0.060
Reference white	0.3127	0.3290

6.3 From the red, green and blue tristimulus values, three nonlinear primary components R' , G' and B' shall be computed according to the optoelectronic transfer function of ITU-R BT.709, where L denotes a tristimulus value and V' denotes a nonlinear primary signal:

$$V' = \begin{cases} 4.5L, & 0 \leq L < 0.018 \\ 1.099L^{0.45} - 0.099, & 0.018 \leq L \leq 1 \end{cases}$$

6.4 To ensure the proper interchange of picture information between analog and digital representations, signal levels shall be completely contained in the range specified between reference black and reference white specified in Sections 8.7 and 11.5, except for overshoots and undershoots due to processing.

6.5 The Y' component shall be computed as a weighted sum of nonlinear $R'G'B'$ primary components, using coefficients calculated from the reference primaries according to the method given in SMPTE RP 177:

$$Y' = 0.2126 R' + 0.7152 G' + 0.0722 B'$$

NOTE – Because the Y' component is computed from nonlinear $R'G'B'$ primary components, rather than from the linear tristimulus RGB values, it does not represent the true luminance value of the signal, but only an approximation. For more information, see *Poynton, Charles, A Technical Introduction to Digital Video* (Annex F).

6.6 Color-difference component signals P'_B and P'_R having the same excursion as the Y' component shall be computed as follows:

$$P'_B = \frac{0.5}{1 - 0.0722} (B' - Y')$$

$$P'_R = \frac{0.5}{1 - 0.2126} (R' - Y')$$

P'_B and P'_R are filtered and may be coded as C'_B and C'_R components for digital transmission. Example filter templates are given in Figure D.2.

7 Raster Structure

NOTE ON INTERLACED VERSIONS – All of the image structure systems defined in this document require at the interface a total of 1125 lines per picture. In an analog-only system, this would normally imply that the interlaced versions would divide this total into two equal-length fields of $562\frac{1}{2}$ lines each. However, because a digital interface must also be supported, only whole numbers of lines in each field are allowed, in order to permit unambiguous identification of lines by the digital timing reference sequences (see Section 9). Therefore the interlaced versions define integer, and hence unequal, numbers of lines (563 and 562) in each of the two fields comprising one frame. Analog vertical sync sequences, however, must remain equally spaced in time and are therefore not fully aligned to the fields as defined for the digital interface. This results in the analog vertical sync for the second digital field beginning one half-line before the end of the first digital field.

7.1 For details of vertical timing, see Figures 1 and 2.

7.2 In a progressive system, the assignment of lines within a frame shall be:

- Vertical blanking: lines 1 through 41 inclusive (including vertical sync, lines 1 through 5 inclusive) and lines 1122 through 1125; and
- Picture: 1080 lines, 42 through 1121 inclusive.

7.3 In an interlaced system, the first field shall comprise 563 lines including:

- Vertical blanking: lines 1 through 20 inclusive and lines 561 through 563; and
- Picture: 540 lines, 21 through 560 inclusive.

The second field shall comprise 562 lines, including:

- Vertical blanking: lines 564 through 583 inclusive and lines 1124 and 1125; and
- Picture: 540 lines, 584 through 1123 inclusive.

Interlaced analog vertical sync shall be located on lines 1 through 5 for the first field and from halfway through line 563 to halfway through line 568 for the second field.

7.4 During time intervals not otherwise used, the R' , G' , B' or Y' , P'_B , C'_B , P'_R and C'_R components shall have a blanking level corresponding to zero.

7.5 The production aperture defines a region 1920 samples by 1080 lines. The horizontal extent of the production aperture shall have the 50% point of its leading transition at reference luminance sample 0 and the 50% point of its trailing transition at luminance sample 1919. The production aperture defines the maximum extent of picture information. For further information, consult informative Annex E.

7.6 The clean aperture of the picture defines a region 1888 samples in width by 1062 lines high, symmetrically located in the production aperture. The clean aperture shall be substantially free from transient effects due to blanking and picture processing.

7.7 The aspect ratio of the image represented by the production aperture and the clean aperture shall be 16:9. The sample aspect ratio is 1:1 (square pixels).

7.8 The center of the picture shall be located at the center of the 1920x1080 sample structure, midway between sample number 959 and 960, and midway between lines 581 and 582 in a progressive system, and midway between lines 291 and 853 in an interlaced and segmented frame system.

7.9 Each edge of the picture width, measured at the 50% amplitude point, shall lie within six reference clock intervals of the production aperture.

NOTE – Ancillary signals, as distinct from ancillary data, may be conveyed in a progressive system during lines 7 through 41 inclusive, and in an interlaced system during lines 7 through 20 inclusive and lines 569 through 583 inclusive. The portion within each of these lines that may be used for ancillary data is defined in Annex B.3. Ancillary signals shall not convey picture information although they may be employed to convey other related or unrelated signals, coded similarly to picture information. Further specifications of ancillary signals is outside the scope of this standard.

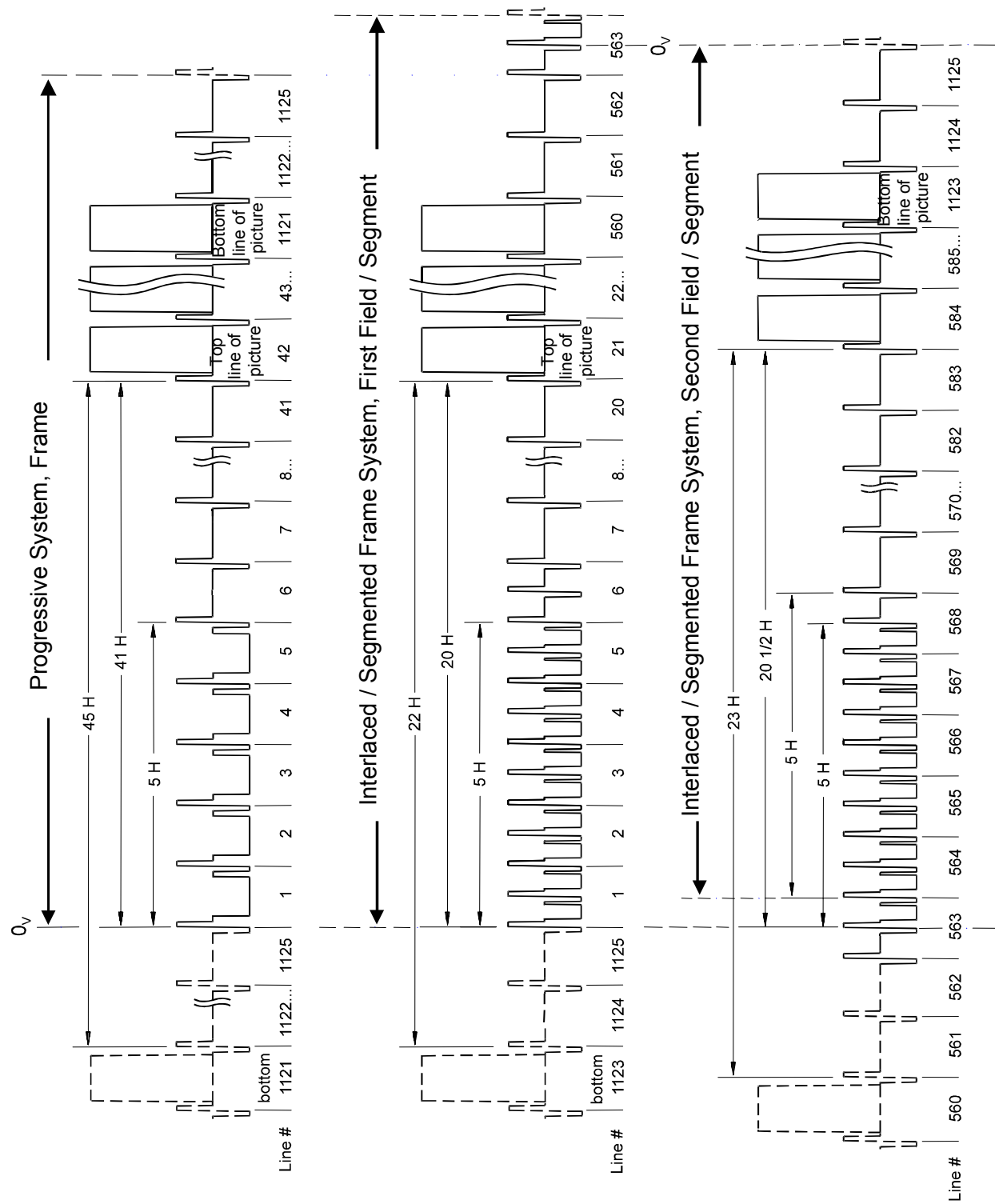
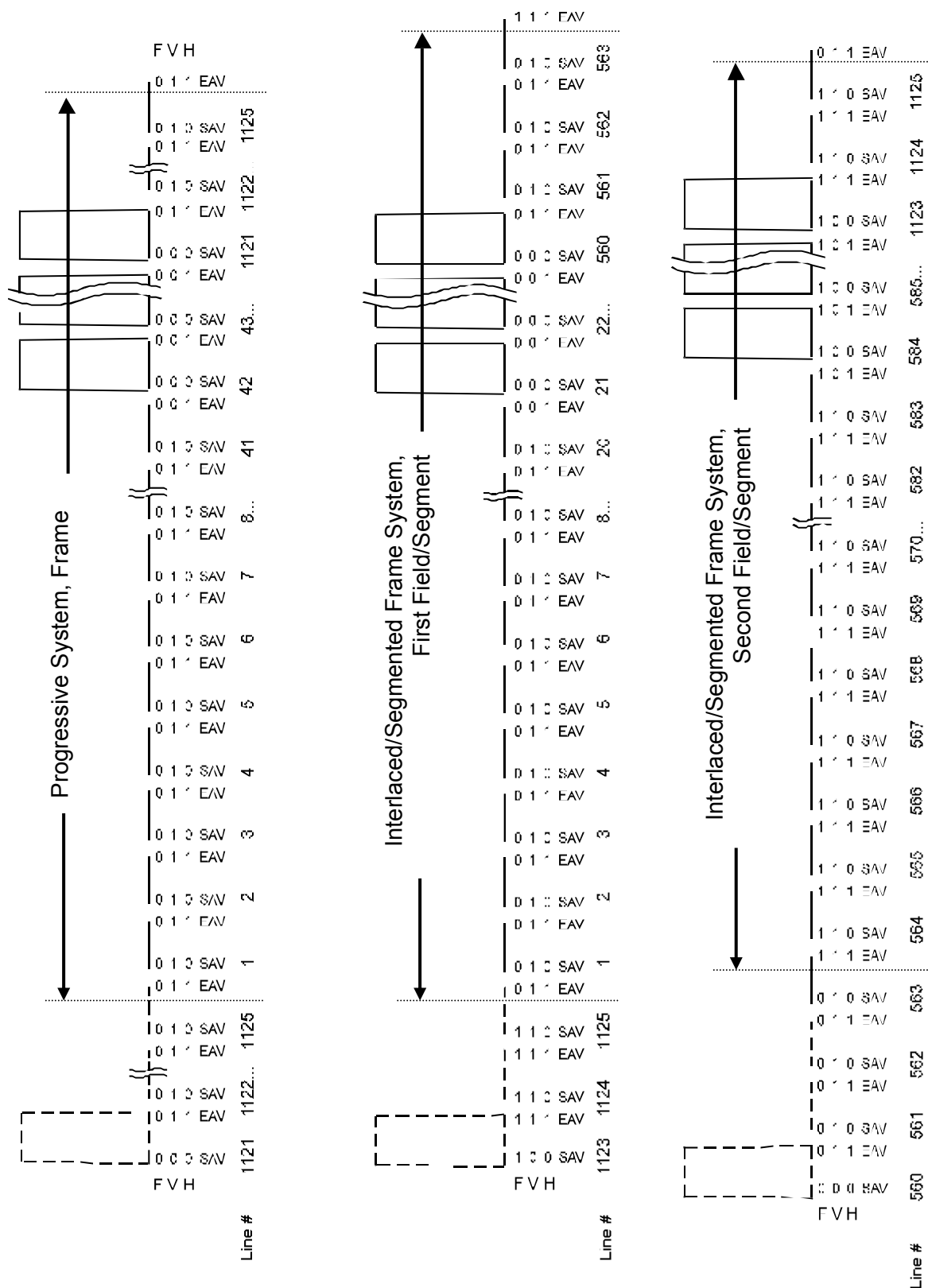


Figure 1 – Analog interface, vertical timing details



8 Digital Picture Representation

8.1 Digital representation shall employ either R'G'B' or Y'C_BC_R components as defined in Section 6, uniformly sampled.

8.2 The digital signals described here are assumed to have been filtered to reduce or prevent aliasing upon sampling (see Annex D).

8.3 R'G'B' signals and Y' signals shall have a nominal bandwidth of 60 MHz for systems 1, 2 and 3 in Table 1 and 30 MHz for systems 4 through 11. C_BC_R shall have bandwidth nominally half that of the associated Y' signal in the case of a 4:2:2 system and the same bandwidth as the associated Y' signal in the case of a 4:4:4 system as shown in Table 2.

8.4 R'G'B' signals and the Y' signal of the YC_BC_R interface shall be sampled orthogonally, line- and picture-repetitive. The interface sampling frequency f_s shall be as shown in Table 2. The period of the sampling clock shall be denoted T. R'G'B' samples shall be cosited with each other.

8.5 A sampling instant in a line is denoted in this standard by a number from 0 through one less than the total number of samples in a line. Sample number zero corresponds to the first active video sample. The sample numbering is shown in Figure 3.

8.6 Sampled data at the interface shall be such that appropriate $\sin(x)/x$ correction occurs during conversion of the signal to the analog domain.

8.7 Digital R'G'B' and Y' components shall be computed as follows:

$$L'_D = \text{Floor}(219DL' + 16D + 0.5); D = 2^{n-8}$$

where L' is the component value in abstract terms from zero to unity, n takes the value 8, 10 or 12 corresponding to the number of bits to be represented, and L'_D is the resulting digital code. The unary function floor yields the largest integer not greater than its argument.

NOTE — This scaling places the extrema of R'G'B' and Y' components at code words $10_h(16)$ and $EB_h(235)$ in an 8-bit representation, code words $040_h(64)$ and $3AC_h(940)$ in a 10-bit representation or code words $100_h(256)$ and $EB0_h(3760)$ in a 12-bit representation as shown in Table 3.

8.8 Digital C_B and C_R components of the Y'C_BC_R set shall be computed as follows:

$$C'_D = \text{Floor}(224DC' + 128D + 0.5); D = 2^{n-8}$$

where C' is the component value in abstract terms from -0.5 to + 0.5 and C'_D is the resulting digital code.

NOTE — This scaling places the extrema of C_B and C_R at $10_h(16)$ and $F0_h(240)$ in an 8-bit representation, code words $040_h(64)$ and $3C0_h(960)$ in a 10-bit representation or code words $100_h(256)$ and $F00_h(3840)$ in a 12-bit representation as shown in Table 3.

8.9 C_B and C_R signals shall each have the same number of horizontal samples as the Y' component in the case of a 4:4:4 system but shall be horizontally subsampled by a factor of two with respect to the Y' component in the case of a 4:2:2 system as shown in table 2. C_B and C_R samples, when subsampled, shall be cosited with even-numbered Y' samples. The subsampled C_B and C_R signals shall be time-multiplexed by sample basis in the order of C_B and C_R. The multiplexed signal is referred to as C_B/C_R.

8.10 Code values having the 8 most-significant bits all zero or all one — that is, 8-bit codes $00_h(0)$ and $FF_h(255)$ in the case of an 8-bit system, 10-bit codes $000_h(0)$ through $003_h(3)$ and $3FC_h(1020)$ through $3FF_h(1023)$ in the case of a 10-bit system, and 12-bit codes $000_h(0)$ through $00F_h(15)$ and $FF0_h(4080)$ through $FFF_h(4095)$ in the case of a 10-bit system as shown in Table 3 — are employed for synchronizing purposes and shall be prohibited from video or ancillary data/signals.

8.11 A system having an 8-bit interface shall address the conversion of 10-bit video data to 8 bits with an appropriate process that minimizes video artifacts such as quantization noise. Ancillary data in 10-bit format shall be converted to 8-bit format by truncating the two least significant bits. In both cases, when converting 8-bit data to 10-bit data the least two significant bits of the 10-bit word shall be set to 0. Every conversion among 8-, 10- and 12-bit systems shall be handled in the same manner.

8.12 For Y' , R' , G' and B' signals, undershoot and overshoot in video processing may be accommodated by the use of code words $01_h(1)$ through $0F_h(15)$ and code words $EC_h(236)$ through $FE_h(254)$ in an 8-bit system, code words $004_h(4)$ through $03F_h(63)$ and code words $3AD_h(941)$ through $3FB_h(1019)$ in a 10-bit system, or code words $010_h(16)$ through $0FF_h(255)$ and code words $EB1_h(3761)$ through $FEF_h(4079)$ in a 12-bit system as shown in Table 3.

For C'_B and C'_R signals, undershoot and overshoot in video processing may be accommodated by the use of code words $01_h(1)$ through $0F_h(15)$ and code words $E1_h(241)$ through $FE_h(254)$ in an 8-bit system, code words $004_h(4)$ through $03F_h(63)$ and code words $3C1_h(961)$ through $3FB_h(1019)$ in a 10-bit system, or code words $010_h(16)$ through $0FF_h(255)$ and code words $F01_h(3841)$ through $FEF_h(4079)$ in a 12-bit system as shown in Table 3.

Table 2 – Bandwidth and interface sampling frequency

Bandwidth and sampling frequency	Signal component	Systems 1, 2 and 3 in Table 1		Systems 4 through 11 in Table 1		Note
		4:2:2	4:4:4	4:2:2	4:4:4	
Maximum bandwidth	R' , G' , B'	60MHz	60MHz	30MHz	30MHz	Section 8.3
	Y'	60MHz	60MHz	30MHz	30MHz	
	C'_B , C'_R	30MHz	60MHz	15MHz	30MHz	
Interface sampling frequency	R' , G' , B'	148.5MHz	148.5MHz	74.25MHz	74.25MHz	Section 8.4
	Y'	148.5MHz	148.5MHz	74.25MHz	74.25MHz	
	C'_B , C'_R	74.25MHz	148.5MHz	37.125MHz	74.25MHz	
Horizontal sample number	R' , G' , B'	1920	1920	1920	1920	Section 8.9
	Y'	1920	1920	1920	1920	
	C'_B , C'_R	960	1920	960	1920	

NOTE – Interface sampling frequency is also scaled by 1/1.001.