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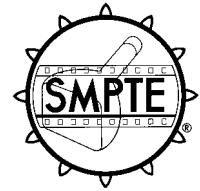
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SMPTE STANDARD

for Television — 1920 × 1080 50 Hz — Scanning and Interfaces



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1 Scope

This standard defines a family of raster scanning systems for the representation of stationary or moving two-dimensional images sampled temporally at a constant frame rate and having an image format of 1920 × 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 interfaces;
- Y'P'B'P_R color encoding and analog interface; and
- Y'C'B'C_R color encoding and digital interface.

An auxiliary component A may optionally accompany Y'C'B'C_R; this interface is denoted Y'C'B'C_RA.

2 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.

SMPTE RP 160-1991, Three-Channel Parallel Analog Component High-Definition Video Interface

SMPTE RP 177-1993, Derivation of Basic Television Color Equations

IEC 169-8 (1978), Part 8: R.F. Coaxial Connectors with Inner Diameter of Outer Conductor 6.5 mm (0.256 in) with Bayonet Lock — Characteristic Impedance 50 Ohms (Type BNC), Appendix A(1 993), and Amendment No. 1 (1996)

3 General

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

- which of the scanning systems of table 1 are implemented;
- which of the analog R'G'B' or Y'P'B'P_R and/or which of the digital R'G'B', Y'C'B'C_R, or Y'C'B'C_RA interfaces are implemented;
- whether the digital representation employs eight bits or ten bits.

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Table 1 – Scanning systems

System nomenclature	Samples per active line (S/AL)	Lines per picture height (L/PH)	Frame rate (Hz)	Scanning format	Sampling frequency f_s (MHz)	Samples per total line (S/TL)	Total lines per frame
1 1920 × 1080/50/1:1	1920	1080	50	Progressive	148.5	2376	1250
2 1920 × 1080/50/2:1	1920	1080	25	2:1 interlace	74.25	2376	1250

3.2 Digital code word values in this standard are expressed as decimal values in the ten-bit representation. An eight-bit system shall round or truncate to the most significant eight bits according to provisions to be described.

4 Scanning

4.1 Scanning shall be based on a reference clock of the sampling frequency indicated in table 1, which shall be maintained to a tolerance of ± 10 ppm.

4.2 A frame shall comprise the indicated total lines per frame, each of equal duration, determined by the sampling frequency and the samples per total line (S/TL). Each line shall be uniformly scanned from left to right; lines in a frame shall be uniformly scanned from top to bottom. Lines are numbered in time sequence according to the raster structure described in clause 6.

4.3 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 clauses 8 and 14. Each line shall be divided into a number of reference clock intervals, of equal duration, indicated by the column S/TL in table 1.

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

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

The first field shall convey 540 active picture 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.

5 System colorimetry

5.1 New equipment should be designed in accordance with the colorimetric analysis and optoelectronic transfer function defined in this clause. This corresponds to ITU-R BT.709.

5.2 Digital representation and treatment of wide-gamut color signals are not specified in the current edition of the international standard for HDTV colorimetry, ITU-R BT.709. In particular, coding ranges for digital primary components R' , G' , and B' are not specified. Designers of new equipment are urged to take into account the approach and current status of international agreement.

5.3 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 white reference conforms to CIE D_{65} as defined by CIE 15.2:

	<u>CIE x</u>	<u>CIE y</u>
Red primary	0.640	0.330
Green primary	0.300	0.600
Blue primary	0.150	0.060
White reference	0.3127	0.3290

5.4 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:

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

5.5 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 7.7 and 15.5, except for overshoots and undershoots due to processing.

5.6 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 of SMPTE RP 177:

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

NOTE – The computed values differ in the fourth decimal place from those given in ITU-R BT.709. For reference, the values given in that document are:

$$Y' = 0.2125R' + 0.7154G' + 0.0721B'$$

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

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

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

These components may be coded as C'_B and C'_R components for digital transmission.

NOTE – The computed values differ in the fourth decimal place from those given in ITU-R BT.709. For reference, the values given in that document are:

$$P'_B = \frac{0.5}{1 - 0.0721} (B' - Y')$$

$$P'_R = \frac{0.5}{1 - 0.2125} (R' - Y')$$

6 Raster structure

6.1 For details of vertical timing, see figures 1 and 2.

6.2 In a progressive system according to this standard, the assignment of lines within a frame shall be:

– Vertical blanking: lines 1 through 160 inclusive and lines 1241 through 1250 inclusive; and

– Picture: 1080 lines, 161 through 1240 inclusive.

6.3 In an interlaced system according to this standard, the first field shall comprise 625 lines including:

– Vertical blanking: lines 1 through 80 inclusive and lines 621 through 625 inclusive; and

– Picture: 540 lines, 81 through 620 inclusive.

The second field shall comprise 625 lines, including:

– Vertical blanking: lines 626 through 705 inclusive and lines 1246 through 1250 inclusive; and

– Picture: 540 lines, 706 through 1245 inclusive.

6.4 Ancillary signals may be conveyed in a progressive system during lines 2 through 160 inclusive, and in an interlaced system during lines 2 through 80 inclusive, and lines 627 through 705 inclusive. 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 specification of ancillary signals is outside the scope of this standard.

6.5 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.

6.6 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 clock 309 and the 50% point of its trailing transition at clock 2229. The production aperture defines the maximum extent of picture information. For further information, consult annex A.

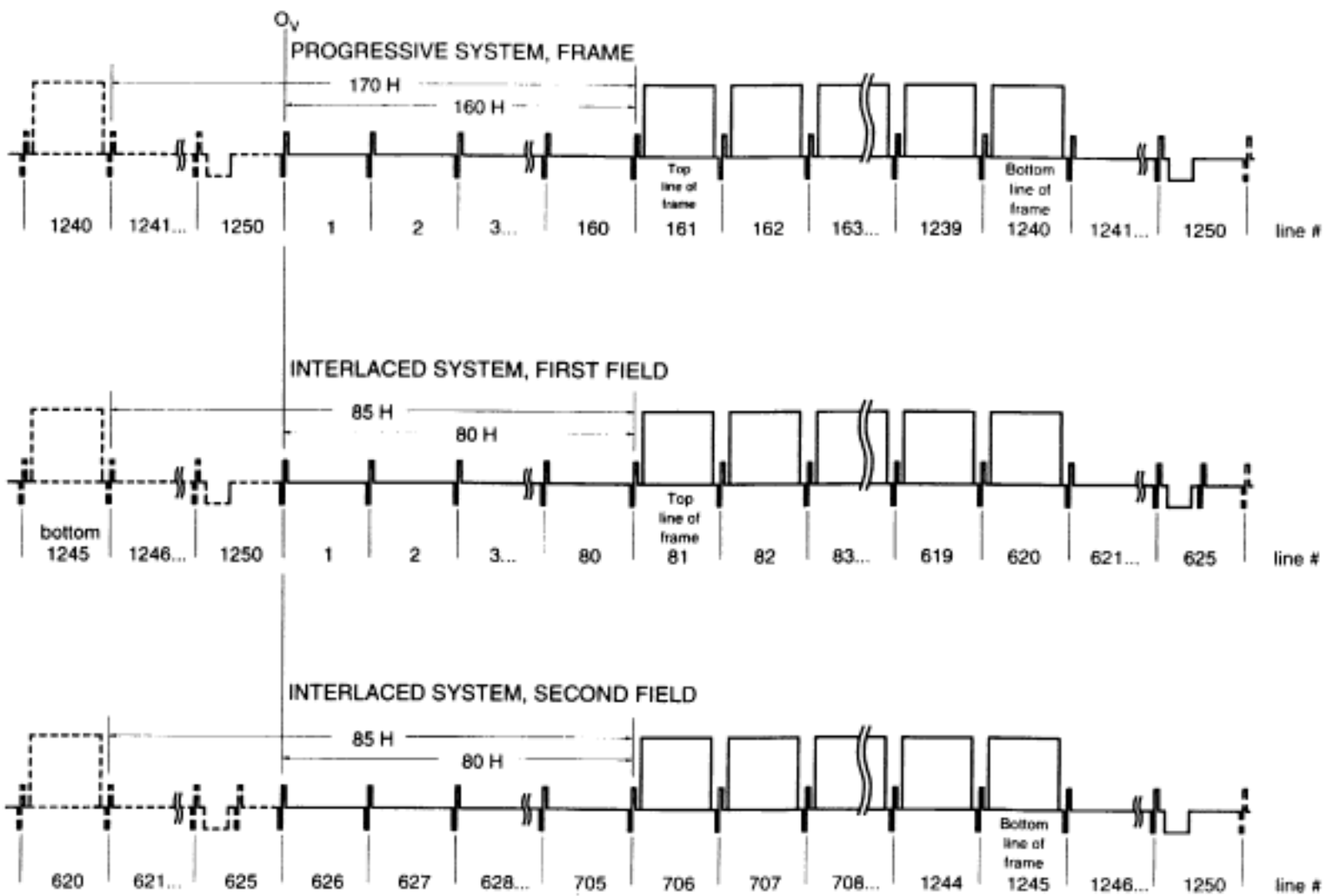


Figure 1 - Analog interface vertical timing details

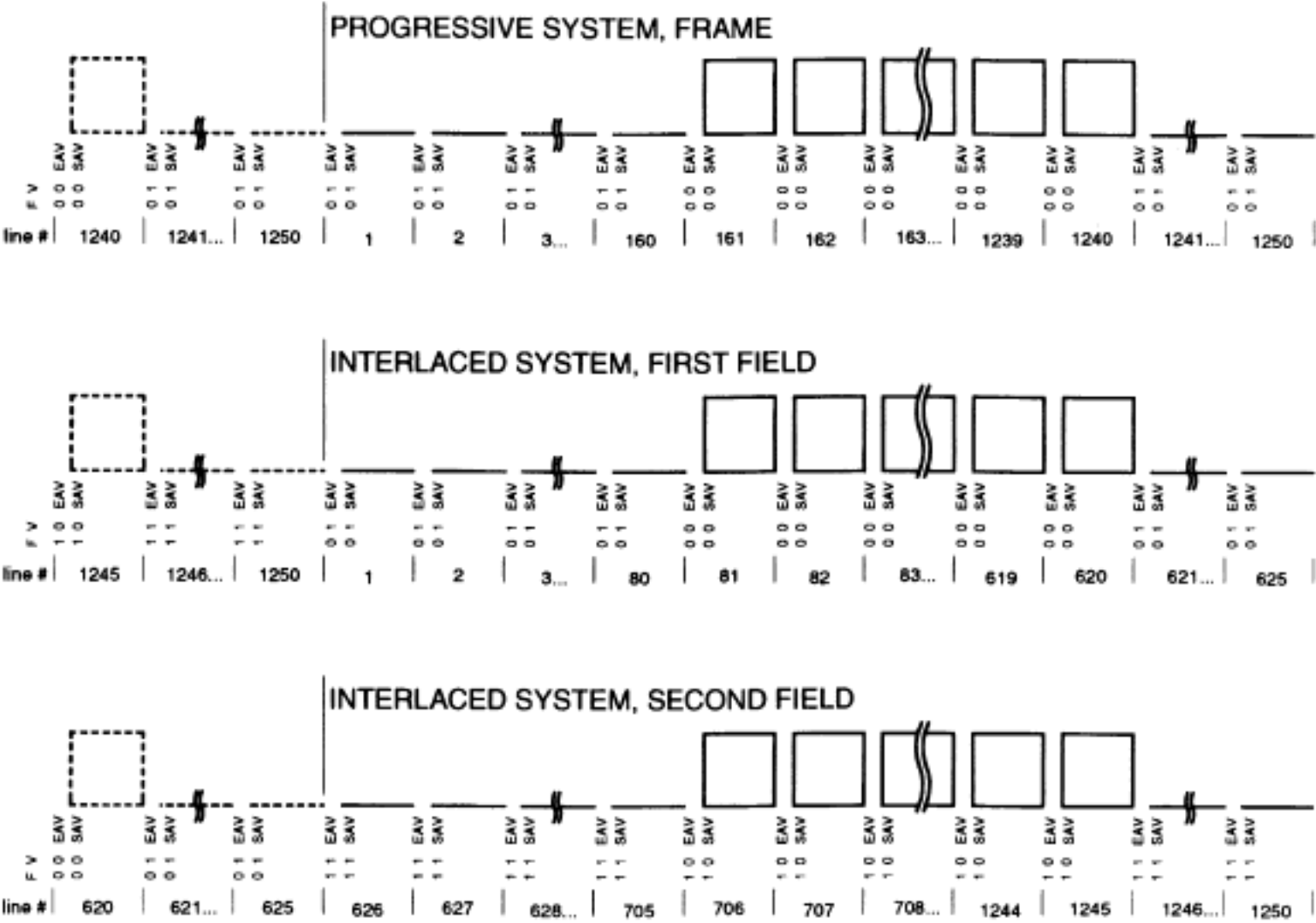


Figure 2 - Digital interface vertical timing details

6.7 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.

6.8 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).

6.9 The center of the picture shall be located at the center of the clean aperture (and of the production aperture), midway between samples 1268 and 1269, and midway between lines 700 and 701 in a progressive system, and midway between lines 351 and 976 in an interlaced system.

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

7 Digital representation

7.1 Digital representation shall employ either R', G', B' or Y', C'_B, C'_R components as defined in clause 5, uniformly sampled.

7.2 The digital signals described here are assumed to have been filtered to reduce or prevent aliasing upon sampling (see annex B).

7.3 R', G', B' signals and Y' signals shall have bandwidth nominally 60 MHz for progressive systems and 30 MHz for interlaced systems. C'_B, C'_R signals shall have bandwidth nominally half that of the associated Y' signal.

7.4 R', G', B' signals, and the Y' signal of the $Y'C'_B, C'_R$ interface, shall be sampled orthogonally, line- and picture-repetitive, at the sampling frequency, f_s . The period of the sampling clock shall be denoted T .

7.5 A sampling instant in a line is denoted in this standard by a number from zero through one less than the total number of samples in a line. Sample number zero corresponds to the 0_H datum. The sample numbering is shown in figure 3.

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

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

$$L'_d = \lfloor 219DL' + 16D + 0.5 \rfloor; D = 2^{n-8}$$

where L' is the component value in abstract terms from zero to unity, n takes the value 8 or 10 corresponding to the number of bits to be represented, and L'_d is the resulting digital code.

The operator $\lfloor x \rfloor$ denotes floor, the largest integer not greater than its argument.

NOTE – This scaling places the extrema of R', G', B' , and Y' components at code words 64 and 940 in a ten-bit representation or code words 16 and 235 in an eight-bit representation.

7.8 Digital C'_B and C'_R components of the $Y'C'_B, C'_R$ set shall be computed as follows:

$$C'_d = \lfloor 224DC' + 128D + 0.5 \rfloor; D = 2^{n-8}$$

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 code words 64 and 960 in a ten-bit representation or code words 16 and 240 in an eight-bit representation.

7.9 C'_B and C'_R signals shall be horizontally subsampled by a factor of two with respect to the Y' component. C'_B and C'_R samples shall be cosited with even-numbered Y' samples (see annex B).

7.10 Code values having the eight most significant bits all zero or all one — that is, ten-bit codes 0, 1, 2, 3, 1020, 1021, 1022, and 1023 — are employed for synchronizing purposes and shall be prohibited from video or ancillary data.

7.11 A system having an eight-bit interface may round video signals to eight bits and then discard the two least significant bits. The two least significant bits of all other data across the interface shall be truncated without rounding.