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SMPTE STANDARD

for Television —

720 x 483 Active Line at 59.94-Hz

Progressive Scan Production —
Digital Representation**Contents**

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1 Scope

1.1 This standard defines the digital representation of stationary or moving two-dimensional images for television production. The representation is sampled linearly in the spatial domain and sampled temporally at a constant frame rate. The scanned image has an aspect ratio of 16:9. The scanning format details are given in table 1. This standard includes both R',G',B' and Y',C'_B,C'_R expressions for the signal representation.

1.2 The principal application of this standard is for the production of content for EDTV-II, which employs an NTSC letterbox encoding scheme, compatible with SMPTE 170M.

NOTES

- 1 R',G',B' and Y',C'_B,C'_R refer to nonlinear "gamma" corrected signals derived from the linear components arising from the analysis of the image which are denoted as R,G,B , etc.
- 2 The signals C'_B,C'_R refer to digital expressions of the color-difference signals. The signals P'_B,P'_R refer to the analog color-difference signals. Although this standard defines the digital representation, references to analog signal representations are given where considered appropriate.
- 3 The primary purpose of this standard is to specify the parameters of the active area of the image. An additional set of parameters is included for real-time applications that consist of the frame rate, vertical and horizontal blanking, and total number of lines. The values of these parameters are included in table 1.
- 4 The term "line" in this standard refers to the digital line in the 483-line frame raster as described in figure B.1. In the case of an analog video signal, the word "analog line" is used. The line numbering is based on the 525 digital line numbers as described in figures 1 and B.1.

Table 1 – Scanning system

System nomenclature	Samples per digital active line (S/AL)	Lines per active image	Frame rate	Sampling frequency f_s (MHz)	Samples per total line	Total lines per frame	Colorimetry
720 x 483/59.94	720	483	60/1.001	27.0	858	525	SMPTE 170M

2 General

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 described in 5.10.

3 Scanning

3.1 Scanning parameters are specified in terms of the reference clock frequency indicated in table 1. The clock frequency shall be maintained to a tolerance of ± 3 ppm.

3.2 A frame shall comprise the total lines per frame indicated in table 1. Each line is of equal duration, determined by the sampling frequency and the samples per total line (S/TL). Each line shall be scanned uniformly from left to right; lines in a frame shall be scanned uniformly from top to bottom. Lines are numbered in time sequence according to the raster structure described in annex B.

3.3 Each line shall be represented by the number of samples specified in table 1. These samples shall be equally spaced. Sample instants shall be defined with respect to a horizontal datum denoted by 0_H , which is also the sync reference instant for the analog signal. The timing of sample instants with respect to 0_H is shown in figure B.1.

4 System colorimetry and transfer characteristics

Signals in conformance with this standard shall be computed by the color analysis, optoelectronic transfer, scaling, and coding characteristics defined in annex A, unless indicated otherwise in an associated video index message (see SMPTE RP 186).

NOTE – The values indicated in annex A are identical to those of SMPTE 170M for NTSC production.

5 Digital representation

5.1 Signals may be expressed as either R', G', B' or Y', C'_B, C'_R digital component sets.

5.2 The digital signals described here are assumed to have been filtered to reduce or prevent aliasing upon sampling. Annex C provides additional information regarding such filtering.

5.3 R', G', B' signals and the Y' signals have a nominal bandwidth of 12 MHz. C'_B and C'_R signals shall have a bandwidth nominally one-half that of the associated Y' signal.

5.4 R', G', B' signals and the Y' signal of the Y', C'_B, C'_R set shall be sampled orthogonally, line and picture repetitive, at the reference clock frequency f_s . The period of the sampling clock is denoted $t = 1/f_s$. C'_B and C'_R signals shall be horizontally subsampled by a factor of two with respect to the Y' component. The C'_B and C'_R samples are cosited with even-numbered Y' samples (sample 0, sample 2, sample 4, etc.) of each line.

5.5 A sampling instant in a line is denoted in this standard by a sample number from zero through one less than the total number of samples in a line. Sample number 736 corresponds to the 0_H datum. The sample numbering is shown in figure 2 (for additional details, refer to figure B.1).

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

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

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

where L' is the component value ($0 \leq L' \leq 1$), n takes the value 8 or 10 corresponding to the number of bits in the digital code word, and L'_d is the resulting digital code.

NOTE – This scaling places the peak values of the 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.

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

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

where C' is the component value ($-0.5 < C' < +0.5$), n takes the value 8 or 10 corresponding to the number of bits in the digital code word, and C'_d is the resulting digital code.

NOTE – This scaling places the peak values of the C'_B and C'_R components at code words 64 and 960 in a ten-bit representation or code words 16 and 240 in an eight-bit representation.

5.9 Code values having the eight most-significant bits all zeros or all ones — 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.

5.10 A system having an eight-bit code word precision may round video signals of 10-bit precision 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.

5.11 For Y' , R' , G' , and B' signals, undershoot and overshoot in video processing may be accommodated by the use of code words 4 through 63 and code words 941 through 1019 in a ten-bit system, or code words 1 through 15 and code words 236 through 254 in an eight-bit system. For C'_B and C'_R signals, undershoot and overshoot in video processing may be accommodated by the use of code words 4 through 63 and code words 961 through 1019 in a ten-bit system, or code words 1 through 15 and code words 241 through 254 in an eight-bit system.

5.12 For Y' , R' , G' , and B' signals, the data words occurring during the digital blanking intervals, that are not used for timing reference codes EAV, SAV, or for ancillary data/signal, shall be filled with the sequence of code word 64 (for 10-bit data) or 16 (for 8-bit data). For C'_B and C'_R color-difference signals, the code word shall be 512 (for 10-bit data) or 128 (for 8-bit data).

6 Raster structure

6.1 The details of the digital horizontal line are shown in figure 2. The figure also includes reference to the location of 0_H of the analog horizontal sync.

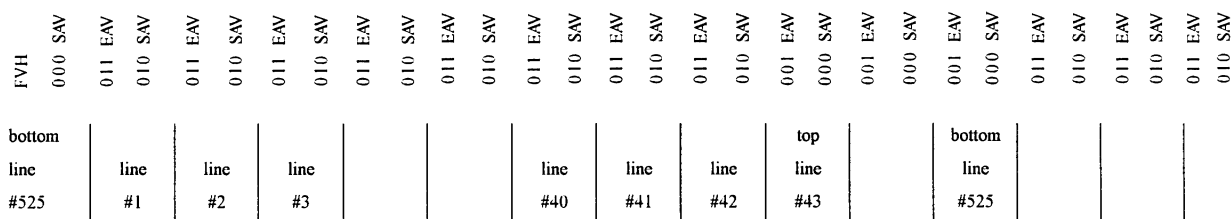
6.2 The details of the vertical scanning structure are shown in figure 1. The figure also includes the line-numbering definition and details of digital vertical blanking.

6.3 The production aperture is defined by the number of active lines and active pixels as shown in table 1.

6.4 The clean aperture shall extend vertically from line 44 to line 523, inclusive. Horizontally, the clean aperture shall extend from sample 6 to sample 713, inclusive. Analog blanking edges and other edge processing artifacts should be confined to the area outside the clear aperture.

6.5 The center of the picture is defined as the center of the clean aperture. Vertically, the center of the picture lies between line 283 and line 284. Horizontally, the center of the picture lies between sample 359 and sample 360.

6.6 Each active line has a 4 sample/byte preamble, start of active video (SAV), and a postamble end of active video (EAV), which are described in clause 7.



Total lines	Bottom line #	Top line #	Line #1	Lines available for data
525	525	43	Next to bottom line	42

Figure 1 – Vertical timing details specified in line numbers and the coding of EAV/SAV data