

SMPTE Standard for television— signal parameters— 1125/60 high-definition production system

1. Scope

This standard defines the basic characteristics of the video signals associated with origination equipment operating in the 1125/60 high-definition television production system. As this standard deals with basic system characteristics, all parameters are uninterlaced.

2. Scanning Parameters

The video signals represent a scanned raster with the following characteristics:

- Total scan lines per frame 1125
- Active lines per frame 1035
- Scanning format Interlaced 2:1
- Aspect ratio 16:9
- Field repetition rate 60.00 Hz
- Line repetition rate (derived) 33750 Hz

3. System Colorimetry

The system is intended to create a metameric reproduction (visual color match) of the original scene under conditions of equal color temperature and luminance between the original scene and its reproduction. To this end, the combination of a camera's optical spectral analysis and linear signal matrixing shall match the CIE color-matching functions (1931) of the reference primaries. Further, the combination of a producer's linear matrixing and reproducing primaries shall be equivalent to the reference primaries. (See Appendix A1.)

Colorimetric analysis and signal amplitude transfer function are defined in the following sections:

3.1 Chromaticity of Reference Primaries:

- G: $x = 0.310$ $y = 0.595$
- B: $x = 0.155$ $y = 0.070$
- R: $x = 0.630$ $y = 0.340$

where

x and y are CIE 1931 chromaticity coordinates.

3.2 Reference White. The system reference white is an illuminant which causes equal primary signals to be produced by the reference camera, and which is produced by the reference reproducer when driven by equal primary signals. For this system, the reference white is specified in terms of its 1931 CIE chromaticity coordinates, which have been chosen to match those of CIE illuminant D_{65} :

- $x = 0.3127$ $y = 0.3291$

3.3 Opto-Electronic Transfer Characteristic of Reference Camera:

- $V_c = 1.1115 \times L_c^{0.45} - 0.1115$ for $L_c \geq 0.0228$
- $V_c = 4.0 \times L_c$ for $L_c < 0.0228$

where

V_c is the video signal output of the reference camera normalized to the system reference white, and L_c is the light input to the reference camera normalized to the system reference white.

3.4 Electro-Optical Transfer Characteristic of Reference Producer:

- $L_r = [(V_r + 0.1115) / 1.1115]^{1/0.45}$ for $V_r \geq 0.0913$
- $L_r = V_r / 4.0$ for $V_r < 0.0913$

where

V_r is the video signal level driving the reference reproducer normalized to the system reference white, and L_r is the light output from the reference reproducer normalized to the system reference white.

4. Reference Clock

Signal durations and timings are specified both in microseconds and in reference clock periods:

- Reference clock periods in total line: 2200
- Reference clock frequency (derived): 74.25 MHz

5. Video Signal Definitions

The image is represented by three parallel, time-coincident video signals. Each incorporates a synchronizing waveform. The signals shall be either of the following sets:

- Color Set**
 - E_G' — green
 - E_B' — blue
 - E_R' — red
- Color Difference Set**
 - E_Y' — luminance
 - E_{PB}' — blue color difference
 - E_{PR}' — red color difference

where

$[E_G' E_B' E_R']$ are the signals appropriate to directly drive the primaries of the reference reproducer (being non-linearly related to light levels as specified in Secs. 3.3 and 3.4), and $[E_Y' E_{PB}' E_{PR}']$ can be derived from $[E_G' E_B' E_R']$ through a linear matrix.

Specifically,

- $E_Y' = (0.701 \times E_G') + (0.087 \times E_B') + (0.212 \times E_R')$
- E_{PB}' is amplitude-scaled $(E_B' - E_Y')$, according to
- $E_{PR}' = \frac{(E_R' - E_Y')}{1.826}$

and E_{PR}' is amplitude-scaled $(R - Y)$, according to

$$E_{PR}' = \frac{(E_R' - E_Y')}{1.576}$$

where the scaling factors are derived from the signal levels given in Sec. 6.3, and the transformation equations which follow.

The derived transformation between the two sets is

$$\begin{bmatrix} E_G \\ E_B \\ E_R \end{bmatrix} = \begin{bmatrix} 1.000 & -0.227 & -0.477 \\ 1.000 & 1.826 & 0.000 \\ 1.000 & 0.000 & 1.576 \end{bmatrix} \begin{bmatrix} E_Y \\ E_{PB} \\ E_{PR} \end{bmatrix}$$

$$\begin{bmatrix} E_Y \\ E_{PB} \\ E_{PR} \end{bmatrix} = \begin{bmatrix} 0.701 & 0.087 & 0.212 \\ -0.384 & 0.500 & -0.116 \\ -0.445 & -0.055 & 0.500 \end{bmatrix} \begin{bmatrix} E_G \\ E_B \\ E_R \end{bmatrix}$$

6. Video and Synchronizing Signal Waveforms

The combined video and synchronizing signal shall be as shown in Fig. 1. For illustrative purposes, a video signal of the form E_G' , E_B' , or E_R' is shown. The details of the synchronizing signal are identical for the E_{PB}' and E_{PR}' color-difference signals.

6.1 Timing

6.1.1 The timing of events within a horizontal line of video is illustrated in Fig. 1(a) and summarized in Table 1. All event times are specified, in terms of the reference clock period, at the midpoint of the indicated transition.

Table 1
Timing of Events of a Video Line

Reference Clock Periods	
Rising edge of sync (timing reference)	0
Trailing edge of sync	44
Start of active video	192
End of active video	2112
Leading edge of sync	2156

6.1.2 The durations of the various portions of the video and sync waveforms are illustrated in Fig. 1 (b), (c), and (d), and summarized in Table 2.

Table 2
Duration of Video and Sync Waveforms

Reference Clock Periods	Time (Derived) (μsec)
a	44
b	0.593
c	1.185
d	88
e	44
f	0.593
g	132
h	1.778
i	192
j	2.586
k	4
l	0.054
m	29.63
n	25.86

6.2.2 The color difference set $[E_r' E_{rs}' E_{rs}']$ comprises a luminance signal E_r' whose nominal bandwidth is 30 MHz, and color difference signals E_{rs}' and E_{rs}'' whose nominal bandwidth is 30 MHz for analog originating equipment, and 1.5 MHz for digital originating equipment.

6.3 Analog Representation. The video signals are represented in analog form as follows:

$E_r', E_{rs}', E_{rs}'', E_{rs}'''$ Signals	(mV)	0
Reference black level	(mV)	700
Reference white level	(mV)	± 300
Synchronizing level	E_{rs}'', E_{rs}''' Signals	
Reference zero signal level	(mV)	0
Reference peak levels	(mV)	± 350
Synchronizing level	(mV)	± 300

6.2 Bandwidth
6.2.1 The color set $[E_r' E_{rs}' E_{rs}']$ comprises three equal-bandwidth signals whose nominal bandwidth is 30 MHz.

Appendix

(This Appendix is not part of the SMPTE Standard, but is included for information only.)

A1. System Colorimetry

The parameter values in Sec. 3 are based on current practice and technical constraints. It is recognized that the availability of a wider color gamut is highly desirable in an originating system. Furthermore, it is useful, for purposes of picture processing, to have available video signals proportional to light levels. In particular, the encoding of linear signals, commonly identified as a "constant-luminance" system, is believed to be desirable.

In order to achieve a practical implementation of these desirable characteristics, it is necessary to incorporate non-linear processing (according to the equations of Sec. 3) at various points in the system, within the originating production plant, along the distribution chain, and within the home receiver.

It has not yet been demonstrated that this processing can be achieved with an appropriate balance of precision and cost. Further study of this matter is required in order to demonstrate the feasibility of incorporating such signal processing into commercial equipment where appropriate.

With respect to color gamut, it is felt that the system should embrace a gamut at least as large as that represented by the following primaries:

G: $x = 0.210$ $y = 0.710$
 B: $x = 0.150$ $y = 0.060$
 R: $x = 0.670$ $y = 0.330$

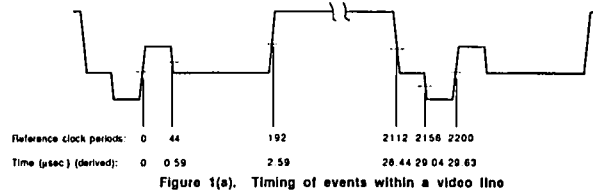


Figure 1(a). Timing of events within a video line

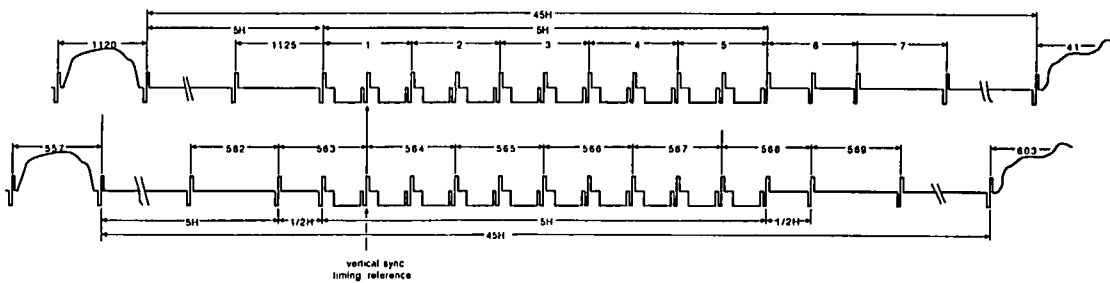


Figure 1(b). Detail of field blanking periods

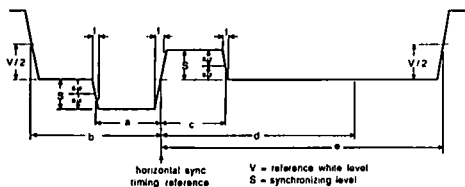


Figure 1(c). Detail of line blanking period

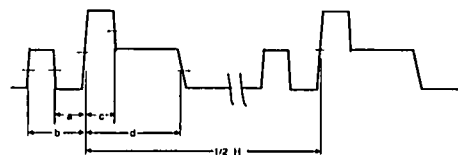


Figure 1(d). Detail of field synchronizing pulse

Fig. 1
Timing, Blanking and Synchronizing Waveforms

A2. Digital Representation

It will be necessary to define the digital representation of the 1125/60 HDTV signal. Current practice and experience have not clarified the most suitable value for certain parameters, in particular, the number of bits per sample and the coding law. An appropriate form for the specifications would be the following:

$E_r', E_{rs}', E_{rs}'', E_{rs}'''$ Signals	(bits)	[]
Quantization	(bits)	[]
Coding law	(bits)	[]
Sampling frequency	(MHz)	74.25
Samples per active line		1920
		960

The sampling structure is orthogonal; line, field, and frame repetitive.

A3. Tolerances

A3.1 Parameter Aim Points. Tolerances are not affixed to any of the parameters specified in this document since it specifies aim points for system design rather than detailed system specifications. Furthermore, it was not possible to determine comprehensive tolerances for all parameters on the basis of current information. It was concluded that tolerancing should be left to future documents which give detailed specifications for specific components or equipment operating in the 1125/60 HDTV system.